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# Let`s Twist again

*An empirical study of Operation Twist - and the Maturity Extension programs effect on the 10-year Treasury yield in 1961 and 2011-2012.*

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## ABSTRACT

This report investigates whether Operation Twist (1961) and the Maturity Extension Program (MEP) (2011-2012), has induced a decline in the 10-year Treasury yield. I discuss the economic starting points for the two monetary policies and if the broader objective of economic stimuli is achieved in the American economy today. By estimating-and predicting the 10-year yield I assess whether fundamental conditions in the American economy warrant the level of the 10-year yield today-and in 1961. I further review whether the current low level can be explained by other monetary policies-or macroeconomic conditions.

My results indicate that MEP might have given a downward pressure on the 10-year Treasury yield. By predicting the 10-year Treasury yield with the variables PMI, inflation, the trade balance, the effective federal funds rate, federal debt held by foreign-and international investors and the St. Louis Financial stress index there still remains, on average, a 55 basis point unexplained spread between the model-predicted yield and actual yield. My results especially indicate that foreign inflow of capital to Treasuries has been an important determinant for the development in the 10-year yield in the last years.

I further find a small-and short lived effect of Operation Twist on the 10-year Treasury yield. My conclusions are mainly based on a marginal decline in the actual 10-year yield in 1961, but also because the amount of U.S marketable federal debt held by the public remains roughly unchanged in 1961.

Overall I conclude that MEP might have been stimulating for the economy; longer-term yields have declined and there are signs of eased credit conditions. However, Quantitative easing programs in 2008-2010 and continuous forward guidance by the Federal Reserve are factors that most likely have contributed to the current low levels of the longer-term Treasury yields.

## FOREWORD

After five years at the Norwegian School of Economics I had to make a choice in the fall of 2012 on what interested me as a dawning economist. I had already made one choice regarding my professional future by choosing NHH and a Master in Financial Economy, but the question remained; what have I learned during my higher education that motivated me to use a full semester investigating? As a financial economics student, I have probably used most of my time in the study hall trying to separate terms and mechanism from each other. Interest rates, currency, financial derivatives, yields, bonds, options, present value; the list goes on. However, among all the macroeconomic terms- and phrases an original name surfaced the fall of 2011: Operation Twist. A monetary policy adopted in 2011 with roots in the 1960`s, with the aim to reduce longer-term interest rates by the purchase of longer-term Treasury securities. It is not a less complex issue, but the actuality of Operation Twist, the underlying mechanisms and the importance of its envisioned effects has really interested me. More importantly, Operation Twist as a subject has forced me to put theory in practice and has given me a dawning insight in the cobweb of macroeconomics.

There already exist empirical studies on the effects of large-scale asset purchase programs, but since the maturity extension program is still being conducted the accumulated effects on the economy are uncertain. In addition, I cannot exactly say that Ben Bernanke, Franco Modigliani & Eric Swanson are colleagues of mine; the other empirical studies that exist on the subject are of a fare more sophisticated nature. But, everybody has to start some place.

I want to thank my coach and counselor Jan Tore Klovland for valuable guidance and interest in the subject. I also want to thank DNB for helping me construct a model for the 10-year Treasury yield.

Bergen 15<sup>th</sup> of December, 2012

Julie Anette Lyngstad Erdal

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# 1. INTRODUCTION

## 1.1 THE TWIST

The twist became a worldwide dance craze in the early 1960`s. Although prized and loved by young people, the dance also drew fire from people who felt it was provocative. No one is quite sure where it originated, but some mean it was a part of an African dance brought to the U.S. in the slavery era. The dance was easy to do; a simple swiveling of the hips. The dance attained so much popularity that it gave inspiration to many other dances, and surprisingly to a monetary policy first adopted in 1961 called the Operation Twist. This operation did not involve swiveling of the hips, but twisting of interest rates in the yield curve. Chubby Checker, the hit maker with “Let`s twist again”, recently summed up the development by saying “the twist has always meant money for everybody”.

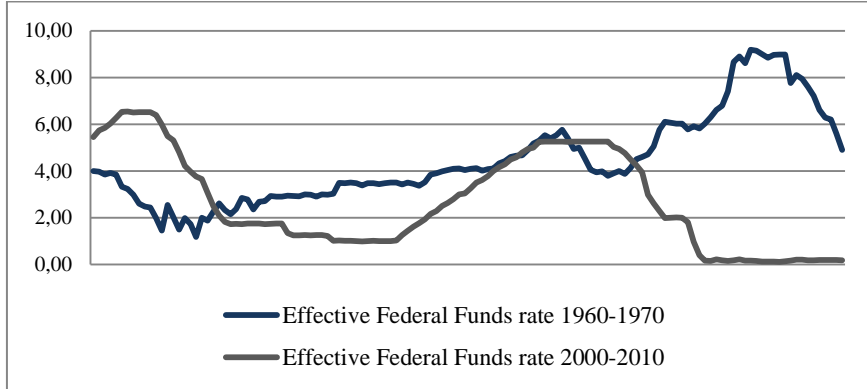
## 1.2 OPERATION TWIST

The Kennedy administration was in 1961 the first to propose Operation Twist. The operation entailed trying to lower long-term interest rates while keeping short-term interest rates unchanged (Alon & Swanson, 2011). Under this program the Federal Reserve is selling or redeeming shorter-term Treasury securities and using the proceeds to buy longer-term securities to shorten the average maturity of government debt held by the public (Bernanke, 2012). Operation Twist is therefore also an attempt to change the “quantity and mix of financial assets held by the public” trough the portfolio rebalancing channel of monetary policy (Bernanke, 2010). Longer-term interest rates are supposed to decline to trough this monetary channel by reducing the longer-term securities held by private investors. The main action underlying this monetary policy is the Federal reserve`s open market operations and the Treasury debt management operations (Bernanke, Reinhart & Sack 2004). The initiative extends the average maturity of the securities in the Federal Reserve`s portfolio, without increasing money supply (Board of Governors of The Federal Reserve System, 2012c). This key feature has also given Operation Twist the name Maturity extension program (MEP) in the last year.

In 2011 the Federal Open Market Committee (FOMC) embraced the same initiative, 50 years after its first trial run. You could say that the economic conditions were somewhat different in these two eras,

but what they have in common is that the central bank had to rely on “non-standard” policy alternatives to stimulate the economy.

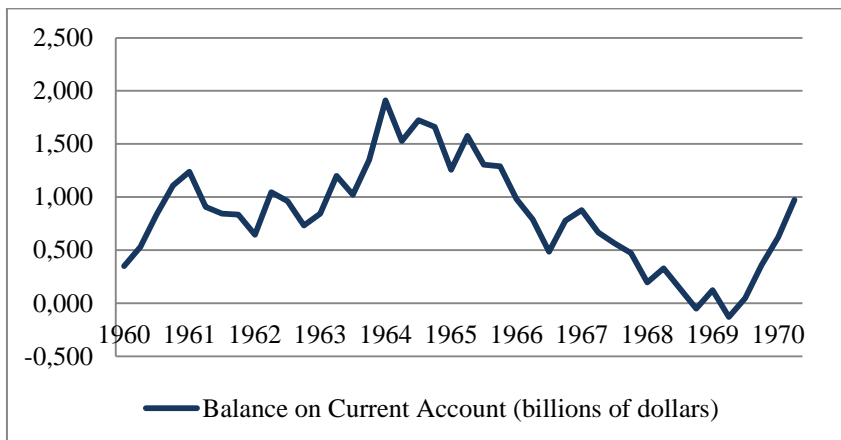
Figure 1-1 Zero lower bound?



Source: (FRED, Data: Effective federal funds rate, monthly: FEDFUNDS)

In 2011, the nominal interest level was constrained by a zero lower bound and is essentially still ranging around zero today. In 1961, the Kennedy administration could not lower the nominal interest rates without worsening the outflow of gold- and the growing trade deficit (Zaretsky, 1993).As the following graph displays, the balance of current accounts was roughly reduced to half the value from 1960 to 1961.

Figure 1-2 Balance on Current Account 1960-1970



Source: (FRED, Data: Balance on Current Account, quarterly: BOPBCA)

What 1961 and 2011 have in common is that the Federal Reserve could no longer rely on reductions in the nominal interest rate to stimulate aggregate demand but turned to other policies to fulfill their dual mandates. The policy makers in both eras wanted a reduction in the longer-term interest rates without supplying liquidity to the economy. The program in 1961 will therefore hereafter be referred to as Operation Twist and the program in 2011-2012 as the Maturity Extension Program (MEP).

Despite differences in starting points for Operation twist in 1961 and MEP in 2011; the theory for the term structure of interest rates could be the same. A hypothesis for this study will be to see if the determinants regarding inflation, real interest rates and term premium have changed in the last 50 years. Therefore an empirical study for both periods using the approximate the same determinants for the longer-term interest rates will be conducted, to see if longer-term interest rates can be reduced by programs like Operation Twist and MEP.

### 1.3 LET`S TWIST

In February 1961, the Fed moved away from their “bills only” policy, where the FOMC was restricted to conduct open market operations in the short-end of the market, to direct the Federal Reserve Bank of New York to purchase intermediate-or-long-term U.S securities up to ten years in maturity (Zaretsky, 1993). An important feature of Operation Twist was the alleged joint participation by both the Federal Reserve and the U.S Treasury. The Treasury was instructed to reduce its issuance of longer-term notes- and bonds and only issue primarily shorter-term securities. While the Fed would maintain the current low level of the federal funds rate and purchase longer-term securities (Swanson, 2011 p. 4). Zaretsky (1993) states that in the beginning of the program the acquisitions were only done in the range of five- and half years in maturities, allowing the market to adjust to the program. Thereafter, securities with a maturity over 10 years were purchased. In March 1961, the FOMC also permitted purchases of securities with remaining maturities over 10 years (Zaretsky, 1993). In total the Federal Reserve purchased longer-term bonds worth \$ 8, 8 billion and reduced its holdings of short term Treasuries bills by \$7, 4 billion (Meaning & Zhu, 2012).

Table 1-1 Fed`s balance sheet 1960 vs. 1961

Treasuries in Fed balance sheet (% of total)	1960 (before Operation Twist)	1961(after Operation Twist)
Certificates (short term securities)	33 %	6%
Treasury Bills ( less than 1 year)	10,6%	11,1%
Treasury Notes (more than 1 year)	46%	69%
Treasury Bonds (more than 5 years)	9%	13%

Source: (Zaretsky (1993) & Agrawal (2011))

As we can assess from this table, the amount of shorter-term treasuries, here certificates, decreased in terms of total share of Treasuries indicating that the Fed sold treasuries to keep the shorter-term interest rates unchanged. The share of Treasury notes-and bonds, increased in the period 1960-1961, indicating that the Fed purchased longer-term securities, especially in the maturities ranging from 1-5 years. Some claim that the size of the purchases were of limited size, but in reality it is comparable with large-scale asset purchases (LSAP`s) conducted by the Fed as a part of their Quantitative easing programs in 2009 when one adjust the size of the economy and the Treasury market (Swanson, 2011). Operation Twist was in effect in a smaller degree in the years following 1961, but was finally abandoned as a monetary policy in 1965 (Zaretsky, 1993).

#### 1.4 LET`S TWIST AGAIN

The Federal Reserve is today not fulfilling its dual mandate for max employment and stable prices. Unemployment is still high and the economy struggles with recovering from the financial crisis. Bush tax-cuts expire in 2013, if implemented this could lead the economy into a new recession. The so-called “fiscal cliff” could potentially lead to a tightening equivalent to 5 % of GDP (DNB Økonomiske utsikter, 2012). The growth is further limited by the weak development in private consumption, a driver that accounts for 70% of American value creation (DNB Økonomiske utsikter, 2012). In addition uncertainty regarding the Euro crisis has a negative impact on the economy. The ongoing strains in the financial markets make monetary policy very challenging (Bernanke, 2012).

In September 2011 the FOMC turned to MEP by announcing a \$400 billion program that would be completed by the end of June 2012 (Boards of Governors of the Federal Reserve System, 2012c). In June 2012, the FOMC announced a continuation of the program through the end of 2012 for additional \$267 billion in purchases- and sales of Treasury securities. The Open Market Trading desk was

especially directed to purchase Treasury securities with remaining maturities of 6 to 30 years, and sell- or redeem securities with maturities of 3 years or less (Federal Reserve Bank of New York, 2012b).

Table 1-2 Distribution of purchases under MEP with approximate weight

Nominal coupon Securities with remaining maturity				TIPS
6-8 years	8-10 years	10-20 years	20-30 years	6-30 years
32%	32%	4%	29%	3%

Source: (Federal Reserve Bank of New York, 2012b)

The longer-term securities purchased under MEP should have an average duration of approximately 10 to 11 years, while the sales- and redemptions of securities have an average duration of 1, 5 years. At the end of the total \$ 667 billion program, the Federal Reserve`s portfolio should therefore have an increased duration from 5 to 8 years (Federal Reserve Bank of New York, 2012b).

In the U.S, private consumption and investments decisions are rarely taken on the basis of short-term rates. Those decisions respond more to longer-term yields (Bernanke, Reinhart & Sack, 2004). The overall purpose of MEP is therefore to provide additional support for the economic recovery by reducing the supply of longer-term Treasury securities. A reduction in the duration from the portfolio of private investors should put a downward pressure on longer-term interest rates, more than should otherwise prevail (Federal Reserve Bank of New York, 2012b). Since longer-term Treasury securities are considered substitutes for other financial assets, the hope is that a reduction in yields on these securities will spin off to interest rates on a range of instruments including corporate bonds, home mortgages and loans to households- and businesses (Board of Governors of the Federal Reserve System, 2012c). The sales of shorter-term securities could put some upward pressure on the yields but the FOMC communications about the exceptionally low level of the federal funds rate through mid-2015 should anchor short-term rates near current levels (Board of Governors of the Federal Reserve System, 2012c). The effect on shorter-term yields is therefore likely to be small.

## 1.5 OUT OF AMMUNITION?

Operation Twist was criticized by many in 1961; according to Modigliani & Sutch (1966) there was little evidence that changes in the maturity structure of federal debt could bring to bear a significant influence on the relationship between long- and short term rates. In addition, some meant the

experiment in 1961 never happened. Bank of International Settlements (2009) suggests that the Treasury's extension of maturities counteracted the sale-and purchases of securities by the Fed. Other forms of criticism stem from different beliefs regarding the term structure of interest rates- and if demand has any pressuring effects on the longer-term rates in the economy.

In the event that there has been a direct effect through Operation Twist and MEP, there have been other stimulating monetary policies at the same time that could have induced a decline in longer term rates simultaneously. And even if Operation Twist and MEP stimulates the economy; its effect is difficult to estimate precisely because you cannot observe how the economy would perform in the absence of the Federal Reserve's actions (Bernanke, 2012). In addition, to study the macro economic effects from MEP with models can be challenging to get right as it is likely that the recent crisis can have impaired some of the normal monetary transmission channels assumptions that the models rely on (Bernanke, 2012). In addition, it is difficult to estimate how persistent macroeconomic effects of large-scale asset purchases have been on financial conditions (Bernanke, 2012).

## 1.6 RESEARCH QUESTION

In this study I wish to analyze whether Operation Twist and MEP have had an effect on the longer-term yields in the economy, more precisely an effect on the 10-year Treasury yields. Analysis for both Operation Twist and MEP will be conducted, but emphasis will be on MEP. Firstly, this program was much larger in size; finding effects on longer-term yields is therefore more likely. Secondly, I limit myself for practical reasons; gathering useful data has been more challenging for the 60's.

I will limit myself to analyze long-term interest rates in the analysis of MEP since there is little expected effect on short-term yields in today's economy as they are anchored by FOMC announcements regarding the federal funds target rate. In addition, the effect on longer-term interest rates is more important in terms of economic stimuli. For Operation Twist, the goal was to keep shorter-term interest rates unchanged, therefore I will also in the analysis of Operation Twist limit myself to analyze the 10-year treasury yield.

I will analyze which variables can explain movements in 10-year Treasury yield, and if fundamental conditions in the economy have exhaustive explanatory power-, or if effects like MEP- and demand pressuring channels have altered the course of longer-term interest rates. If I find this to be the case, I

will reflect on other monetary policies- and macroeconomic conditions that might have influenced the fall in the 10-year yields. The analysis will therefore display two directions: which variables can explain the variation in the 10-year yields for a more general purpose, and which variables can explain the variation in the last year. These two results might differ and emphasis is on the latter, but one is difficult to do without the knowledge of the other.

The study will be structured as follows. Firstly, I will review relevant theory which may be useful for my research question. Secondly, I will discuss the methodology and which variables I have used as a starting point for the analysis. Thereafter, I will investigate the robustness of the model, adjusting the data series if necessary. Following this will be a thoroughly review of results from the analysis, including results when expanding the model and when testing the model towards a random data series to check the general explanatory power of the first variables used. In the end I will discuss to what degree the objectives of broader economic stimuli from MEP have anchored in the American economy and what other reasons there might be for declining Treasury yields. An integral part of this section will be a review of what other empirical studies have found on the effect of MEP and Operation Twist. As a conclusion I will reflect on possible economic costs of the MEP, how the central bank wishes to exit its accommodating policies, and “the road ahead” for the Federal Reserve.



## 2 THEORY

When discussing macroeconomics, it is challenging to limit what theory is relevant and exhaustive. In each theory section I will therefore explain and motivate why I regard this theory useful for this study.

### 2.1 THE TERM STRUCTURE OF INTEREST RATES

The theory of term structure of interest rates is one of the most important- and relevant theory`s for the research question. The whole effect of Operation Twist and MEP relies on certain assumptions about the term structure of interest rates and what information lies in the yield curve. This theory is also essential when arguing for which variables to include in the analysis and the interpretation of the results. I will first review important concepts regarding interest rates before I derive the most dominant theories explaining the relationship between shorter-and longer-term interest rates. The majority of this theory is found in Mishkin (2009).

#### **Interest rates**

In a basic sense, we can say that interest rates are what we pay to avoid waiting, i.e. the price of time. Interest rates can have an impact of the health of the overall economy and are therefore among the most monitored variables in the economy (Mishkin, 2009). The level of interest rates will for instance influence willingness to spend- or save money for both households and corporations. Indirectly, interest rates can therefore influence aggregate demand in the economy and ultimately investment decisions that could create jobs (Mishkin, 2009). We often refer to just “interest rates”, but in reality there are several financial instruments where the interest rate on each instrument is determined by supply and demand in that market. All tough interest rates in different markets are determined by market specific conditions, the central bank decide the overall interest rate level (Mork, 2004)

#### **Nominal-and real interest rates**

When discussing interest rates the first distinguish needs to be made between nominal-and real interest rates. Nominal indicate that values are measured at current price levels. Real interest rates take inflation into account by extracting expected changes in the price level (Mishkin, 2009, p.84). We differentiate between these two types of interest rates to more accurate measure the cost of borrowing and the incentives to lend- or borrow at a given real rate. The real interest rate is more accurately

defined from the Fisher equation which reads that the nominal interest rate ( $i$ ) equals the real interest rate ( $i_r$ ) plus the expected rate of inflation ( $\pi^e$ ). Alternatively that the real interest rates equal the nominal interest rate less the expected rate of inflation (Mishkin, 2009 p.84):

$$i = i_r + \pi^e$$

By more accurately displaying the cost of borrowing through the real interest rates, we also get a better indicator of how market participants will be affected by changes in the credit market- and monetary policy (Mishkin, 2009). This is because nominal- and real interest rates does not always move in the same direction. If inflation expectations are high, the real interest rate is low even in times of very high nominal interest rates (Mishkin, 2009).

### **Term to maturity**

A factor that influences the yield on bonds is their term to maturity. For bonds with a fixed maturity the term equals the time to maturity. Term in its most isolated form, disregarding default risk and for instance convertibility- and floating rate provision, is a study of the market price of time (Shiller & McCulloch, 1987). Even though bonds can have the same default risk and liquidity characteristic, the interest rate might differ when the maturity differ. A plot of these interest rates, for particular types of bonds with different maturities, forms the yield curve (Mishkin, 2009). The yield curve therefore displays the relationship between interest rates on bonds with different maturities; the term structure of interest rates (Mishkin, 2009, p.131).

Mishkin (2009, p.131) claims that there are three important empirical observations about the yield curve. Firstly, interest rates on bonds with different maturities seem to move together. Secondly, when short-term interest rates are low the yield curve is more likely to have an upward slope. Similarly the yield curve is often inverted for high short-term interest rates. And lastly, yield curves almost always slope upward.

#### **2.1.1 EXPECTATIONS THEORY**

Expectations theory state the following proposition; “the interest rate on a long-term bond will equal an average of the short-term interest rates that the market expects over the life of the long-term bond”

(Mishkin, 2009, p.132). In other words, expectations theory explains the relationship between rates with different maturity by the fact that short-term interest rates will have different values at future dates (Mishkin, 2009). Expectation theory claims that bonds with same expected return, but different maturities, are perfect substitutes. Therefore a key assumption behind this theory is that investors do not have any preference for maturity as long as expected return is the same (Mishkin, 2009).

Mishkin (2009) describes two investment strategies to illustrate expectations theory. One can consider an investment of \$1 in discount bonds, i.e. bonds that are issued for less than its par value, with a holding period of two years. The investor has the choice between two investment strategies; holding a two-year bond or two one-year bonds (i.e. purchase a one-year bond today and when this bond matures in one year, buy another one-year bond). Formulas for interest rates in coupon bonds would be slightly different, but the same principles in calculation apply. For these two strategies to be perfect substitutes the expected return needs to be equal.

- Expected return from holding a two-year bond (Mishkin,2009, p.133):

$$(1 + i_{2t})(1 + i_{2t}) - 1 = 1 + 2i_{2t} + (i_{2t})^2 - 1 = 2i_{2t} + (i_{2t})^2$$

Where

$i_t$  = today's interest rate on a one-period bond

$i_{t+1}^e$  = interest rate on a one-period bond expected for next period (t+1)

$i_{2t}$  = today's interest rate on the two-period bond

The rate of return is given by subtracting the initial investment from what the investment is worth after two years  $(1 + i_{2t})(1 + i_{2t})$  and dividing it by the initial amount of \$1. Since  $(i_{2t})^2$  is so small, we can simplify the expected return for a two-year holding period to:  $2i_{2t}$

- Expected return from a two one-year holdings (Mishkin, 2009,p.133):

$$(1 + i_t)(1 + i_{t+1}^e) - 1 = 1 + i_t + i_{t+1}^e + i_t(i_{t+1}^e) - 1 = i_t + i_{t+1}^e + i_t(i_{t+1}^e)$$

After the first period the initial investment has become  $1 + i_t$ , and this amount is reinvested in a one-period bond for the next year yielding a new amount:  $(1 + i_t)(1 + i_{t+1}^e)$ . Using the same procedure as above, subtracting-and dividing with the initial investment gives the expected return.  $i_t(i_{t+1}^e)$  is also such a small amount that we can simplify expected return to:  $i_t + i_{t+1}^e$ .

- The bonds are only perfect substitutes if the expected return is the same (Mishkin, 2009,p.134)

$$2i_{2t} = i_t + i_{t+1}^e$$

- Solving for  $i_{2t}$  in terms of the one-period rates gives the following equation:

$$i_{2t} = \frac{i_t + i_{t+1}^e}{2}$$

The equation above show that the two-period rate must equal the average of the two one-period rates; the proposition expectations theory display as the relationship between longer-and shorter-term interest rates. To display a longer term structure one can replace 2 with n-period and see that the same relationship applies (Mishkin, 2009, p.134):

$$i_{nt} = \frac{i_t + i_{t+1}^e + i_{t+1}^e + \dots + i_{t+(n-1)}^e}{n}$$

Expectations theory can explain two of the empirical observations mentioned in the top of this section. Firstly, bonds with different maturities seem to move together over time. Since longer-term interest rates are an average of shorter-term rates, the rates must have the same movement over time. Secondly, when short-term rates are low the yield curve is most likely upward sloping. Short- term rates have the characteristics that if they increase today they tend to increase in the future, this influences people's expectations of the interest rate path (Mishkin, 2009).To demonstrate this one can use a numerical example. In modeling we use expected short-term rates likely to in the lifetime of the bond, therefore the market's expectations about future levels of the short-term interest rates is the only determinant of development in longer term rates. We can for instance assume that one-year interest rates are expected to be 3%, 4%, 5%, 6% and 7% respectively, in other words the market expects a rise in the short-term rates as they are at a current low level. A three-year bond, for instance, therefore has to have an interest rate that is the average of the three one-year expected interest rates:

$$i_{3t} = \frac{3\%+4\%+5\%}{3} \rightarrow i_{3t} = 4\%$$

The corresponding interest rate for a five-year bond would be:

$$i_{5t} = \frac{3\%+4\%+5\%+6\%+7\%}{5} \rightarrow i_{5t} = 5\%$$

As the numerical example shows, the long-term rate is higher than the current short-term rate and this can only happen if the short-term interest rate is expected to rise. However, this is not always the case. When the long-term interest rates are lower (the average of future short-term rates is lower) than the current short-term rate, the yield curve is inverted. This is the case when it is expected that the short-term interest rates will fall more than the current level (Mishkin, 2009). Because it is as likely that rates will fall as rise, expectations theory cannot explain empirical observations three; that the yield curve is usually upward sloping (Mishkin, 2009).

### 2.1.2 SEGMENTED MARKETS THEORY

The segmented market theory is the extreme opposite to expectations theory. This theory's key assumption is that different classes of financial assets are not perfect substitutes in an investor's portfolio (Mishkin, 2009). Imperfect substitutes of assets imply that a change in supply for various assets available to private investors can affect the price and yield of those assets through the portfolio rebalance channel (Bernanke, 2010). This theory is valuable to look at because it can explain why yield curves are normally upward sloping, and this theory's key assumptions is essential for the purchases under MEP to work in the envisioned way because the theory assumes less elasticity in demand.

Segmented markets theory concern bonds with different maturities as separated markets, where supply and demand in each market affect the price- and interest of that bond (Mishkin, 2009). There will therefore develop differing yield curves for each market. As mentioned above, since the investors have a strong preference for a particular maturity, the expected return from other bonds with other maturities has little effect on the demand- and supply in each market (Mishkin, 2009). This preference for a certain maturity can stem from financing needs, some buyers can be forced to buy in the longer-term part of the market, other wishes to do so; the results either way is that demand can give fluctuations in the interest rates that is not caused by change in growth- or inflation outlooks (Bernhardsen & Åmås, 2009). Pension funds or insurance companies might for instance have claims that mature in a certain amount of years. If preferred holding period equals the maturity of a certain bond, a risk-free return can be achieved (Mishkin, 2009).

As I will later discuss, there is a risk structure in interest rates. The essence of the risk structure of interest rates is that longer-term bonds often are more risk-sensitive in price- and the possibility of

default. There is therefore, according to segmented markets theory, lower demand for longer-term bonds, creating higher interest rates and lower prices in these markets. Longer-term interest rates are therefore often higher than short-term interest rates, creating an upward sloping yield (Mishkin, 2009). But since this theory regard bonds with different maturities as segmented markets, it cannot explain the relationship between short-and long-term interest rates. Empirical observation 1 and 2 therefore remains unexplained (Mishkin, 2009).

### 2.1.3 LIQUIDITY PREMIUM THEORY

The liquidity premium theory is in reality a combination of the expectations-and segmented markets theory, and can provide theoretical explanations for all three empirical observations about the term structure of interest rates because it takes both expectations- and preferences of the investor into account. The key assumption in liquidity premium theory is that bonds with different maturities are substitutes and the investor can prefer one bond over another (Mishkin, 2009). In other words, the investor compares expected returns on bonds with different maturities when deciding to invest. However, since long-term bonds are considered more risky in terms of risk-, default- and liquidity than short-term bonds, the investor needs to be compensated for holding longer-term bonds. The key difference from expectations theory is therefore that liquidity premium theory states that long-term interest rates are an average of future short-term interest rates that is expected in the life of the bond *plus* a liquidity premium that respond to demand and supply conditions for that bond (Mishkin, 2009, p.136). In other words, the basic principle for calculation from expectations theory of long-term rates still apply, but the inclusion of the liquidity premium reflect that each bond can have certain demand- and supply characteristics that affects the interest rate for that bond. Liquidity theory gives a modification of expectations theory by adding a positive liquidity premium in the equation that shows the relationship between short and long interest rates (Mishkin, 2009, p.137):

$$i_{nt} = \frac{i_t + i_{t+1}^e + i_{t+1}^e + \dots + i_{t+(n-1)}^e}{n} + l_{nt}$$

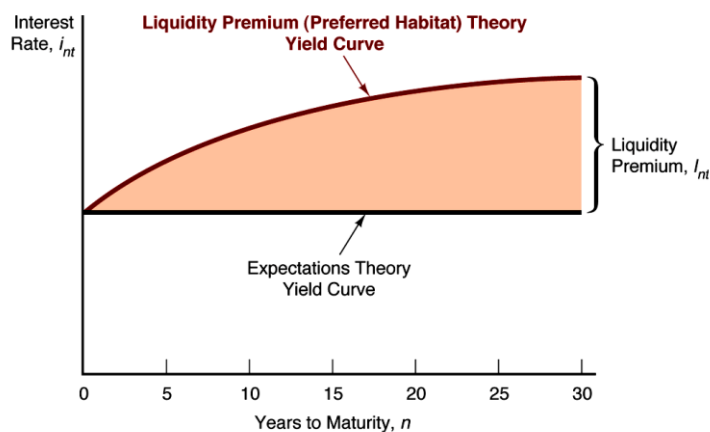
The liquidity premium ( $l_{nt}$ ), for an n-period bond, rises with the term to maturity and is according to theory always positive. Liquidity premium theory therefore incorporates the uncertainty regarding future interest rates and that the investor can face capital losses if he sells the bond in the secondary market prematurely. The longer the holding period, the larger the possibility of capital losses becomes;

hence a larger liquidity premium (Bernhardsen & Åmås, 2009). Liquidity premium theory can therefore explain why the yield curve usually is upward sloping.

#### 2.1.4 PREFERRED HABITAT THEORY

The preferred habitat theory is closely related to liquidity-premium theory, and makes the same conclusion about the term structure of interest rates but with slightly different assumptions. This theory was proposed by Modigliani & Sutch (1966) as an attempt to merge the previous three explanations of the term structure of interest rates. Preferred habitat theory assumes that investors have a preferred habitat, i.e. they prefer a particular bond of one maturity over another. However, they will be willing to buy a bond of a different maturity than the preferred maturity (habitat) if the expected return on this bond is higher (Mishkin, 2009). This conclusion connects the preferred habitat theory with the liquidity premium theory; the higher expected return needed to give investors incentive to hold a bond with longer maturity, is the liquidity premium that rises with maturity (Mishkin, 2009, p.137). We therefore get the same equation that shows the relationship between long-and short term rates in preferred habitat theory as is the case for liquidity premium theory. As concluded over, since the liquidity premium is positive and rises with the term to maturity, the yield curve is almost always upward sloping. Liquidity premium -and preferred habitat theories also produce yield curves more steeply upward than expectations theory, because of investor's preference for short-term bonds.

Figure 2-1 the Relationship between liquidity premium (preferred habitat)- and expectations theory



Source: (Mishkin, 2009, p.138)

To summarize we need to look at how the liquidity- and preferred habit theory explains all three empirical observations about the term structure of the interest rates. Firstly, the equation used to display the relationship between short- and longer term rates show that longer term rates are an average of expected future short term rates. It therefore follows that rates on bond with different maturities move together over time.

Secondly, empirically we see that when short-term interest rates are low, yield curves typically have an upward slope. Since investors usually expect higher interest rate levels when the current short-term rate is low, it follows through our equation that longer-rates will be higher based on the average of these expectations. When we in addition add the positive liquidity premium to the average, the longer term interest rates will be significantly higher than the current level of short-term rates (Mishkin, 2009).

These results support our empirical observations and the yield curve gets an upward slope when current short interest rates are low. In contrast, when short-term interest rates are at high levels the market will expect them to fall to more normal levels. The estimates for longer rates will be lower despite a positive liquidity premium and the curve will slope downward. The curve can also invert if the short-term interest rates are expected to fall so much that the average of the expected short-term rates are far under the current level of the short-term rates (Mishkin, 2009).

Lastly, because of investor's preference to hold shorter-term bonds and therefore the need to add liquidity premium in the interest rates, the yield curves are almost always upward sloping. Even if the short-term rates are expected to be relatively stable, the liquidity premium will keep longer-term rates above shorter-term rates and we get an upward sloping yield curve (Mishkin, 2009, p.139).

Expectations- and liquidity premium theory (preferred habitat) theories have another important feature. By the use of the yield curve we can see how the market predicts the future interest rate path. When one see an upward sloping yield curve we know that the market is expecting higher future short-term interest rates, and the opposite can be said in the event of a downward sloping yield curve (Mishkin, 2009).

### 2.1.5 EMPIRICAL CONSIDERATIONS

So far we have discussed general empirical observations regarding the term structure of interest rates, without much regard to which theory is the most applicable in explaining longer-term interest rates. One can establish that all three main theories prevail in empirical observations to some extent, but the degree of which theory is more dominant is still uncertain. This discussion is important, because the

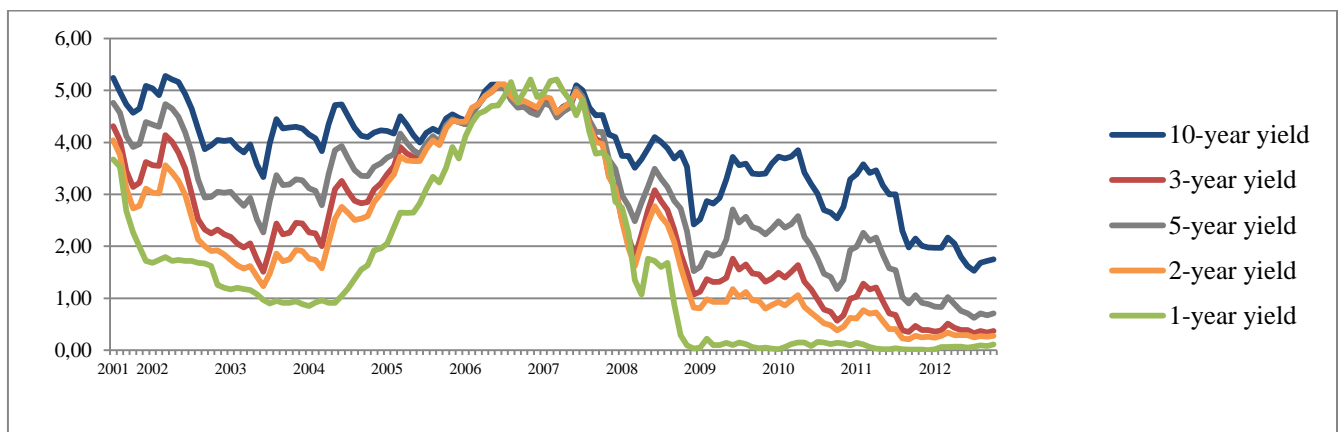


theories assume that the demand for bonds rely on different factors, or more explicitly they assume the elasticity in the demand for bonds to differ. Expectations theory assume full elasticity in demand, while segmented markets-, liquidity premium-and preferred habitat theory assume that there is less elasticity in demand (Klovland, 2011a). The elasticity in the demand curve will influence how much an effect shifts in demand- and supply of bonds have on the bond price- and the connected yield. Which theory is more dominant in reality, will therefore have implications for how well the Fed will succeed in their goal to reduce longer-term interest rates by increasing the demand for bonds with certain maturities. A review of empirical studies concerning the term structure of interest rates is therefore essential.

### Expectations; a convenient theory?

Firstly, it could be plausible to state that expectations play some role in determination of longer-term interest rates. We for instance see how many central banks around the world rely on forward-guidance in their monetary policy trying to form the market's expectations about the future interest-rate path, hoping this will transfer to longer-term interest rates. By viewing the development in the 1-, 2-, 3-, 5 and 10-year yields on Treasury Securities, we can also see that short-and long-term interest rates seem to move together over time, as calculations in expectations theory suggest.

Figure 2-2 Does interest rates with different maturities move together over time?



Source: (FRED), Data: 1 (GS1)-, 2 (GS2)-,3 (GS3)-,5(GS5)-and 10 (GS10)-year yield)

The figure above also displays another empirical fact about the relationship between short-and longer term rates; longer term rates seem less volatile than shorter rates. This can be explained by the basic calculations in expectations theory. If interest rates are mean-reverting, i.e. that they tend to move back

down or up after unusual high- or low levels, than the average of these short-term rates (the longer-term rates) is much less volatile than the short-term rates themselves (Mishkin, 2009).

Browne and Manasse (1989), claims that most of the empirical testing of expectations theory gives unfavorable results. The authors partly attribute these negative findings to the fact that expectations theory assumes rational expectations. Some researchers` might reject expectations theory based on this assumption, rather than invalidity of the theory itself. Browne and Manasse (1989) attribute different factors to the relatively poor performance of expectations theory; time-varying risk premium, excess volatility of the long-term interest rate and some degree of market segmentation due to the preferred habitat of investors. Much research has therefore been devoted to identifying risk that is significantly related to longer-term rates. However, there has been failure in determining a risk measure that explains variations in the term structure because risk premiums also vary over time (Browne & Manasse, 1989). Kloster (2000) however, claim that these results does not indicate that the term structure of interest rates is uninteresting for monetary policy, variation in short term rates can still explain a substantial amount of the variance in longer-term interest rates.

Schich (1999, referred to in Kloster 2000, p. 30) highlights another important factor about the term structure of interest rates. When modeling the connection between the term structure- and expected future inflation for USA, Germany, Canada, Great Britain, France, Italy and Japan, he finds that the connection between the countries varies over time. Schich (1999, referred to in Kloster, 2000, p.30) concludes that this variation can be explained by monetary regime changes. If the markets have high confidence in the monetary policy makers keeping inflation low, the term structure includes less information about future inflation (Kloster, 2000). In other words, changes in monetary objectives- and in the financial regulation- and structure can change the information in the term structure over time.

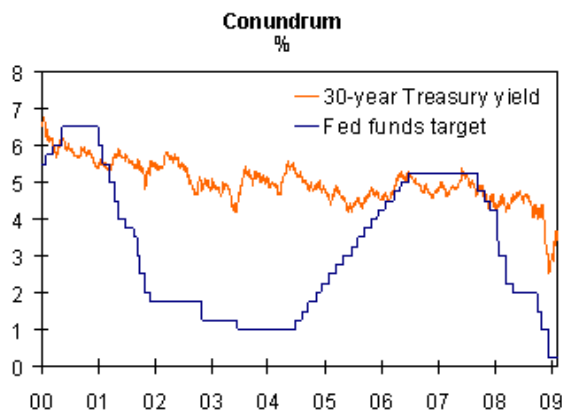
D`Amico & King (2010) find support for segmentation- or imperfect substitutes in their study of price elasticities- and substitutability in the market for Treasuries. By studying the effects of a \$600 billion purchase in longer-term Treasuries during 2009, they distinguish between a “flow”- and “stock “effect. The same day each purchase took place, the yields in these sectors declined on average 3, 5 basis points. This is what the authors call the “flow effect”. In addition, they find that the total effect gave a persistent downward shift in the yield curve of 50 basis points; the “stock” effect. The largest effect was on Treasuries with 10 to 15 years left of maturity (D`Amico & King, 2010). There is also empirical

evidence that interest rates follows a random walk. Phillips & Pippinger (1976), claim that movements in interest rates in one period can be independent of movements in previous periods. The authors suggest that if there are in fact efficient markets, than interest rates reflect all available information but there is no use in predicting or collecting information in the yield curve.

### **Bond yield conundrum and global savings glut**

The bond yield conundrum describes the unusual behavior of long-term interest rates between 2004 and 2007. In this time era long-term rates were declining despite very restrictive- and tight monetary policy by the Fed (Kienzler, 2012). According to expectations theory, an increase in short-term rates should have led to an increase in longer-term rates. Theory also predicts that interest rates with different maturities move together. However, none of these theoretical predictions applied for this time era. Even with a high economic growth, rising oil prices and increasing budget deficit, the long-term interest rates stayed the same (Kienzler, 2012). A growing budget deficit should at least have boosted long-term rates by significantly increasing supply of bonds (Kienzler, 2012). Craine & Martin (2009) claim that the increase in foreign holdings of U.S Treasury bonds explained at least half of the decline in longer-term interest rates in this time era. Increased liquidity in the treasury market due to higher foreign demand could have reduced the term premiums. Craine & Martin (2009) found that foreign demand did not affect short-term forward rates, but as a determinant for bonds with maturities between eight and fifteen years, foreign holdings were largely significant.

Figure 2-3 The Bond Yield conundrum



Source: (Chan, 2009)

Ben Bernanke (2005) regarded a “global saving glut” as a driver for the low long-term interest rates that prevailed in this time period. The “global saving glut” was a situation where there worldwide were more savers than investment opportunities. This led to a tendency for savings to finance current account deficits in other countries (Bernanke, 2005). The growth in savings could have come from large emerging economies which had been running large current account surpluses (Beltran et al, 2012). From 1994 to 2007 the share of foreign holdings of U.S Treasury bonds with maturities over a year grew from 20-to 57% (Craine & Martin, 2009). As a result of this increased demand the yields were driven down.

Beltran et al (2012) claim that if foreign official inflows to U.S Treasuries declined by \$ 100 billion, the 5-year Treasury yield would increase by about 40-60 basis points in the short run. By allowing foreign private investors to be a part of the analysis, the long run effect should be about 20 basis points. Beltran et al (2012) therefore suggest that as nations become more increasingly financial integrated, the longer-term yields are often determined in international markets. As result the central bank`s ability to influence the longer-term yields by reducing the short-term yields might be limited (Beltran et al, 2012). International capital flows to the U.S, and therefore demand pressuring effects, are thus believed to be an important explanatory factor for the development in treasury yields.

### **The need for a hybrid**

What is apparent is that the scholars disagree. If any conclusion can be made regarding the term structure of interest rates it is that the reality must be a hybrid of several theories that prevail at different time series. One theory alone does not seem to provide an exhaustive explanation for all empirical movements of the longer-term interest rates. The importance for MEP lies in the assumption that there is less elasticity in demand, in other words that demand pressuring affects that can change the yield in certain sectors. The drivers behind “the bond yield conundrum” and the effects of the “global saving glut” seem to be evidence that increased demand for treasuries can affect the yield in those markets.

## **2.2 THE BOND MARKET**

I now turn to theory about the bond markets and special characteristic- and trends in the American bond market. Not only is the bond market especially important because it enables corporations and governments to finance their activities, but it is in this market the longer-term interest rates are

determined and therefore where MEP purchases of U.S. government securities will be conducted. To be able to see the desired effects of Operation Twist and MEP, we need to have knowledge about the mechanism- and characteristics of the American bond market and the instruments traded there. I will also touch upon the risk structure of interest rates in this section, as this have important implications for the pricing of debt securities and the supply- and demand for bonds.

### 2.2.1 GENERAL CHARACTERISTICS OF THE BOND MARKET

The issue of bonds provides a long-term source of funds and is one of two ways firms and individuals can obtain external funding. A bond issue is a contractual agreement in which the borrower promises to pay the holder of the instruments fixed dollar amounts in until a specified date when a final payment is made (Mishkin, 2009, p.27-28). The length of this contractual agreement is the maturity of the bond, and the maturity is always over a year for bonds. Bonds are often classified by time to maturity to get an accurate reporting of prices and yields. However, it is the time to maturity from now that matters; the residual time to maturity (Howells & Bain, 2007). In addition, the term of any bond steadily shrinks over time; a two-month bond becomes a one-month bond after a month (Shiller & McCulloch, 1987). Bonds are first issued in a primary market and can thereafter be resold in the secondary market where the price of the bond fluctuate according to demand and supply (Santomero & Babbel, 2001). Most bonds have a fixed nominal value, which means that their real value can be eroded by inflation. Times of high and variable interest rate- and inflation have therefore led to many innovative products in the bond markets to mitigate these risks. Combined with other risk factors, the bond holders are exposed to capital risk if they choose not to hold the bond to maturity (Howells & Bain, 2007).

### 2.2.2 YIELD TO MATURITY

The yield to maturity is the interest rate that equates the present value of cash flow payment received from a debt instrument with its value today, also called the internal rate of return (Mishkin, 2009, p.72-73). The yield to maturity for a discount bond can be calculated by dividing the difference of the price of the debt when issued (P) and the face value, amount paid at maturity, (F) and divide this on the price of the debt (Mishkin,2009, p. 79) :

$$i = \frac{F-P}{P}$$

The yield to maturity is by many economists believed to be the most accurate measure of interest rate. In addition, this equation also shows the essential relationship between the yield to maturity and the price of the bond; the yield to maturity is negatively related to the current bond price. If the bond price increases, the yield of maturity decreases. Similarly when we see a price decrease in the bond market, this implies that the yields have increased. We can also derive the price and yield to maturity for a coupon bond with  $n$  years to maturity (Leite, 2011).

$$P_0 = \sum_{t=1}^n \frac{C}{(1+i)^t} + \frac{F}{(1+i)^n}$$

Where  
 $C$  = coupon  $C$  in % of face value  
 $i$  = yield to maturity  
 $F$  = face value of the bond  
 $P_0$  = Price of the coupon bond  
 $n$  = years to maturity

This expression can be simplified to:

$$P_0 = \frac{c}{i} \left[ 1 - \frac{1}{(1+i)^n} \right] + \frac{100}{(1+i)^n}$$

When solving for yield to maturity by calculator or computer, one finds the effective rate that the holder of the bond receives when holding the bond to maturity (Leite, 2011).

### 2.2.3 RATE OF RETURN

For any security, the rate of return is defined as the payment received up to maturity date and the change in its value, expressed as a fraction of its purchase price (Mishkin, 2009 p.80). The rate of return by holding a bond from time ( $t$ ) to ( $t + 1$ ) can be written as (Mishkin, 2009, p.80):

$$R = \frac{C + P_{(t+1)} - P_t}{P_t}$$

Where  
 $R$  = return from the holding the bond from time  $t$  to time  $t+1$   
 $P_t$  = price of bond at time  $t$

$$P_{(t+1)} = \text{price of bond at time } t+1$$

$$C = \text{coupon payment}$$

If we rewrite this formula we can see that rate of return and yield to maturity can differ (Mishkin, 2009, p. 81):

$$R = \frac{C}{P_t} + \frac{P_{t+1} - P_t}{P_t}$$

The first term is the current yield ( $i_c$ ), the coupon payment over the purchase price. The second term is the rate of capital gain ( $g$ ), the change in the bond price from initial purchase price, i.e. the yield to maturity for a discount bond. The rate of return can therefore be written as:  $R = i_c + g$  (Mishkin, 2009, p.81). Fluctuations in the bond price can therefore affect total rate of return, even when  $i_c$  is an accurate measure of yield to maturity.

The longer the maturity of the bond, the more risk-sensitive the price of the bond is regarding changes in the interest rate (Mishkin, 2009). For the holder of the bond this can have two important implications regarding rate of return. Firstly, if the interest rate increases during the holding period the investor can suffer so called “paper loss” because the price of the bond decreases, even if the investor holds the bond to maturity (Mishkin, 2009). A “paper loss” imply that the investor would have been able to buy more bonds after the price decrease to a lower price had he placed his funds in a bank and waited to invest (Mishkin, 2009). Secondly, if the maturity is longer than the holding period, the investor can suffer substantial capital losses if the price of the bond falls. This leads us to the conclusion that prices- and return for longer-term bonds are more volatile than for shorter-term debt instruments because their maturity is longer (Mishkin, 2009). Hence, longer-term bonds are considered as riskier assets.

Not all longer-term bonds are, however, regarded as entailing a large investment risk. Bonds where the maturity equals the holding period are interest rate risk-free. For this general purpose of illustration we can say that this apply for both discount- and coupon bonds, even though there might be marginal uncertainty regarding the interest rate when one reinvest coupon payments. Since the bond price at maturity is fixed at face value, there is no room for the interest rate affecting this face value and the return is known at the purchase time of the bond (Mishkin, 2009).

#### 2.2.4 ASSET DEMAND THEORY

Asset demand theory gives a review of which factors determine the quantity of demand- and supply for any security, namely wealth, inflation, expected return, risk and liquidity. These factors are important to keep in mind, as they represent some of the independent variables in the analysis and therefore possible reasons for variation in the 10-year yield. When we review these factors as determinants for demand we hold everything else constant; *ceteris paribus*.

Wealth is defined as the total amount of resources held by an individual or a firm (Mishkin, 2009, p.91). When our wealth increases we have more resources to purchase assets and as a result the quantity demanded of assets rise. The second factor is expected return on assets relative to other assets. A determinant for choosing a particular asset is, intuitively, that we wish to gain the most from holding this asset relative to other assets. As expected return on an asset relative to other assets increase, the quantity demanded increase (Mishkin, 2009).

Risk is the degree of uncertainty associated with the return of an asset (Mishkin, 2009, p.92). Relative risk on an asset compared to other assets is therefore the third factor in asset demand theory. Even though some people are risk-preferring, most people are risk-averse when it comes to financial decisions. Generally we can therefore say that when risk on an asset increase relative to risk on other assets, the quantity demanded for this asset falls (Mishkin, 2009).

Liquidity is how fast an asset can be converted into cash at low cost (Mishkin, 2009). In a market where there are many buyers and sellers, the assets are very liquid. Assets such as longer-term bonds or houses have fewer buyers and the holder might have to sell at a low price with high transaction costs- all this lowers the return on that asset. Therefore, the more liquid an asset is relative to other assets, the higher demand for this asset (Mishkin, 2009, p.93).

To summarize asset demand theory, the quantity demanded of an asset is positively correlated to increase in wealth, expected return and liquidity and negatively correlated to risk.

#### 2.2.5 DEMAND-AND SUPPLY FOR BONDS

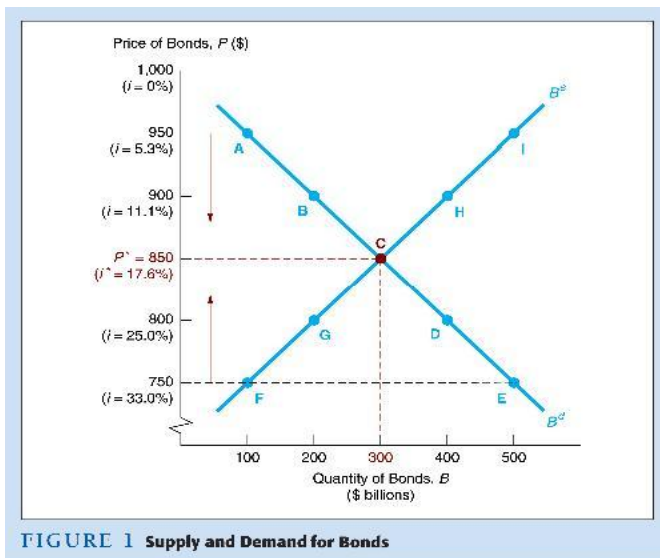
Each bond price is associated with a particular level of interest rate. We have also seen that the yield to maturity is negatively correlated to the current bond price. The demand curve for bonds will therefore



display the relationship between the price of the bond and the quantity demanded under the assumption that all other economic variables are held constant beside the bond price-and interest rate. An important assumption is that supply and demand are always in terms of stock and not flow. This is the basis for the asset market approach which is most widely used in determining asset prices and understanding financial behavior (Mishkin, 2009). We therefore analyze the stock equilibrium, taking accumulated portfolio changes over time into account. In this analysis, I will look at discount bonds, but conclusions derived will be applicable for all types of bonds as the negative relationship between interest rate and price still apply. Here, the coupon effect on expected rate of return is disregarded and the assumption is therefore that the interest rate, as measured by yield to maturity, and expected return are the same when holding the bond to maturity. Hence; the return is known and absolute.

Keeping the theory of asset demand in mind, we know that when expected return increases (and consequently a lower bond price) the quantity demanded ( $B^d$ ) of this bond increases. If we calculate the interest rate using the formula for yield to maturity ( $\frac{F-P}{P} = i_c = R^e$ ) for different prices of the bond we can derive the demand curve. We see that the demand curve is downward sloping and increasing as the bond price decreases.

Figure 2-4 Supply and demand for bonds



Source: (Mishkin, 2009, p.95)

The supply curve displays the relationship between the price of the bond and the quantity supplied ( $B^s$ ), when all other economic variables are held constant (Mishkin, 2009). For suppliers of bonds the reasoning about interest rate- and bond price is opposite from the demand curve. A decrease in interest rate (and a corresponding higher bond price) means it is less costly to borrow by issuing bonds. Consequently the suppliers will be willing to borrow more through the issue of bonds and the quantity of supplied bonds increases. The supply curve has the usual upward sloping curve, showing that when the price of bonds increases the supply of bonds increase (Mishkin, 2009). Equilibrium occurs when the quantity demanded equals the quantity supplied at a given price, in other words the equilibrium shows at which interest rate and bond price the market will settle:

$$B^d = B^s$$

At the interception between demand and supply we find the equilibrium- or market clearing price. The interest rate that corresponds to this price is the market clearing interest rate (Mishkin, 2009). In the case where the price is higher than the market clearing price we have excess supply of bonds, i.e. there are more sellers than buyers of bonds. Consequently, the price of the bond has to fall until it reaches market clearing price where also buyers have incentives to purchase due to higher expected return. Similarly, when a bond price is lower than the market clearing price, we find that the quantity demanded is higher than the quantity supplied. It follows that the price on bonds has to increase, and the interest rate has to fall, in order for supply and demand to meet.

## 2.2.6 CHANGES IN SUPPLY-AND DEMAND FOR BONDS

Changes in demand and supply alter the price and corresponding interest rate connected to each bond. There can be movements along the demand or supply curve, in which these movements are induced by a change in price- or interest rates of a bond. Here, we review what happens when there is a shift in the demand or supply curve. When there is a shift, the quantity demanded or supplied changes for each given price-and interest rate in response to a change in some other economic variable that is not the price- or interest rate of the bond (Mishkin, 2009, p.97). When a shift in either the demand or supply curve occurs, there will be a new equilibrium price- and market clearing interest rate. This section will review why these new equilibriums occur and which factors induce these shifts. The assumption of *ceteris paribus* still apply.

## Shift in demand of bonds

Wealth was the first discussed factor in our review of asset demand theory. We often see that the wealth of individuals and firms increase due to higher asset prices- and income in a business cycle expansion. Wealth is also influenced by public savings tendencies. If one saves more, the wealth increases and so does the demand for bonds. The quantity of bonds at the same price must therefore rise (Mishkin, 2009). If we derive this conclusion for every point on the demand curve we can see that the demand curve shifts out to  $B_2^d$ . A recession will give a negative shift in demand as wealth decreased.

Figure 2-5 Shift in demand for bonds

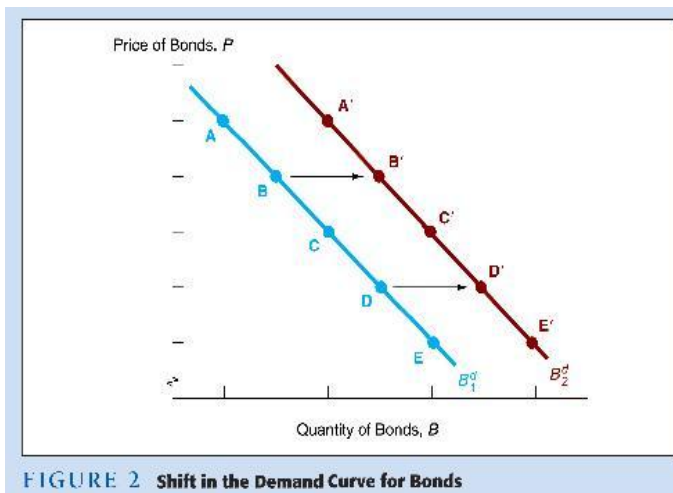


FIGURE 2 Shift in the Demand Curve for Bonds

Source: (Mishkin, 2009, p.98)

The second factor discussed in asset demand theory was expected return to relative assets, and this factor has several characteristics that affect the demand of bonds. We have previously established that because of interest rate risk, there is more uncertainty regarding expected return for longer-term bonds. The yield to maturity and expected rate of return could be different when the holding period does not match the bonds maturity. The longer the maturity, there more sensitive the bond price is for changes in the interest rate level. Given the negative relationship between yield to maturity and the bond price, on can therefore conclude that higher expected interest rates in the future, with corresponding lower bond prices-and expected return, causes a negative shift in demand. When there is expected lower

future interest rates, expected return increases and so does the demand for bonds at each given price (Mishkin, 2009).

A second factor worth mentioning as a driver for shifts in demand is expected inflation. Bonds are nominal papers, indicating that their value can be eroded by inflation. When there is expected higher inflation, the relative value difference between nominal-and real assets increase. This is because the value of a bond is measured taking current price levels into account, while holding real assets can give higher nominal gains if the price on the real asset increases (Mishkin, 2009). In addition, with higher expected inflation the Fisher equation show that the real interest rate decrease, and therefore the real cost of borrowing goes down. Expected return on bonds relative to real assets goes down for both mentioned reasons, and we see a negative shift in demand with a corresponding interest rate increase. Lastly, optimism for a particular type of financial instrument can increase its price and return in the market (Mishkin, 2009). If the return on bonds is held constant, it becomes less favorable to hold this bond compared to other asset, and the result can be a negative shift in demand.

The third factor in question in asset demand theory was volatility in prices and therefore expected return. Intuitively, most economic agents will favor investments that oppose less risk for their returns. Therefore, when risk on other assets increase relative to the risk of holding a bond, the demand for bonds increase (Mishkin, 2009). A so called “flight to quality” illustrates this demand shift. When there is large price-and therefore return fluctuations in financial markets, investors often flee to high-quality government debt securities where there is low probability of default (Kenny, 2012a). This phenomenon will be discussed later as a factor contributing to reductions in longer-term interest rates.

The final factor that can lead to shifts in demand for bonds is the relative liquidity in the market for bonds compared to other markets. When trading activity increases in the bond market, the bond is often easier to sell at lower transaction costs. These factors make the liquid bond favorable to hold and demand for bonds increase (Mishkin, 2009).

### **Shift in supply of bonds**

Many of the same factors that drive shifts in demand also determine shifts in the supply of bonds. Firstly, expected profitability of investment opportunities often increase in an economic expansion. This makes firms- and individuals are more willing to borrow to through the issue of bonds to make

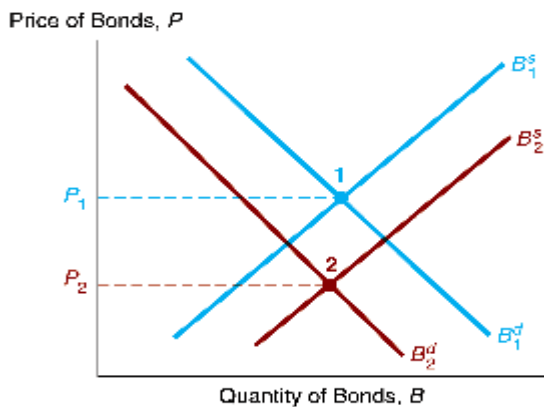
these investments (Mishkin, 2009). It follows that the supply of bonds increases for each price- and corresponding interest rate. Secondly, increased expected inflation has a positive effect on the supply of bonds. Since the real interest rate, and therefore the real cost of borrowing, declines with higher expected inflation, the quantity supplied at any given bond price increase (Mishkin, 2009). The supply curve shifts to the right.

The last factor to influence the supply of bonds is the government financing needs. The U.S. Treasury issue bonds when their financing needs- or budget deficit is high (Mishkin, 2009). In these cases the supply of bonds rise at any given bond price and the curve shifts to the right. The purchase- and sale of bonds is also an important part of the U.S monetary policy open market operations. By conducting sales- and purchases in the Treasury markets the Fed can control the supply of reserves in the banking system and the target interest rate for overnight loans in the market for bank reserves (Mishkin, 2009).

### 2.2.7 THE FISHER EFFECT AND AN BUSINESS CYCLE EXPANSION

So far we have looked at isolated shifts in the demand- and supply of bonds and how this affects interest rates and bond prices. In reality, these shifts often happen simultaneously affecting the interest rate and bond price in opposite directions. Expected inflation has for instance been thoroughly analyzed through shifts in both the demand- and supply curve. In the section above we concluded that a rise in expected inflation would cause a rightwards shift in the supply curve and a leftwards shift in the demand curve, creating a new equilibrium bond price- and interest rate.

Figure 2-6 The Fisher

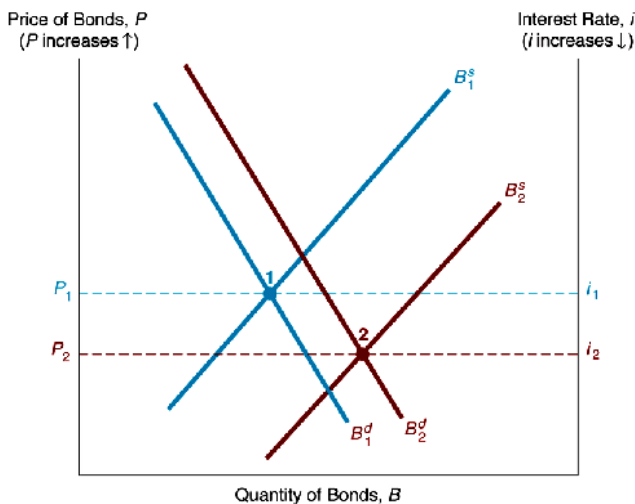


Source: (Mishkin, 2009 p.103)

As we see from figure 2-6 a rise in expected inflation has caused the quantity of demand to fall ( $B_2^d$ ) and the quantity of supply ( $B_2^s$ ) to rise, creating a new equilibrium (2) with a lower bond price (from  $P_1$  to  $P_2$ ) and a higher interest rate than the previous equilibrium (1). This figure is drawn so that the equilibrium quantity of bonds remains the same for both points 1 and 2. The equilibrium quantity of bonds can change when expected inflation rise, this depends on the sizes of the shifts in demand and supply (Mishkin, 2009). The increase in interest rate caused by a rise in expected inflation is the so called Fisher effect. The Fisher effect and its conclusion have been very central in monetary policy, because it highlights the importance of keeping inflation low in order to keep nominal interest rates low (Mishkin, 2009).

A second scenario analyzes what happens to the interest rate caused by shifts in demand- and supply of bonds in a business cycle expansion. Investors will have a greater wealth- and income to invest, and firms will be more willing to issue bonds if expected profitability of new investments is high. On other words, a rise in demand- and supply will cause both curves to shift to the right at each given bond price.

Figure 2-7 Response in demand- and supply of bonds following a business expansion



Source: (Mishkin, 2009, p.105)

In figure 2-7 the shifts in demand- and supply curve has created a new equilibrium at point 2, at a lower price and a higher interest rate. However, depending on which shift is the largest; the interest

rate can both increase and fall. There is therefore not a definite answer to what happens to the interest rate in an economic expansion (Mishkin, 2009). However, we see from figure 2-8 that empirically, a rise interest rate is what happens during economic expansions. Similarly we empirically see a decline in the interest rate following an economic recession (blue shaded area in graph).

Figure 2-8 Business cycles and interest rates (three-month Treasury Bills), 1951-2008



Source: (Mishkin, 2009, p.106)

## 2.2.8 THE RISK STRUCTURE OF INTEREST RATES

In the theory about bond markets we have simply focused on the “interest rate” without further review of why bonds with the same maturities have different interest rates. That can be explained by the risk structure of interest rates. In section 2.1 we briefly mentioned liquidity premiums- and interest rate-risk in segmented markets-, liquidity premium- and preferred habitat theories as factors increasing the longer-term interest rates, i.e. explaining why interest rates on bonds with different maturities is different. This is the term structure of interest rates. I will now give a more detailed review of the risk structure of interest rates as this will affect the formation of longer-term yields.

In general nominal government interest rates reflect different factors like inflation expectations, expected future interest rates and a series of risk premiums associated with the countries financial conditions (Bernhardsen & Åmås, 2009). So called credit default swaps (CDS) show how much it cost to secure oneself from default of government debt and gives an expression for credit premiums in the

government securities market (Bernhardsen & Åmås, 2009). Default is the risk that the borrower is not able to repay the face value to the holder of the bond at maturity, in other words unable to meet its debt obligation (Mishkin, 2009). Lenders therefore charge rates of return that correspond to the issuers default risk to alleviate the impact of default. In contrast, bonds issued by the U.S Treasury are regarded as default- and risk-free. In theory, a government can always increase taxes if they struggle to meet their debt obligations (Mishkin, 2009). The spread between government issued bonds- and bonds with default risk is therefore the risk premium. This size indicates how much an investor wants to be compensated for holding a riskier bond (Mishkin, 2009). Credit-rating agencies like Moody`s, Standard and Poor`s and Fitch rate the quality of corporate-and government bonds in terms of probability of default. Bonds with relatively low probability of default are called investment grade bonds and are rated BBB or higher. Bonds rated Baa or lower are called junk-or high yield bonds because of their high interest rate. These ratings influence the size of the risk premium demanded by investors (Mishkin, 2009). The credibility-and objectivity of these credit-rating agencies is therefore very important for the health-and well functioning of the financial system.

Another factor present in the risk structure of interest rates is liquidity. The liquidity premium compensates the holder of the bond for that he can affect the bond price by purchase- and sales of securities (Bernhardsen & Åmås, 2009). U.S Treasury bonds are the most liquid of all long-term bonds because they are so widely traded and can therefore easily be sold at a low cost (Mishkin, 2009). Corporate bonds are less liquid because corporations issue fewer bonds than the government, selling these bonds can therefore be more difficult. Liquidity, in the same way as the risk of default, influences the desirability of holding a bond. If a corporate bond becomes less liquid compared to other bonds the quantity demanded for these bonds will fall, creating a higher interest rate to a lower bond price. The interest spread between less liquid corporate bonds- and for instance U.S. Treasuries increase (Mishkin, 2009). The spread in interest rate between these two types of bond can therefore more accurately be described as a risk- and liquidity premium.

Based on the risk structure in interest rates, expected inflations effect on real interest rates and the uncertainty regarding return for longer-term bonds, we can do a further decomposition of longer-term interest based on factors that the risk-averse investor wants to be compensated for:

$$i = \pi^e + r^e + rp_x + rp_{\text{liquidity}} + rp_{\text{default}} + rp_{\text{maturity}}$$



This equation shows that nominal interest rates comprises of inflation expectations ( $\pi^e$ ), expected real interest rate ( $r^e$ ), inflation risk premium ( $rp_x$ ), liquidity premium ( $rp_{\text{liquidity}}$ ), default risk premium ( $rp_{\text{default}}$ ) and a maturity premium ( $rp_{\text{maturity}}$ ) (Bernhardsen & Åmås, 2009).

## 2.2.9 FEATURES IN THE AMERICAN BOND MARKET

The most central players in the American money- and bond market are the government, government agencies, financial institutions and nonfinancial business enterprises (Santomero & Babbel, 2001). In contrast to bank loans, the only ones who have easy access to security markets are large, well-established corporations. This is partly connected to transaction costs, if you decide to buy a bond the smallest denominations for some bonds are as much as \$10,000 in the U.S. (Mishkin, 2009). If you therefore have limited funds to invest, diversification is difficult. The U.S. terminology for government bonds are Treasury notes, where initial maturity is 1-7 years, and Treasury bonds which have an initial maturity over 7 years (Howell & Bain, 2007). These government bonds are issued by the Treasury to finance budget deficits or to conduct open market operations as a part of monetary policy. U.S. government securities are so widely traded that the volume of transactions can daily exceed \$100 billion (Mishkin, 2009).

Peristiani & Santos (2010) discuss the competitiveness of the American bond market. The authors regard two factors as especially important for the development in recent years. Firstly, the growth of the Eurobond market has created competition for the American bond market. Differences in underwriting costs has opted many American corporations to issue their bonds in the Eurobond market. Secondly, stricter regulation on financial reporting has according to the authors, made it more costly to access external capital. The large accounting scandals with Enron and WorldCom in the 2000`s, led to the implementation of the Sarbanes-Oxley Act in 2000. The act was an attempt to increase investor protection-and corporate governance, but the act also led to more stringent-and costly dissemination of financial reporting. Peristiani & Santos (2010) therefore conclude that these two developments have worsened the conditions-and liquidity in the American bond market.

### 2.2.9.1 WHO OWN TREASURIES?

When the U.S Treasury issue securities, this borrowing adds to the national debt which currently has a legal limit to borrowing at \$16, 4 trillion (Toscano, 2012). Much of the debt is held by the private sector but about 40% is held by the public, including parts of the government. Toscano (2012) highlights the largest owners of federal debt according to monthly figures from the U.S. Treasury.

Table 2-1 The largest owners of Treasuries in 2012

Owner	Data from	Amount
1. Federal Reserve and Intergovernmental holdings	Sep. 2012	\$ 6,328 trillion
2. China	Sep.2012	\$ 1,132 trillion
3. Other investors/ Savings Bonds	June.2012	\$1,107 trillion
4. Japan	Sep.2012	\$1,038 trillion
5. Pensions fund	Sep.2012	\$ 842,2 billion
6. Mutual funds	June.2012	\$ 653,5 billion
7. State and local governments	Sep.2012	\$484,4 billion
8. United Kingdom	Sep.2012	\$ 429,4 billion
9. Depository institutions	June. 2012	\$ 284,5 billion
10. Insurance companies	Sep.2012	\$250,1 billion

Source: (Toscano, 2012)

The largest owner of federal debt is of today the Federal Reserve themselves, and large funds such as the Medicare Trust Fund and the Social Security Trust Fund. Fed`s holdings are at an all time high, especially because of MEP and other large-scale-asset purchase programs. In comparison, ten years ago their holdings were only \$2, 5 trillion (Toscano, 2012). China is the largest foreign holder of U.S Treasuries, and the overall second largest holder of Treasuries. As will be further discussed, Chinas asset position in American Treasuries is indirectly a consequence of the large trade deficit between the U.S. and China. As previously mentioned regarding the “global savings glut” and the “bond yield conundrum”; extensive inflow of foreign capital into U.S Treasuries could have been important determinants for the price development in the Treasury market in recent years.

The third largest holder of federal debt is a diverse group of investors. Among them include individuals, government sponsored enterprises, corporate and non-corporate businesses and saving bonds. This amount has not increased significantly in the last decade, but the number and type of

holders within this group has nearly quadrupled since 2007 (Toscano, 2012). This highlights that the money-and bond markets have become increasingly “common” investment arenas for different groups in the society. For both mutual funds and state- and local governments the amount of federal debt has diminished since the outbreak of the financial crisis. Also for commercial-and saving banks the holding amount has tripled since its low in 2008 (Toscano, 2012). This demonstrates the “liquidity squeeze” that often characterizes the financial crisis impact on American financial institutions.

### 2.3 THE MONEY MARKET

The money market is the marketplace for shorter-term debt instruments with maturities under a year. Under Operation Twist and MEP the U.S Treasury sells shorter-term treasuries with the desire to keep the shorter-term interest rates unchanged. Because the American money market is the market for these large-scale-asset sales a quick review of special characteristic is in its place.

Santomero & Babbel (2001) describe the money market as a series of closely connected markets that bring together short period borrowing needs with those with large sums to lend. The money market is therefore a low cost- and risk vehicle to channel funds between two economic agents (Santomero & Babbel, 2001). Among the major participants in the American money market are about 30 large commercial banks, many government securities dealers and specialized securities dealers (Santomero & Babbel, 2001).

The instruments in the American money market share some common characteristics. Firstly, all the instruments are debt obligations, and all the instruments have maturities ranging from one day to one year, although the most common maturity for most instruments is three-months or less (Santomero & Babbel, 2001). Thirdly, the instruments in the money market are in general more widely traded and are therefore more liquid than markets for longer-term debt (Mishkin, 2009). Because of high trading activity in the secondary market, most instruments can be sold prior to maturity at low cost. Fourthly, the debt instruments are issued by borrowers with generally high credit rating. Default risk is therefore not a significant factor and not reflected in the pricing of the instruments (Santomero & Babbel,2001) Lastly, because of shorter term to maturity there are less price fluctuations making interest-rate risk negligible (Mishkin,2009).

### 2.3.1 TREASURY BILLS

Three of the most important instruments in the American money market represent claims to the federal state; Treasury Bills, federal agency discount notes and municipal notes (Santomero & Babbel, 2011). I will here limit my discussion to Treasury Bills.

Treasury Bills or T-bills, as they are more commonly called, is debt issued by the U.S government and constituted in June 2012 for about 14 percent of all U.S government marketable debt (Treasury Bulletin, 2012). U.S. Treasury bills are the most liquid of all the money instruments because they are most actively traded, but also because there is almost no possibility of default (Mishkin, 2009). Because of negligible default risk and short maturity, many financial investors find T-bills as attractive investment and therefore accept a lower yield. In addition, the return made on T-bills are exempt from state and local taxes, making the expected return on these debt instruments relatively higher than on other assets (Santomero & Babbel, 2001). T-bills are mainly held by banks, but also by households, corporations and other financial intermediaries (Mishkin, 2009). In addition, foreign central banks have large holdings of Treasury Bills. They hold them for the same reasons as American investors, but also because foreign governments often accumulate cash to make debt service payment on their dollar-denominated foreign debt. This cash is often placed in T-bills until the payments are due (Santomero & Babbel, 2001). As a result, foreign central banks own a large fraction of the outstanding U.S debt.

T-bills are sold at auctions held by the Federal Reserve Bank of New York on behalf of the U.S. Treasury. Since there is huge demand for funds to keep the government going and refinance debt, auctions for T-bills of three-month –and six-month maturities are auctioned every week. In the auctions dealers and investors bid the lowest interest rate they are willing to accept, a so-called Dutch auction, thereby resulting in the lowest interest cost for the U.S. Treasury (Santomero & Babbel, 2001).

## 2.4 ECONOMIC CLIMATE 1961 AND 2011

In previous sections the most useful theory in order to conduct the analysis has been reviewed. Now I turn to a more specific discussion about the two time eras in which Operation Twist and MEP were conducted and why an approach like these programs was necessary. MEP was larger in size than Operation Twist and the financial markets functioned more poorly in 2011 than in 1961. In addition, in

1961 Europe was not facing a recession, which also affects the starting point for this initiative. Despite these differences, the central banks in 1961 and 2011 were both restrained from using the federal fund target as a main tool for expansionary policy and therefore had to turn to “untraditional” tools to stimulate the economy.

#### 2.4.1 1961: AN ATTACK ON BOTH FRONTS

After World War 2 the winning nations developed the Bretton Woods system. This was a fixed exchange rate regime which was based on the convertibility of U.S dollars into gold at \$35 dollar per ounce (Mishkin, 2009). The member countries were responsible for maintaining a fixed exchange rate between their currencies and the dollar by actively intervening in the foreign exchange markets (Mishkin, 2009). The U.S. played an especially important role in this system, as they were the world’s largest economic power and stored a greater part of the world’s gold (Beggs, 2012). As a result, the U.S was on a gold standard and the world on a dollar standard (Zaretsky, 1993). The Bretton Wood system also led to the development of the International Monetary Fund (IMF). The IMF’s role was to promote international trade by setting the “ rules of the game” in the fixed exchange rate system and lend funds to countries that suffered from balance-of-payment difficulties (Mishkin, 2009). But the IMF had no force to pressure surplus countries to revise their exchange rate upwards or to make them conduct more expansionary policies (Mishkin, 2009, p.475). As a result, member countries with a surplus on their balance of payments would not intervene in the foreign exchange market if their exports would be hurt by rising prices (Beggs, 2012).

When Kennedy was elected president in 1961, the American economy had been in recession for a while and it had a persistent international balance-of-payment deficit (Zaretsky, 1993). Even though it was necessary to conduct expansionary policies to stimulate the domestic economy, the U.S., as the reserve currency country in the Bretton Wood system, could not devalue the dollar even though it was overvalued (Mishkin, 2009). The Kennedy administration therefore had two pressing problems; a domestic recession and a balance of payment deficit, but since the nature of these problems called for different responses their monetary tools were limited. Interest rates needed to be lowered to stimulate the weak domestic economy, but interest rate differentials between the U.S. and Europe, which at the time was not in a recession, lead to cross-currency arbitrageurs converting U.S dollars into gold and

invest the proceeds in high-yield European assets (Alon & Swanson, 2011). Severe outflow of gold further worsened the trade deficit.

As a possible solution to this dilemma, the Kennedy Administration proposed to lower longer-term interest rates while keeping short-term interest rates unchanged. As previously mentioned, the open-market purchases was aimed at affecting the interest rate structure rather than to provide liquidity. The logic behind the initiative was that a lowering of long-term interest rates could stimulate business investments and household demand, while cross-currency arbitrage was primarily determined by cross-country differentials in short-term interest rates (Alon & Swanson, 2011). This way aggregate demand could be stimulated without worsening the outflow of gold-and the trade deficit since the short-term rates remained unchanged (Alon & Swanson, 2011). On February second 1961, the Kenney administration announced Operation Twist; an attack on both fronts.

#### 2.4.2 2011: NEW AMMUNITION FOR THE FINANCIAL WAR

Former Chairman of the Fed Alan Greenspan described the financial crisis as a “once-in-a-century credit tsunami” (Quinn, 2008). In August 2007, defaults in the subprime mortgage market sent a shiver through the entire financial system in the U.S., leading to hundred of billion dollar losses- and defaults for Wall Street and commercial banks. A credit squeeze and following high lending rate made it very difficult to obtain credit and meet debt obligations for households and businesses. A following economic contraction completed the crisis (Mishkin, 2009). The U.S unemployment rate went from 6, 1 % in September 2008 to a staggering 10% in October 2009 (Bureau of Labor Statistics, 2012a). Since the recovery phase in January 2010 there has been created about 4 million jobs, but 8 million were lost during the financial crisis (DNB Økonomiske utsikter, 2012). In October 2012, 12, 3 million people were still unemployed (Bureau of Labor Statistics, 2012b).

Bernanke (2012) describes the range of monetary easing policies that were conducted as an attempt to hinder a full collapse of the American economy. The FOMC first responded with liquidity actions cutting the discount rate and extending term loans to banks. In September 2007, the FOMC lowered the federal funds target rate by 50 basis points. In the spring of 2008 the target was further reduced by 325 basis points leaving the target at 2 percent. Despise these cuts there were still signs of a dramatic economic slowdown in December 2008 making it necessary to reduce the target further to a range of 0 to 25 basis points. Several cuts in the federal funds target rate were not sufficient to revive the

American economy, the credit markets were still dysfunctional in early 2009 and the FOMC continued to establish emergency lending facilities to provide liquidity (Ben Bernanke, 2012).

Bernanke (2012) describes forward guidance as another important tool for the FOMC to anchor the market expectations. In March 2009, the FOMC post meeting statement noted that economic conditions “are likely to warrant exceptionally low levels of the federal funds rate for an extended period” (Boards of Governors of the Federal Reserve System, 2009). This has now several times been extended and the latest statement signals low levels for the federal funds target “to at least mid 2015” (Boards of Governors of the Federal Reserve System, 2012b). The Fed also turned to its balance sheet as a monetary easing tool through the purchase of longer-and short-term securities, often referred to as large-scale asset purchases or quantitative easing. This was viewed as an untraditional monetary policy; even though it could be guided by some basic monetary principles there was limited historical experience. Ben Bernanke (2012) described it as a “learning by doing” process for the Federal Reserve.

In 2011, the U.S- and world economy were still struggling with the repercussions of the financial crisis. Even though the outburst of the financial crisis was three years ago, the financial war was far from over. Despite all accommodating policies from the Federal Reserve they were still not fulfilling their dual mandate. With a federal fund target ranging from 0 to 25 basis points, the remaining ammunition was lying in the balance sheet. Operation Twist was therefore reborn as MEP in September 2011.

### 3 METHODOLOGY

In the methodology section I will comment on using regression analysis as a statistical-and predictive tool. I wish to emphasize both explanation and prediction. I want to make accurate guesses about the value of the dependent variable in a prediction, but part of the model purpose is also to locate which variables that allows me to make these accurate guesses (Beck, 1993a). The model is, however, ad-hoc and it is possible that the models predictive- and explanatory powers are correlated to which time series one analyzes. The model might therefore not function optimally for all data series used.

#### 3.1 REGRESSION ANALYSIS

As the main tool to establish determinants for 10-year Treasury yields, I will use the method of regression analysis. This is a tool for the investigation of relationship between variables and to establish the causal effect of one variable upon another. I wish to figure out if the chosen variables are related, how strong this relationship is and if one variable can be predicted from observations of the others (Johnson & Bhattacharyya, 2006, p.431). From the multiple regressions there are produced equations that I later use to predict the 10-year Treasury yield. By using a multiple regression one takes into account that several variables affect the response variable, and one can estimate the effect of these variables separately. Hence, by using a multiple regression I can get a fuller explanation of the dependent variable. Following is the regression equation with the four variables representing fundamental conditions in the American economy:

$$I = \alpha + \beta \text{Trade} + \gamma \text{Inflation} + \delta \text{PMI} + \theta \text{Fed fund effective} + \varepsilon$$

Where  $\alpha$  = a constant amount

$I$  = the dependent variable 10-year Treasury yield

$\beta$  = the effect on 10-year Treasury yield from one unit increase in trade balance

$\gamma$  = the effect on 10-year Treasury yield from one unit increase in inflation

$\delta$  = the effect on 10-year Treasury yield from one unit increase in PMI

$\theta$  = the effect on 10-year Treasury yield from one unit increase in fed fund



$\varepsilon$  = The “noise” term reflecting other factors that influence 10-year Treasury yield

The variable  $I$  is the dependent or endogenous variable, in this case the 10-year Treasury yield. The effective fed fund, PMI, trade balance and inflation are the independent variables and  $\beta, \gamma, \delta, \theta$  are the coefficients for the independent variables. The coefficients on the independent variables give the changes in the dependent variable for one unit change in the independent variable, while the other independent variables remain constant. The dataset includes observations about the independent- and dependent variables, but the noise variable  $\varepsilon$  comprises of factors that are unobservable. Regression analysis therefore relies on some assumptions about this noise component.

### 3.1.1 HYPOTHESIS

With the regressions I simply wish to establish if there is a significant relationship between the chosen independent variables and the movement in 10-year Treasury yields, and how much of the changes in the yield the independent variables can explain. Therefore my null hypothesis is that the coefficients on the independent variables are zero and my alternative hypothesis becomes that the coefficients have value different from zero and therefore plays a significant role in the regression. As I proceed in the analysis by extending or replacing independent variables in the model, the hypothesis unchanged.

$$H_0 : \beta, \gamma, \delta, \theta = 0$$

$$H_1 : \beta, \gamma, \delta, \theta \neq 0$$

### 3.1.2 THE LEAST SQUARE PRINCIPLE

One commonly assumes linearity among variables. For instance numerous relationships have empirically been found to be linear. In addition an inspection of the data themselves, can fail to suggest an alternative to linearity (Beck, 1993a, p.5). If we assume linearity, we want to relate the 10-year Treasury yield to the independent variables with a straight line, but we still do not know which line to choose among all the possible ones. For each observation in the dataset we can therefore calculate a prediction error (Beck, 1993a, p.6):

$$\text{prediction error} = \text{observed} - \text{predicted} = I - \hat{I}$$

Summing up these prediction errors for all observations gives a total prediction error (TPE)

$$\Sigma = (I - \hat{I})$$

However, TPE is an inadequate measure of error since positive errors cancel out negative errors. To overcome this problem, one can square each error. This leads to the conclusion to select the line which minimizes the sum of the squares of the errors (SSE) (Beck, 1993a, p.6):

$$SSE = \Sigma = (I - \hat{I})^2$$

### 3.1.3 THE COEFFICIENT OF DETERMINATION

In order to use the results found in the regression analysis, one has to assess the degree of confidence that the true relationship between the variables is close to the estimated relationship, in other words how powerful an explanation the regression provides (Beck, 1993a). The coefficient of determination ( $R^2$ ) illustrates the proportion of variation in the dependent variable explained by the regression (Beck, 1993a, p. 12). However, there will always be deviations in the dependent variable that the model is unable to explain. The total variation (TSS) can therefore be divided into two parts; the regression explained sum of squared deviations (RSS) and unexplained sum of squared deviations (ESS). One wants the explained deviation (RSS) to be large relative to the total deviation. This concept forms the measurement of  $R^2$  (Beck, 1993a, p. 13)

$$R^2 = \frac{RSS}{TSS}$$

The coefficient of determination is often a misused measurement of explained variation. The more independent variables one include in the model, the higher  $R^2$  becomes, even though the new variables have no real explanatory power. This implies that a model with more independent variables is not necessarily a better model, because more uncertain parameters have to be estimated. Therefore one adjusts the coefficient of determination for the number of independent variables when comparing different models. The adjusted  $R^2$  takes this into account (Møen, 2010):

$$R^2_{adjusted} = 1 - \frac{ESS/(n - k - 1)}{TSS/(n - 1)}$$

Where  $k$  = number of independent variables  
 $n$  = number of observations

### 3.1.4 TEST STATISTICS

Since the data sets I use are of limited size, the coefficients can give a value different from zero even though there is no connection between the independent and dependent variable. In order to test for the sizes of the coefficients, one can use a t-test with the following hypothesis:

$$H_0 : \beta, \gamma, \delta, \theta = 0$$

$$H_1 : \beta, \gamma, \delta, \theta \neq 0$$

When t-values are high we can reject the null hypothesis and claim that the variables included in the model are statistical significant. Critical values of t-statistics give a signal of statistical significance (Ryan & Joiner, 2001).

$$t = \frac{\beta - 0}{\text{StDev for } \beta}$$

One can also use the p-value to determine statistical significance of the coefficients. The p-value gives the probability for observing the value in the null hypothesis (Møen, 2010). The normal critical levels to reject a null hypothesis are at a 10-, 5- or 1 percentage levels ( $\alpha$ ). If the p-value is under 0,05 this means that there is less than 5 % likely that the null hypothesis is true. One reject the null hypothesis when  $p \leq \alpha$ . In that event one can conclude that the sample estimates did not just come from random noise, but that there is a meaningful linear relationship between the variables.

One uses the F-test to test the hypothesis that none of the independent variables have explanatory power (Møen, 2010). The alternative hypothesis is that at least one of the independent variables explanatory power is different from zero. For high values of F and low values of p we reject the null hypothesis. If one experiences multicollinearity, the t-test might suggest that coefficients are insignificant, but the F-test might reveal that all the coefficients cannot be zero at the same time (Møen, 2010).

### 3.1.5 ASSUMPTIONS FOR THE LEAST SQUARE PRINCIPLE

The statistical tests often rely on certain assumptions about the “noise” component. An important part of regression analysis is to examine the residuals because it can detect inconsistency between the data and the postulated model (Johnson & Bhattacharyya, 2006, p.495). In general, there are two types of errors that affect the result of the analysis. Type 1 error occur when the null hypothesis is rejected when it is true, and Type 2 error occur when the null hypothesis is not rejected when it is false (Møen, 2010). The least square method relies on four assumptions (1, 2, 3 & 4 under) to be sure the regression coefficients are BLUE (Best linear Unbiased Estimator). The BLUE criterion secures that the estimators provided from the regression have the least variance and are unbiased under the assumption of linearity (Møen, 2010). Usually, there is also often a fifth assumption regarding normality on order to test hypothesizes about the parameters and the use of t-and F-tests. In addition, since I am using a multiple regression the assumption regarding no multicollinearity is of importance (Møen, 2010).

#### 1. The mean of the error term is 0.

$$E(\varepsilon_j) = 0$$

In reality, this assumption is trivial if one has a constant in the model. If violated, the only affected coefficient is the intercept (Møen, 2010)

#### 2. Homoscedasticity

$$VAR = (\varepsilon_j) = \sigma$$

For each set of values for the  $n$  independent variable, the variance of the error-term is constant (Beck, 1993b, p. 160). If this is not the case, we have heteroscedasticity. One typical situation for heteroscedasticity is when the dependent variable is measured with error and the amount of error varies with the value of the independent variable (Beck, 1993b, p. 224). When heteroscedasticity is present, and it is not due to measurement problems, it is often the case that there is interaction between an independent variable and an omitted variable (Beck, 1993b).

### 3. Independent error term

$$COV = (\varepsilon_j, \varepsilon_h) = 0$$

For each set of values of the  $n$  independent variables, the error terms need to be uncorrelated (Beck, 1993b, p.160). If this is not the case we have autocorrelation. Auto correlation is often a problem when using time series data, and implies that the error term in period ( $t$ ) is positively or negatively correlated to the error term in ( $t - 1$ ) or ( $t + 1$ ). The same economic climate in two periods can, for instance, give auto correlation when the model is not controlling for business cycles (Møen, 2010).

### 4. Endogeneity

If the independent variables are stochastic they have to be independent from the error terms. Violation of this assumption can create biased coefficients, but a model with correlated variables and residuals can still be used for prediction purposes (Møen, 2010).

### 5. Normality

For each set of values for the  $n$  independent variables,  $\varepsilon$  is normally distributed. The estimation of parameters in the regression will not be affected if this assumption is violated (Beck, 1993b, p.161).

### 6. Multicollinearity

When using multiple regressions, the assumption regarding multicollinearity is of importance. This assumption implies that no independent variable is perfectly linearly related to one or more of the other independent variables (Beck, 1993b, and p.161). In other words, some of the independent variables can have a strong covariance and bring the same information to the model. Multicollinearity is not a technical problem, but more the case that one does not have enough information in the data set (Møen, 2010).

## 4. DATA

In this section I will explain which independent variables represent fundamental conditions in the American economy and why these variables are valuable in predicting the 10-year Treasury yield. I will also touch upon my choices for estimation-and prediction period, as well as thoughts on the data collection.

It can be a challenging task to identify and quantify all the myriads of factors that determine the development in 10-year yield. Long-term interest rates are in addition influenced by forward looking variables, like expectations for future inflation-and real interest rates that are often unobservable. I have therefore received help from DNB Markets on formulating a basic multiple regression with four variables that represent fundamental conditions in the economy. When I in the analysis expand the model by including new variables, further explanation-and reasoning for my choices will be discussed.

### 4.1 THE 10-YEAR TREASURY YIELD

I have used the 10-year Treasury yield with constant maturity as dependent variable throughout the entire analysis. Constant maturity means that yields are “interpolated” by the Treasury from the daily yield curve” (U.S. Department of Treasury, 2012). In other words, an index is computed based on average yields from treasuries with different maturities (Investopedia, 2012). This method provides a measure of a 10-year yield to maturity, even though the Treasury has no securities outstanding with exactly 10-years left of maturity (U.S Department of Treasury, 2012). In addition, constant maturity treasury yields are often used as a reference when pricing debt securities issued by corporations and institutions (Investopedia, 2012).

One reason for using the 10-year Treasury yield as the dependent variable is that DNB Markets uses it in their model. In addition, for MEP the majority (64%) of the purchases are in maturities ranging from six to ten years. Also, the Treasury securities purchases under MEP are expected to have an average duration of 10-11 years, extending the average maturity of the Fed’s portfolio from five to eight years (Federal Reserve Bank of New York, 2012b). 10-year Treasury yields therefore seem like an appropriate response variable since the likely dominating effect on the yields will be in this market. The 10-year Treasury yield is gathered from the Board of Governors of the Federal Reserve System

and will be used as a monthly measure (see: Boards of Governors of the Federal Reserve System , Selected interest rates (Daily)-H.15).

## 4.2 BALANCE OF PAYMENTS

“The balance of payments is a bookkeeping system for recording all receipts and payments that have direct bearing on the movements of funds between a nation and foreign countries” (Mishkin, 2009, p.468). The current account shows international trade in goods and services, while the capital account shows net receipts from capital transactions such as bond-and stock purchases and bank loans. The sum of the capital-and current account show the net change in the government international reserves (Mishkin, 2009, p.469):

$$\text{current account} + \text{capital account} = \text{net change in government international reserves}$$

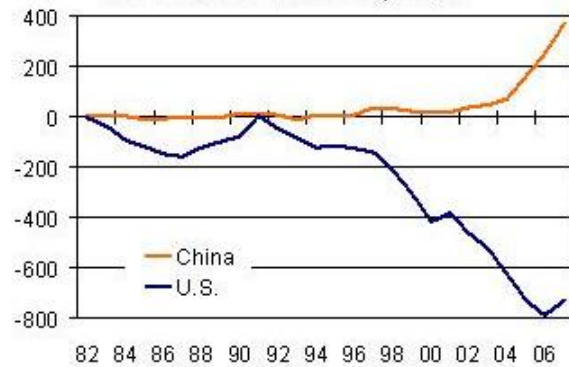
When a country is experiencing large trade deficits this means they are effectively exchanging capital assets for goods and services (Federal Reserve Bank of New York, 2012a). That means that when U.S payments in export is insufficient in covering the price of U.S import, the U.S must on net borrow this difference in international capital (Bernanke, 2005). The current account can therefore show if the U.S. are decreasing or increasing in debt to foreign countries (Mishkin, 2009). In 2011 the U.S. current account showed a trade balance deficit of \$ 465,926 million (US Department of Commerce, 2012).

### **“Hu`s your daddy”**

In section 2.2.9.1 one could establish that China was the second largest holder of Treasuries and the largest foreign owner. After China entered the World Trade Organization in 2001 there has been an extraordinary growth in trade between China and the U.S (Scott, 2012). According to BBC, imports from China hit a record this June, making the trading gap between these countries \$29.4 billion (BBC, 2012).

Chinas export to the U.S makes up over half of U.S import from less-developed countries (Scott, 2012). The U.S pays for its imports from China in U.S dollars and China uses the proceeds to purchase various assets (Chan, 2009). These assets are mostly U.S Treasuries, but also debt from government agencies such as Fannie Mae and Freddie Mac (Chan, 2009). The U.S. trade relationship with China has therefore led to the U.S accumulating many billions worth of foreign debt to China and China improving its asset position in U.S Treasuries. This is the “China-effect”.

Figure 4-1 Current accounts; China and U.S.



Source: (Chan, 2009)

### **The balance of payments as a variable in the model**

The trade balance is included in the model first and foremost to incorporate the China-effect on the Treasury market. As mentioned here, the trade relationship between the U.S. and China has contributed to make China the second largest owner of Treasuries and the largest foreign owner. This relationship could implicate that China's demand in these markets have influence on the longer-term yields by pushing them down when they further expand their asset position in the U.S Treasury market. Beltran et al (2012) investigate what effect foreign official inflow to U.S Treasuries has on longer-term yields. Between 1995 and 2010 the Chinese acquired about \$1,1 trillion In Treasuries, had they not, all other things being equal, the authors find that the 5-year Treasury yield would have been about 2 percentage points higher by 2010 (Beltran et al, 2012). The trade balance will therefore display if foreign governments have proceeds to further increase their position in the Treasury market and thereby influencing the yields. As a variable, the trade balance might be able to explain parts of the variation in the 10-year yield.

I have collected the data for the balance of payments from the U.S Census Bureau, Foreign Trade Division. The dataset is U.S international Trade in goods and services presented on a balance of payments (BoP) basis (see United States Census Bureau). These numbers are in millions of dollars and are seasonally adjusted. In the models this variable is referred to simply as “trade”.



### 4.3 INFLATION

As a measurement of inflation I have used the monthly inflation rate, calculated on the basis of the Consumer Price Index (CPI) published each month by The Bureau of Labor Statistics (BSL). CPI measures the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services (Bureau of Labor Statistics, 2011). By using expenditure information gathered from consumer surveys, 200 item categories are weighted into eight groups in the CPI-index structure. BSL uses 1982-84 as the reference base when calculating the specific CPI indexes. They measure changes in relation to that reference base to calculate the rate of inflation. In order to see the underlying trend in short-time price changes, the data is seasonally adjusted to extract changes in price level not caused by normal seasonal patterns (Bureau of Labor Statistics, 2011).

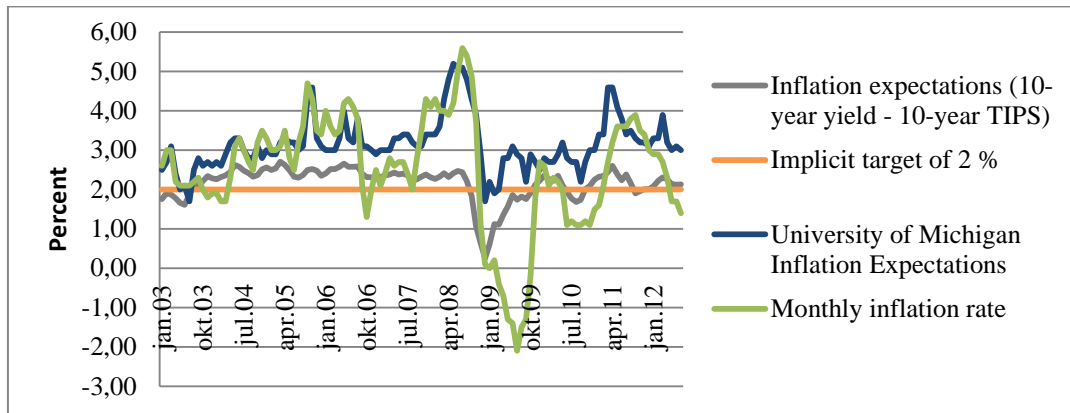
#### **Inflation as a variable in the model**

Inflation is important in this analysis for many reasons. Firstly, the co-equal goal of the Federal Reserve dual mandate is price stability and maximum employment. There should therefore be information about inflation expectations in the term structure of interest rates. Secondly, inflation expectations are an important determinant for the real interest rate and therefore the real cost of borrowing in the economy. Incentives to lend-and borrow can be determined on the basis of expected inflation. Because of this connection, inflation expectations are an important determinant for shifts in supply- and demand in the Treasury market.

Another interesting factor that highlights the importance of inflation and the return of nominal securities is the development of TIPS (Treasury Inflation Indexed Securities). Since the yields on some securities in the market are lower than the rate of inflation, investors are demanding TIPS to such a great extent that the 10-year TIPS yield is now negative. The investors are actually paying the government to hold its debt.

The difference between the yield on ordinary Treasuries and TIPS is often referred to as the “break even inflation” and can give a good indication of the market inflation expectations (Kenny, 2012b). As one can assess from figure 4-2, both “informal”- and formal measures of inflation expectations are above the implicit inflation target of 2 %, as is the actual inflation rate for August and September 2012.

Figure 4-2 Inflation expectations vs. actual inflation rate



Source: (FRED, Data: University of Michigan Inflation Expectations (MICH), 10-year TIPS (FII10), 10-year yield (GS10) & U.S Inflation calculator (2012), Data: monthly inflation rate)

When inflation expectations are high, as they seem to be now, the yields on TIPS become negative since the yields on ordinary Treasuries are trading below expected rate of inflation. In addition, the 10-year Treasury yield has increased in August- and September 2012, an indication that the holders demand compensation for the expected decline in real return. Using movements in inflation as a predictor for variance in the 10-year Treasury yield therefore seems constructive.

I have collected historical inflation rates from U.S Inflation Calculator These rates are calculated using the current Consumer Price Index published monthly by BSL (see U.S Inflation Calculator, 2012).

#### 4.4 FEDERAL FUNDS RATE

The federal funds rate is the interest rate on overnight loans between two institutions from the close of one business day to the opening of the next (Mishkin, 2009). Fed funds are therefore the shortest-term liabilities of U.S. chartered- depository institutions (Santomero & Babbel, 2001). Technically, transactions are executed by a transfer of funds from one institutions checking account in the Federal Reserve to a clearing account of another institution. Institutions also have needs to finance their ongoing activities and the first place they will seek funding is in the federal funds market (Santomero & Babbel, 2001). As a result it is in the market for reserves that the federal funds rate is determined.

There are in general three tools for monetary policy in the U.S; open market operations, discount lending and reserve requirements (Mishkin, 2009). All these three factors affect the market for banking

reserves and therefore the federal funds rate, but in recent years the use of open market operations has been viewed as the primary tool for monetary policy. This view is strengthened by the fact that since February 1995, the Fed has explicitly announced its target for the federal funds rate at each FOMC meeting (Boards of Governors of the Federal Reserve System, 2010). I will therefore limit my discussion to open market operations, since this is also the primary way the FOMC makes sure the target for the federal funds rate is realized.

### **Open market operations**

Open market operations, purchases and sales of securities, are the primary determinants for the supply of reserves to the banking system- and changes in the interest rate in the market for reserves in the U.S. (Mishkin, 2009). Open market purchases expand the supply of reserves and lower the short-term rates because of increased liquidity in the banking system (Mishkin, 2009). If the excess reserves` in the banking system is too high many banks will have reserves to lend out. If few other banks have needs- or wants to hold these reserves, the federal funds rate falls. Similarly an open market sale reduces the quantity of non borrowed reserves supplied and increases the short-term rates (Mishkin, 2009). The demand for reserves is high; as a result the banks with excess reserves can push the interest rate up. In that event, the federal funds rate increase.

The FOMC only conducts open market operations in U.S Treasury- and government agency securities to avoid conflict of interest (Mishkin, 2009). T-bills are among the most used securities in these operations. As previously mentioned, the market for government securities is widely traded and is therefore very liquid. The Fed can therefore make a substantial amount of transactions without creating significant price fluctuations in the market. Even though it is the FOMC who sets the target for the federal funds rate, it is the trading desk at the Federal Reserve Bank of New York who actually conducts the open market operations on directives from the FOMC. The trading desk executes purchases- and sales of securities trying to reach the target for the federal funds rate by analyzing how large a change in non borrowed reserves is needed (Mishkin, 2009).

### **Federal funds rate as a part of the analysis**

The federal funds target rate is an obvious choice to include in the model. This interest rate is regarded as the shortest-term interest rate in the economy and an important signal of the direction of the Fed`s monetary policy. FOMC`s announcements is therefore the most explicit information to the market of

the course of the federal funds target. The federal funds target can therefore also influence expectations on the course of other interest rates as well. We know there is some truth to the basic calculations in expectations theory, even though the proposition is not exhaustive in explaining variation in longer-term interest rates. Based on the calculations in this theory, and the market's expectations of future monetary policy as a determinant for longer-term interest rates, the effective fed funds rate is included in the model as a fundamental condition that could predict movements in 10-year Treasury yields.

The effective federal funds rate is collected from the Board of Governors of the Federal Reserve System (see Board of Governors of the Federal Reserve System, Selected interest rates (Daily)-H.15).

#### 4.5 ISM PURCHASERS INDEX

The Purchasing Managers' index (PMI) is released monthly by the Institute for Supply Management. The index is developed based on survey answers from purchasing and supply executives in the manufacturing industry in the U.S. The PMI index is published on the first day of the following month of each survey, making this index the earliest indication of changes in the economy's health (Koenig, 2002)

According to Koenig (2002), the PMI index has proved to be a useful tool in predicting growth in the manufacturing industry, predicting changes in Federal Reserve policy and in predicting GDP growth (Koenig, 2002). If the index is considered in isolation from other economic variables, then the level of the index matters. Koenig (2002) suggest that PMI values over 47 can signal expansion in manufacturing where every point above 47 translate to about 0, 6 percentage point of factory output growth. Values over 40 generally signals GDP growth- or overall economic expansion, where each point over 40 translates to about 0, 25 percentage growth in GDP. PMI values over 52, 5 have in fact been associated with a rise in the federal funds target rate. However, these associations are viewed as "rule of thumb". Monetary policy might as easily respond to other factors that move in the same direction as the PMI index (Koenig, 2002).

The survey used to create the PMI index is sent out to executives in about 400 companies in twenty manufacturing industries in the U.S. These executives answer questions about new orders to their firm, the firms' production, employment, inventories, order backlogs, new export order and import of materials and supplies (Koenig 2002). The executives answer if the mentioned variables current level

is higher, lower or the same as the preceding month. The PMI is a diffusion index, meaning it measures the proportions of the components that contribute positively to the index (The Conference Board, 2012). Because the index is a diffusion index, it cannot reflect the intensity in which conditions are changing. A high PMI index simply mean that more executives are reporting improved business conditions then are reporting worsened- or negative developments (Koenig, 2002). Another weakness following from the use of PMI index is that is does not cover all sectors of the economy. The manufacturing sector is diminishing in size compared to other sectors, therefore the PMI might have come less relevant in predicting changes in the strength of the economy as a whole (Koenig 2002). Also, since the PMI index is dominated by large companies that also operate internationally, it might reflect conditions that are not directly linked to American manufacturing-and real economic activity (DNB Økonomiske utsikter, 2012).

### **PMI as a variable in the model**

There are two reasons for including the PMI in a model that predicts longer-term Treasury yields. Firstly, the PMI has proved to have some power in predicting changes in the federal funds rate. Since the index show changes in real economy activity, it can be reasonable to see PMI as an early signal of changes in monetary policy. If one draws on expectations theory, we know that longer-term rates can be affected by the expectations for future short-term rates levels. Therefore, if a rise in the PMI index induces increases in the federal funds target rate, the expectations for future level of short-term rates also alters, which in return can increase the longer-term rates. That way, movements in the PMI might be able to explain variation in the 10-year yield.

Secondly, a rise in the PMI over certain levels can signal GDP growth and therefore growth in income- and asset prices. Economic growth can also make new investments more profitable to undertake. We know from theory of asset demand that an increase in wealth- and prosperous investments from a general economic expansion, will affect the supply and demand of bonds. In other words, an increase in the PMI could implicitly affect the 10-year Treasury yield through increased supply- and demand of bonds.

The PMI index is collected from the Institute of Supply Management. The figures are monthly and I have used the level of the index and not percentage change from preceding month since I look the movement in the index isolated from other variables (see ISM).

#### 4.6 CHOICE OF PREDICTION-AND ESTIMATION PERIOD

For MEP the chosen estimation period is 2000-2007 and the prediction period is 2008 to 2012. My strongest argument for choosing these periods is that I wanted to make a model that under normal circumstances would be able to predict the 10-year Treasury yield. Therefore, by starting the prediction period before MEP was actually conducted, I could see if the model managed to predict the 10-year yield before MEP and how these predictive abilities changed after September 2011. Another argument for using the chosen prediction period is that I could be able to establish which variables were suitable in explaining variation in the 10-year yield in general, and therefore get an indication of possible omitted variables by viewing the periods where the spread between the model-and actual yield increases. A longer prediction period could this way help me shed light on factors that could be used when expanding the model. However, as a concluding remark for the analysis of MEP, I will extend the estimation period to August 2011 and only predict the 10-year yield in the last year, too see if the predictions change significantly.

For Operation Twist the same arguments apply. The estimation period is from 1954 to 1959 and the prediction period is 1960-1964. All Operation Twist as a monetary policy was abandoned in 1965, the purchases were to a smaller degree continued after 1961. Therefore by including a few years before and after 1961, I could establish if the model was able to predict the yields before-, during-and after Operation Twist.

#### 4.7 DATA COLLECTION

When collecting data I have empathized using reliable sources and being critical to possible errors in the data set. Most data is collected from the initial publishers of the time series, but a significant amount of data is also collected from FRED, the Federal Reserve Bank of St. Louis research database. I have chosen to use monthly figures, as this provides more data material for the analysis and because many of the variables are published on a monthly basis. I have not conducted seasonal adjusting or calculations of averages myself in cases where the data has been published on a daily basis. I therefore have confidence that there are small, if any, errors in the data sets used in the model that could lead to measurements errors. A prerequisite is still that there might have occurred punching errors when I have worked with the datasets in various Minitab- and excel sheets. I do not, however, regard eventual

punching mistakes as critical for the analysis. In addition, the variables used might be subject to later revisions by the publishers after I have used them in an analysis. I have collected a majority of the data in the beginning of October 2012. When I mid- November added data for September 2012, some of the previous values for the last months in the dataset had already been revised. I chose not to change the entire dataset based on these revisions, as the changes were marginal and therefore not critical for the results in the analysis. A second prerequisite is therefore that the data has been revised from the period I collected it. As statistical software I have used Minitab 16 and for prediction purposes I have used Microsoft Excel.

## 5. INVESTIGATING THE ROBUSTNESS OF THE MODEL

Financial time series can be challenging to work with because of the possibility that the models will entail much “noise” from omitted variables. The residuals could be dependent on each other and the chosen variables can be a poor fit for the model. It is therefore likely that each regression will be complicated by problems like auto correlation, heteroscedasticity and multicollinearity. In this section I therefore display findings when investigating the robustness of the model. For this analysis, the most important point is that the estimation of the predictors` coefficients is unbiased- and accurate. The regression is a mean to be able to predict the 10-year yields. Therefore I might disregard possible violations if these violations do not impair the goodness of prediction.

### 5.1 AUTO CORRELATION

I chose to check the model for auto correlation first. This is because in an event where positive auto correlation was present, as one should expect using time series data, the entire data sample would have to be modified. In that event, I wanted to make the necessary adjustments before I investigated the rest of the robustness of the model.

To test for auto correlation one can do a Durbin Watson test. Durbin Watson (DW) statistics always have value between 0 and 4 and as a “rule of thumb” one can determine if auto correlation is present by the value of the DW test statistics. Values lower than 1 usually signals positive autocorrelation while DW values close to 2 usually establish that auto correlation is not a problem (University of Delaware). Formally, one uses a table displaying upper- and lower critical DW values and test a null hypothesis.  $\rho = 0$  signals no auto correlation, while  $\rho > 0$  signals positive autocorrelation (National Sun Yat-Sen University).

*If  $d < d_L$  then reject  $H_0: \rho = 0$*

*If  $d > d_U$  then to not reject  $H_0: \rho = 0$*

*If  $d_L < d < d_U$  then the test is inconclusive*

Table 5-1 displays critical upper-and lower limits for DW values allowing levels of significance, observations and regressors to differ. Since positive auto correlation is most likely for data set I will only display critical values for the lower tail ( $\alpha$ ).



Table 5-1 Durbin Watson upper-and lower critical values

Regression	Observations	Regressors	$U_L, U_U$ 1 % sig.	$U_L, U_U$ 2,5 % sig	$U_L, U_U$ 5 % sig.
2000-2007	95	4	1,45,1,63	1,53,1,70	1,59,1,76
2000-2007	95	5	1,44,1,65	1,51,1,72	1,57,1,78
1954-1959	64	4	1,25,1,60	1,33,1,69	1,41,1,77
1954-1959	64	5	1,28,1,56	1,37,1,65	1,44,1,73
1992-1999	94	4	1,45,1,63	1,53,1,70	1,59,1,76

Source: (National Sun Yat-Sen University)

In addition to Durbin Watson tests, an estimate of correlation is useful. Since the errors in most practical cases are unknown, one has to rely on the residuals the regression provides to test for independent error terms. By running a correlation test between the residuals from the regression ( $\varepsilon_t$ ) and a sample of lagged residuals ( $\varepsilon_{t-1}$ ) one gets a Pearson correlation ( $\rho$ ) and an associated p-value that can be interpreted as auto correlation is significant or not, depending on level of significance. This way we find to what degree the residuals are dependent on each other.

Table 5-2 Results from Durbin Watson-and Pearson correlation tests

Regression	Durbin Watson statistics	Pearson correlation $\rho$	P-value from correlation
1. 2000-2007	0,625567	0,682	0,000
2. 2000-2007	0,650527	0,671	0,000
3. 2000-2007	0,667420	0,662	0,000
4. 2000-2007	0,653492	0,669	0,000
5. 1954-1959	0,730929	0,632	0,000
6. 1954-1959	0,588340	0,704	0,000
7. 1992-1999	0,615686	0,679	0,000

From table 5-2 one can assess that DW values for all the regressions lie under the lower-critical value for all significance levels, hence positive auto correlation is present in all models. The Pearson correlation ( $\rho$ ) confirms since all p-values are lower than 1-, 5-, and 10%. Even though the estimates are unbiased; least variance is not used and it follows that statistical inference is invalid (Møen, 2010).

### Cochrane-Orcutt method

As a solution to the auto correlation problem one can use the Cochrane- Orcutt method to adjust the linear model for serial correlation in the error terms. With the Cochrane-Orcutt method one loses the first observation in the model, i.e. in all regressions the observations are lagged one period. In order to adjust the original parameters, one uses the Pearson correlation ( $\rho$ ) (Pennsylvania State University, 2012)

The dependent variable is adjusted as follows:  $y_{t\ new}^* = y_t - \rho y_{t-1}$

The independent variables are adjusted as follows:  $x_{t\ new}^* = x_t - \rho x_{t-1}$

The modified regressions now show reduced auto correlation by viewing the DW values and the Pearson correlations. But all regressions now give DW values that according to upper-and lower critical values give inconclusive results at 5 % significance (ref. table 5-1). In addition, the Pearson correlation shows that auto correlation is gone for 4 regressions, while 3 regressions are still influenced. However, since the estimates are unbiased and the auto correlation seems to be to a large extent reduced, I chose to leave the assumption valid for the purpose of my analysis.

Table 5-3 Results from Durbin Watson-and Pearson correlation tests after adjustments

Regression	Durbin Watson statistics	Pearson correlation $\rho$	P-value from correlation
1. 2000-2007	1,53708	0,185	0,072
2. 2000-2007	1,57004	0,212	0,040
3. 2000-2007	1,55414	0,220	0,033
4. 2000-2007	1,58848	0,202	0,051
5. 1954-1959	1,63899	0,172	0,174
6. 1954-1959	1,56319	0,218	0,083
7. 1992-1999	1,3557	0,319	0,002

### Adjusting prediction methods with Cochrane-Orcutt method

Since the Cochrane-Orcutt method is used to adjust the observations in the regression analysis, the estimated regression equation is influenced by this. In order to make valid predictions for the 10-year yield based, adjustments need to be done to the regression equation. Firstly, one needs to adjust the intercept coefficient for autocorrelation (Pennsylvania State University, 2012)

$$\alpha_0 = \frac{\alpha_0^*}{1 - \rho}$$

$\alpha_0^*$  Is the sample intercept obtained from the regression with the modified variables and  $\rho$  is the Pearson correlation from each correlation test. Secondly, when predicting the 10-year yield, one has to utilize the residuals by adding the error term to the regression equation:

$$y = \alpha_0 + \beta\text{Trade} + \gamma\text{Inflation} + \delta\text{PMI} + \theta\text{Fed fund effective} + \rho\varepsilon_{t-1}$$

When making predictions, the values of 10-year yield ( $y$ ) is computed iteratively. Firstly, one assumes that  $\varepsilon_0 = 0$ , i.e. before  $t = 1$ ,  $\varepsilon = 0$ . One therefore computes the first prediction without the error term.  $\varepsilon_1$  Can then be calculated by  $(y_1 - y_1^*)$ , extracting the actual value of the 10-year yield in the first period less the model prediction of the 10-year yield. Secondly, when predicting  $y_2^*$  one uses  $\varepsilon_1$  (Pennsylvania State University, 2012):

$$y_2^* = \alpha_0 + \beta\text{Trade} + \gamma\text{Inflation} + \delta\text{PMI} + \theta\text{Fed fund effective} + \rho\varepsilon_1$$

## 5.2 MULTICOLLINEARITY

Even though multicollinearity exists in the model, the predicted values and residuals are estimated with accuracy. Multicollinearity does affect the goodness of prediction. However, the standard deviations computed- and the coefficients can be unstable over time. Coefficients can therefore appear to be insignificant even though a significant relationship exists between the response variable and the dependent variable (Minitab, 2010).

To check for multicollinearity one can view the variance inflation factor (VIF). A “rule of thumb” states that one can disregard multicollinearity if VIF does not show a value of 5 or higher (Central Michigan University). Another possible detection method is the use of a tolerance level:

$$\text{tolerance} = 1 - R^2$$

If one regress one independent variable on another independent variable where you expect multicollinearity, you can conclude that it is not a problem if the tolerance is close to 1 (University of Notre Dame, (A)).

Table 5-4 Variance inflation factor (VIF)

Regression	Variance inflation factor (VIF)	Regression	Variance inflation factor (VIF)
1. 2000-2007		2. 2000-2007	
Trade	1,393	Trade	1,642
Inflation	1,249	Inflation	1,278
PMI	1,294	PMI	1,530
Fed Fund	1,255	Fed fund	1,459
		St. Louis index	1,755
3. 2000-2007		4. 2000-2007	
Trade	3,780	Trade	3,777
Inflation	1,338	Inflation	1,347
PMI	1,325	PMI	1,535
Fed fund	1,263	Fed fund	1,470
Federal debt	3,317	Federal debt	3,262
		St. Louis index	1,787
5. 1954-1959		6. 1954-1959	
Public debt	1,291	Public debt	1,948
Inflation	1,985	Inflation	1,785
PMI	2,107	PMI	1,991
Fed fund	1,301	Fed fund	1,465
		Dow Jones	2,339
7. 1992-1999			
Trade	1,252		
Inflation	1,173		
PMI	1,023		
Fed fund	1,179		

Table 5-4 shows that the value of the VIF is consistently below 5. To be certain I have also tested the tolerance of independent variables with high values of VIF against each other, but  $R^2$  was within the tolerance level for all variables. These two tests indicate that multicollinearity is not a problem for these models.

### 5.3 HETEROSCEDASTICITY

Heteroscedasticity can have two implications for the model. Firstly, precision of the coefficients are much lower with non-constant variance. Secondly, the p-values for the regression coefficients assume constant variance, therefore the decisions one makes regarding statistical significance of the predictors can be incorrect when there is non-constant variance (Frost, 2012). The estimates from SSE are still linear and unbiased, but the method is no longer the most efficient since the standard errors could be incorrect. It follows that statistical inference is invalid (Møen, 2010).

To test for heteroscedasticity one can perform a Glejser`s test. One tests if the size of the error increases proportionally to changes in the independent variables by regressing the squared residuals against all the independent variables. If the coefficients are significant, i.e. the p-values are very low or the t-values very high, one rejects the null hypothesis of constant variance (University of Notre Dame (B)). This way one can establish if the independent variables are significantly related to the variance in the residuals.

Table 5-5 Glejser`s test

Regression	p-value from regression	Regression	p-value from regression
1. 2000-2007		2. 2000-2007	
Trade	0,023*	Trade	0,018*
Inflation	0,286	Inflation	0,520
PMI	0,449	PMI	0,178
Fed Fund	0,07	Fed fund	0,272
		St. Louis index	0,968
3. 2000-2007		4. 2000-2007	
Trade	0,134	Trade	0,127
Inflation	0,366	Inflation	0,590
PMI	0,500	PMI	0,195
Fed fund	0,080	Fed fund	0,313
Federal debt	0,899	Federal debt	0,971
		St. Louis index	0,920
5. 1954-1959		6. 1954-1959	
Public debt	0,561	Public debt	0,259
Inflation	0,685	Inflation	0,195
PMI	0,084	PMI	0,003*
Fed fund	0,889	Fed fund	0,282
		Dow Jones	0,322
7. 1992-1999			
Trade	0,535		
Inflation	0,906		
PMI	0,089		
Fed fund	0,771		

*P-values marked\* indicate that one has to reject null hypothesis on 5 % level of significance.*

Since a majority of the test reject heteroscedasticity as a problem for the data series, I choose to leave this assumption valid and pay special care to what statistical significance one ascribe predictors that have shown signs of heteroscedasticity in the analysis.

#### 5.4 NORMALITY

Ryan Joiner test for normality can display if the assumption regarding normality in the residuals are violated (Minitab, 2012). Since my sample size is of limited size, I cannot necessarily rely on the

central limit theory. In this test one reject the null hypothesis that the residuals are normally distributed if the p-value is lower than the chosen level of significance. In addition, one compares the critical values of the test with the approximate critical values for a Ryan Joiner test:

Table 5-6 Critical values for Ryan Joiner test

Observations	1% significance	5% significance	10 % significance
75<n	0,9710	0,9835	0,9865

Source: (Ryan & Joiner, 1976)

As table 5-7 shows, normality in the residuals is apparent for all regressions when viewing both Ryan Joiner critical values and associated p-values.

Table 5-7 Results from Ryan Joiner tests

Regression residuals	Ryan Joiner	P-value
1. 2000-2007	0,992	>0,100
2. 2000-2007	0,991	>0,100
3. 2000-2007	0,989	>0,100
4. 2000-2007	0,990	>0,100
5. 1954-1959	0,991	>0,100
6. 1954-1959	0,987	>0,100
7. 1992-1999	0,998	>0,100

## 5.5 CONCLUSION ROBUSTNESS OF THE MODEL

I mentioned that I would make changes in the datasets if the goodness of prediction- or the accuracy of the estimates were impaired. Firstly, auto correlation is to a large extent removed using the Cochrane-Orcutt method. All though some of the model still shows traces of dependence in the residuals, I choose to leave this assumption valid and pay special care when discussing the statistical results. Both assumptions of normality and no multicollinearity are valid, confirmed by VIF, tolerance and the Ryan Joiner test. Lastly, the data sets seem to have equal variance in the residuals, although some of the coefficients showed non-equal variance in the Glejser`s test. As mentioned, I will pay special care to what statistical significance I ascribe these predictors in the analysis.

## 6. RESULTS AND PREDICTIONS

I will now review the different regressions- and associated predictions, and outline what the most important findings are. As mentioned in the research questions, I expect that two different directions of results will emerge. Firstly, it is natural to try to establish models that explain the variation in the 10-year yield in general in order to understand recent development. Secondly and most importantly, I want to establish which factors can explain the declining 10-year yields in the last years. These two challenges might yield very different results, but I have to see the entire picture before I can establish if MEP and Operation Twist have led to a decline in the yields. One should not, however, infer that the models used give a reliable prediction of the course of the 10-year yield had not MEP occurred.

This section will be structured as follows; I will first, quite thoroughly, discuss the regression- and associated predictions with the four variables representing fundamental conditions in the economy for MEP. Thereafter, I will argue why a few new variables could increase explanatory power and, how adding these to the model influence my findings. Following this, I will briefly review results I got from experimenting with the model. Thereafter, I will turn to Operation Twist, and use the same model-and variable tools as I did for the analysis of MEP. As mentioned previously, the analysis of Operation Twist will receive less attention. Finally, I will test the model on a different time series to see if there can be proof of structural changes in the term structure of interest rates that make the model less fit for all time series. This will highlight that models need to be renewed when the economy- and monetary policy changes.

### 6.1 THE MATURITY EXTENSION PROGRAM

#### 6.1.1 REGRESSION WITH FOUR FUNDAMENTAL VARIABLES

In the first regression I have used the four variables representing fundamental conditions in the American economy thoroughly discussed in section 4: the trade balance, inflation, PMI and the effective federal funds rate. The data sample is from February 2000 to December 2007.

$$10 - \text{year yield} = 0,999 + 0,000030 \text{ Trade} + 0,0877 \text{ Inflation} + 0,0354 \text{ PMI} + 0,235 \text{ Fed Fund}$$

Predictor	t-value	P –value
Constant	5,56	0,000
Trade	5,50	0,000
Inflation	1,76	0,082
PMI	3,13	0,002
Effective Fed Fund	6,53	0,000

### **Trade**

The coefficient for the variable Trade is positive, meaning that a unit change in Trade will increase the 10-year yield by 0,000030, holding the other independent variables constant. We can read from the table above that both the p-value and t-test confirm Trade as a variable significant at 1%-, 5%- and 10% levels in explaining variation in 10-year yield. These results need to be interpreted with caution since the variable trade was shown to be related to the variance in the residuals when tested for heteroscedasticity.

The positive sign of the coefficient implies that a positive trade balance increases the 10-year yield, while a trade deficit will give a negative influence on the 10-year yield. According to theory these results seem logical. Firstly, a trade balance surplus means that there are fewer claims on the U.S. to position in the American Treasury market. As outlined in bond theory, lower demand for bonds will lead to a fall in the bond price and this increases the corresponding yield. A trade deficit implies that other nations have proceeds or claims on the U.S that they can use to purchase American securities. Increased demand for bonds increases the price and reduces the yields. As discussed regarding the China effect, the trade deficit between China and USA has implicit made China the second largest holder of U.S Treasuries. A large negative trade deficit between the two countries, as is the case now, can therefore reduce the yields by leading to increased Chinese demand for Treasuries. Of course, the model does not incorporate Chinas net position in Treasuries alone. The model rather seems to illustrate that in general, trade surpluses have a positive effect on the 10-year Treasury yield, while trade deficits have a negative impact on the yield.

### **Inflation**

The coefficient preceding inflation is positive, indicating that a unit change in inflation will increase the 10-year Treasury yield with 0, 0877. However, viewing the t-test and p-value gives the conclusion that inflation is only significant when using a 10% significance level, meaning that there is less than a



10 % probability that the null hypothesis is true. Craine & Martin (2009) surprisingly also find in their study of the interest rate “conundrum” that CPI has no strong significant effect on six or longer-term forward rates. For this particular model there can be measurement-or specification errors, since inflation expectations in theory is a very important determinant for both decomposition of the longer-term interest rates, and as an influencer for demand- and supply in the bond market.

## **PMI**

The PMI coefficient is positive, again indicating that one unit increase in PMI, holding all the other variables constant, yields a 0,0354 increase in the 10-year Treasury yield. Both p-value and t-test signals a significant relationship between PMI-and the variation in the 10-year yield. These are according to theory plausible results. The level of the PMI index can indicate growth in the manufacturing sector- and GDP, i.e. its presence in this regression equation can be an indicator of real economic activity. As discussed in section 4.5, PMI levels over 40 can signal growth in GDP. We know from bond theory that an economic upturn can increase demand- and supply of bonds. Supply can increase because firms are willing to borrow more to finance a possibly profitable investment, and higher demand can occur because wealth increases. However, if interest rates decrease or increase following an economic expansion depends on which of the shifts in demand or supply is the largest. This model suggests, based on these data that the supply shift is the largest since an increase in the PMI increases the 10-year yield.

In addition, the PMI index is one of several information suppliers to the Federal Reserve in their monetary decision making. As noted in section 4.5, PMI levels over 52, 5 have been associated with rises in the federal funds target. A high PMI can therefore signal an upcoming heating of the economy, making it necessary to take action to control inflation. High levels of PMI in this data series can therefore have led to increases in the short-term interest rates which have thereafter transmitted to longer-term interest rates. If there is information about expected future levels of short-term interest rates in the term structure, this will be reflected in the longer-term yields.

## **Effective Federal Funds rate**

Of all the independent variables in this model the effective federal funds rate seem to be most significant in explaining variations in the 10-year yield, the t-test has a value of 6,35. The positive coefficient of 0,235 implies that a unit change in the effective fed fund gives a 0,235 increase in the

10-year yield. Again, this is a result one expects from theory. The federal funds target rate is a signal of the future course of the Fed's monetary policy, and therefore implies which interest rates levels to expect in the future. An expected increase in interest rate levels gives a negative shift in the demand for bonds as a result of lower expected returns (due to lower bond prices) in the future. This shift increases the yield. According to expectations theory, increased yields is also the result one should expect from higher short-term interest rates as longer-term rates can be interpreted as at least partly, an average of these.

The table below displays the variance characteristics from the regression. As previously mentioned, it does not give meaning to interpret the coefficient of determination ( $R^2$ ) without adjusting it to the number of independent variables. In the analysis I therefore regard adjusted  $R^2$  as the appropriate measure of the models explanatory power.

Analysis of Variance	Regression
R-Sq	41,8%
R-Sq(adj)	39,2%
F-ratio	16,15
P-value	0,000

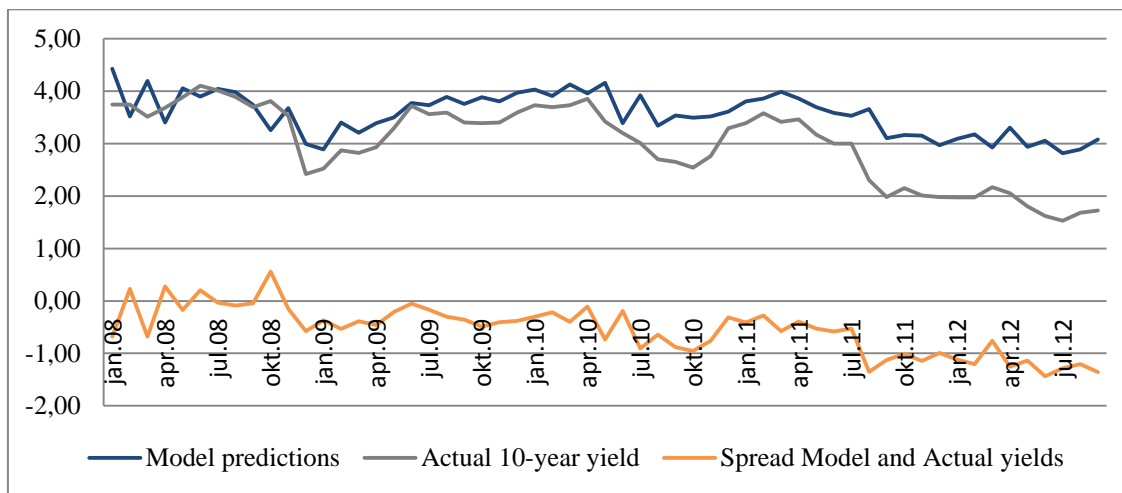
The adjusted  $R^2$  shows that the independent variables can explain 39, 2 % of the variation in the 10-year Treasury yield. This means that 60, 8% of movement in the dependent variable is due to omitted variables or simply "noise". Before I adjusted the data for autocorrelation, the adjusted coefficient of determination was as much as 80, 7%. This signals how much auto correlation can underestimate the true variance in the model. This regression seems to have moderate explanatory power and both t-tests and the F-ratio reject the null hypothesis that all coefficients are zero ( $\beta, \gamma, \delta, \theta = 0$ ). The variance statistics might be misleading, as least variance is not used to due to heteroscedasticity in trade.

### **Predicting the 10-year Treasury yield**

The equation used for predictions is adjusted for auto correlation as described in section 5.1. The sample data is from January 2008 to September 2012.

$$10 - \text{year yield} = 3,1415 + 0,000030 \text{ Trade} + 0,0877 \text{ Inflation} + 0,0354 \text{ PMI} + 0,235 \text{ Fed Fund} + 0,682\varepsilon_{t-1}$$

Figure 6-1 Predicting the 10-year yield with trade, PMI, inflation and the effective federal funds rate



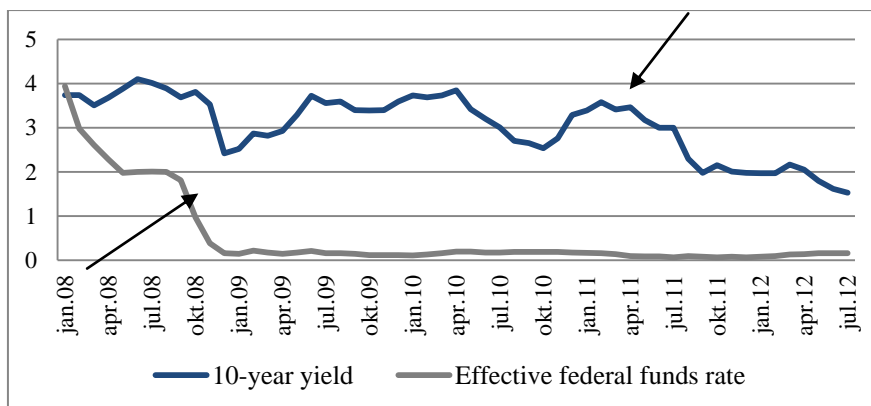
Firstly, we see from the figure 6-1 that the model in general predicts higher 10-year yields than seems to be the case; hence this model consistently misses characteristics that should keep the 10-year yield at lower levels. The model predicted yield does follow the movements of the actual yield, but the spread between the actual yield and the predicted model is almost consistently negative. We also see for September 2012 that the actual-and predicted 10-year yield starts increasing again (the actual 10-year yield increases from 1, 68% to 1, 72 %). The effective federal funds rate is declining from July 2012 to September 2012, but the PMI is marginally increasing and so is the monthly inflation rate. It could therefore be the case that the yields are increasing because of higher inflation expectations. We know from theory of asset demand that increased inflation expectations reduces the real rate of return, so the yield has to increase to compensate the holder of the bond.

The negative spread starts to increase mid-2011 and is especially high in August 2011, two months before the FOMC announced the first round of MEP of \$ 400 billion. The low yields in the last half of 2011 could also be influenced by the quantitative easing programs conducted by the Fed from 2008-2010. The negative spread peaks in June 2012, the same month the FOMC announces an extension of the MEP program for additional \$267 billion. Between August 2011 and June 2012 the spread stays large and negative, more so than in the rest of the prediction periods. This might be a coincidence, since the model consistently predicts higher interest rates in the periods analyzed. But, it is of interest that the spread is especially large from mid- 2011 since none of the independent variables seem to experience a reduction in the same relative magnitude. The effective federal funds target is essentially

ranging between 16 to 7 basis points already from December 2008 and the PMI index had its largest down-dip in the end of 2008 and beginning of 2009 and has essentially been lying over 50 since. The PMI has reached levels under 50 for June-, July and August 2012 which signals lower production in the manufacturing industry. But as an indicator for the entire economy, these levels usually signals a GDP growth of about 2, 25 % (ref. 4.5). The trade deficit has not significantly worsened in the last year, and inflation has seen an increase in the last months. In other words, the variables in the model does not warrant such a large decline in yield as is realized.

With the risk of sounding bold, the development in the 10-year yield can indicate that there is some component of preferred habitat- or segmented markets theory in the term structure, i.e. some traces of MEP? Since the effective federal funds rate is ranging between 0, 07 and 0, 16 percent between August 2011 and July 2012, a large part of the reduction in longer-yields can perhaps be explained by altered expectations about the future interest rate level.

Figure 6-2 The effective federal funds rate vs. the 10-year yield



Source: (Board of Governors of the Federal Reserve System, Selected interest rates (Daily)-H.15)

However, as the figure above displays, the federal funds target was essentially cut to zero in December 2008 without a significant- and continuous decline in the 10-year yield before August 2011. It was also explicitly communicated from the FOMC in March 2009 that the federal funds rate would stay “zero for an extended period”. Treasuries are not exactly characterized with high liquidity- and risk premiums either, so it cannot solely be a large decline in these premiums that are responsible for the current low levels all though “flight to quality” movements might indicate reductions in term premiums. In theory an increase in demand for bonds of a particular maturity will increase the price,

unless a bond with a different maturity is a perfect substitute. The evident decline in the 10-year yield has been large in the year the FOMC has conducted parts of their maturity extension program, which depends on the assumptions that there are investors who have a preferred habitat. Less elasticity in demand, as is the assumptions for preferred habitat theory, means that sufficient large shifts in demand will have a large impact on the yields in those markets, shifts in demand that the variables in this model cannot warrant.

For the entire prediction period the average spread deviation is about 59 basis points. It is also of interest to see how much the model misses of the development in the yields in the last year. A calculation of the average spread deviation from September 2011 to September 2012 gives about 116 basis points. In other words, the model is better at predicting yields in general, than it is in explaining movements in the 10-year yield in the last year. I therefore try expanding the model to see if there are other factors influencing the yields that better can explain the actual movements in the last year.

#### 6.1.2 EXPANDING THE MODEL

There were in particular two factors that I wanted to incorporate in the model that I thought could explain some of the reductions in the 10-year yield. The first factor in question is how inflow of foreign capital can affect the yields in the American Treasury market. As previously mentioned, the “bond yield conundrum” describes the unusual behavior of longer-term interest rates from 2004 to 2007. The conundrum is said to be explained by international capital inflow to the U.S. The “global saving glut”, as named by Bernanke (2005), can be said to be evidence that demand pressuring factors have effect on the American Treasury yields. Secondly, the China effect might not be fully reflected in the trade balance, since this variable only showed international trade in goods and services. Since I wanted the model to pick up increased demand for Treasuries as a result of this “China effect”, some alterations could be made to include a variable that more explicitly describes this relationship. Since the share of foreign holdings of U.S Treasuries has doubled in the last couple of years, foreign inflow of capital seems like an appropriate variable to include when trying to predict the 10-year yield in the last year.

The second factor I wanted to include in the model was “flight to quality”. This phenomenon could also represent an inflow of foreign capital to the U.S, especially in times of global financial instability. As previously discussed, there is often a risk-or term premium connected to longer-term securities in

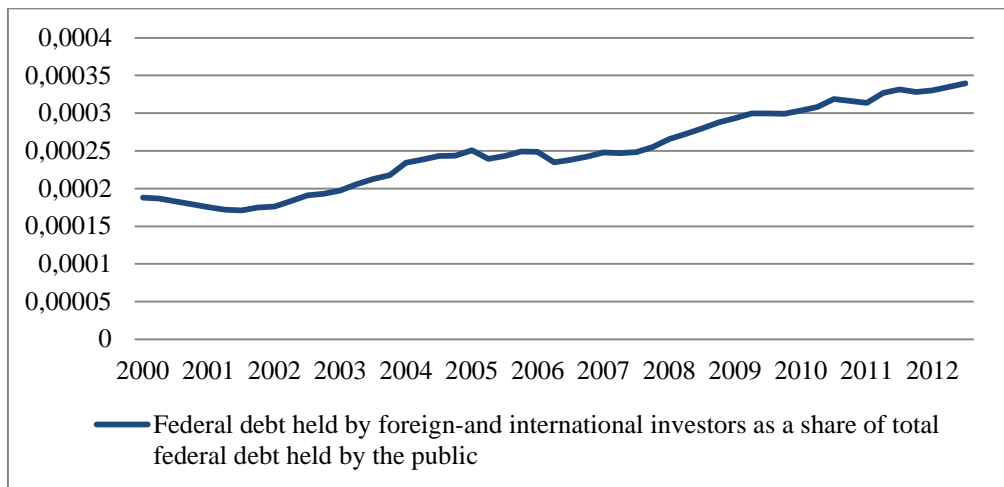
the market. In some cases this risk-or term premium can be negative, indicating that a sufficient large “flight to quality” behavior from economic agents towards a specific market can reduce the yields in those markets. The investors will in pay to avoid risk and this dominate the goal of return- and to beat inflation (Kenny, 2012a). The “safe havens”, where the probability of loss of principal is lowest, is often in government papers of large industrialized countries like the U.S. Treasury market (Kenny, 2012a). While government bond yields in Spain and Italy has increased the last couple of years, the yields for American-and German government bonds have seen a large decline (DNB Økonomiske utsikter, 2012). German-and American government bonds are practically considered default free.

In recent years the European markets have been characterized by debt-crisis and uncertainty. This has affected the overall financial market performance in the world. Daily flows of information from the European markets have been an important determinant for bond market performance in the U.S in the second half of 2011 (Kenny, 2012c). Investors have been worried with what “worst-case-scenarios”, like the collapse of the euro or the default of PIIGS countries, could mean for their investments. The result has been sell-offs in stocks or higher-risk investments towards a higher demand for U.S government securities where investors are more protected from global turmoil. These portfolio adjustments have resulted in higher prices and lower yields for U.S Treasuries (Kenny, 2012a). DNB Økonomiske utsikter (2012) actually describe the U.S Treasury market as a possible “bond bobble” that could burst when the fiscal situation in Europe recovers and when the FOMC terminates the MEP- and other large-scale asset purchase programs. Based on the characteristics- and consequences of “flight to quality” movements, it seems appropriate to include a variable representing this when viewing the development in the 10-year yield in the last year.

### **Federal debt held by foreign and international investors**

“Flight to quality” and the inflow of foreign capital to the U.S could both reduce the 10-year yield. A “flight to quality” from the Euro-zone and a possible “global savings glut” entails an inflow of foreign capital to the U.S. At the same time, the “China effect” is not a “flight to quality”, but rather an effect of the large trade deficit between the U.S and China. In trying to gather some of these effects into one variable, I decided to use the variable Federal debt held by foreign-and international investors. As figure 6-3 displays, since the onset of the financial crisis, the amount of federal debt held by foreign-and international investors as a share of total federal debt held by the public has seen a large increase.

Figure 6-3 Federal debt held by foreign-and international investors as a share of total federal debt



Source: (FRED, Data: Federal debt held by foreign-and international investors (FDHBFIN, Federal Debt: Total federal debt (GFDEBTN))

### St. Louis Financial stress index

I also wanted to catch if there was any “flight to quality” in the American financial markets that had been significant enough to influence the 10-year Treasury yield in the last year, a “flight to quality” that is not necessarily represented as foreign inflow of capital. The St. Louis Financial stress index is a measure of financial stress and released weekly by the Federal Reserve Bank of St. Louis. The index is constructed by using principal components analysis, in which one extract factors responsible for the co movement of a group of variables. In this index the factor responsible for the co movement of variables is financial stress (Federal Reserve Bank of St. Louis, 2010). Each variables movement in the data series can therefore reflect some form of financial stress, and all the variables seem to move together when the level of financial stress in the economy changes.

The St. Louis Financial stress index is constructed using 18 weekly data series over the sample period December 31, 1993 to December 11, 2009 (Federal Reserve Bank of St. Louis, 2010).The data series are divided into three main groups of variables; interest rates, yield spreads and “other” indicators. Both government-and corporate bonds yield spreads-and interest rates are included as well as indicators like the Chicago Board Options Exchange Market Volatility Index (VIX) and Merrill Lynch Bond Market Volatility Index (Federal Reserve Bank of St. Louis, 2010). A high index will therefore signal that the spread between safer- and less safe investments have increased. We know from asset demand theory that when risk on one asset relative to other assets increase, the demand for this asset

declines. Demand is rather shifted to assets with lower risk, and holders of riskier assets wishes to be compensated; hence these movements' increases the spread between yields on assets with different risk profiles. It follows that a high index can indicate increased demand for safer assets and therefore reduced Treasury yields.

Figure 6-4 The St. Louis Financial Stress index



Source: (FRED, Data: St. Louis Financial stress index (STLFSI))

Figure 6-4 shows that financial stress, as measured with this index, was especially high around September 2008 and during the eruptions of the European credit markets in 2010. Now the index is in fact negative indicating that there is less stress in the financial markets. If this in is reality lower stress or the fact that investors accept a more persistent problem, primarily the ongoing Euro fiscal problems and a slow growing American economy, is uncertain. Regardless, the index seems to be an appropriate measure for an eventual “flight to quality” towards U.S Treasuries.

#### 6.1.2.1 REGRESSION WITH THE ST. LOUIS FINANCIAL STRESS INDEX

The St. Louis Financial stress index data (STLFSI) is gathered from FRED from January 2000 to September 2012 and the level of the index is used. The data is not seasonally adjusted and a monthly average is used since the index is published weekly. A remark with this model is that I could not disregard auto correlation as both DW values and Pearson correlation showed that the problem was still, in a smaller extent, present. However, the estimated parameters can still be unbiased so test the model for prediction purposes. The modified regression equation shows the following relationship between the variables:



$$10 - \text{year yield} = 1,36 + 0,000036 \text{ Trade} + 0,106 \text{ Inflation} + 0,0227 \text{ PMI} + 0,194 \text{ Fed fund} \\ - 0,300 \text{ Financial stress index}$$

Predictor	t-value	P -value
Constant	6,44	0,000
Trade	6,61	0,000
Inflation	2,19	0,031
PMI	1,95	0,055
Effective Fed Fund	5,16	0,000
Financial stress index	-3,00	0,004

Inflation is now significant on a 5-and 10% significance level; i.e. this model gives inflation a significant role in explaining variance in the 10-year yield. A higher inflation makes nominal securities less desirable to hold and consequently bond holders wish to be compensated for the reduction in the real rate. This reduces demand for bonds and increases the yields. PMI, on the other hand, seems to have become less significant at a 1-and 5 % significance level. The new variable St. Louis financial stress index has a negative coefficient of -0,300 meaning that when financial stress increases, as a co movement of the variables included in the calculation of the index, the 10-year yield reduces. From what one knows from “flight to quality” characteristics, this reduction can be explained by increased demand for “safe” Treasuries investments when volatility and uncertainty regarding return on other assets increase.

Analysis of Variance	Regression
R-Sq	48,7%
R-Sq(adj)	45,8%
F-ratio	16,88
P-value	0,000

Analysis of variance shows that the models explanatory power has increased with about 7 % when including St. Louis Financial stress index in the model. The F-test confirms that one can reject the null hypothesis that all coefficients are zero. These results must be interpreted with caution since least variance is not valid due to autocorrelation.

## Predictions including the St. Louis Financial stress index

When predicting the 10-year yield I used the following adjusted equation, and data from January 2008-September 2012:

$$10 - \text{year yield} = 4,13 + 0,000036 \text{ Trade} + 0,106 \text{ Inflation} + 0,0227 \text{ PMI} + 0,194 \text{ Fed fund} \\ - 0,300 \text{ Stress index} + 0,671 \varepsilon_{t-1}$$

Figure 6-5 Predicting the 10-year with trade, PMI, inflation, the effective federal funds rate and the St.Louis financial stress index

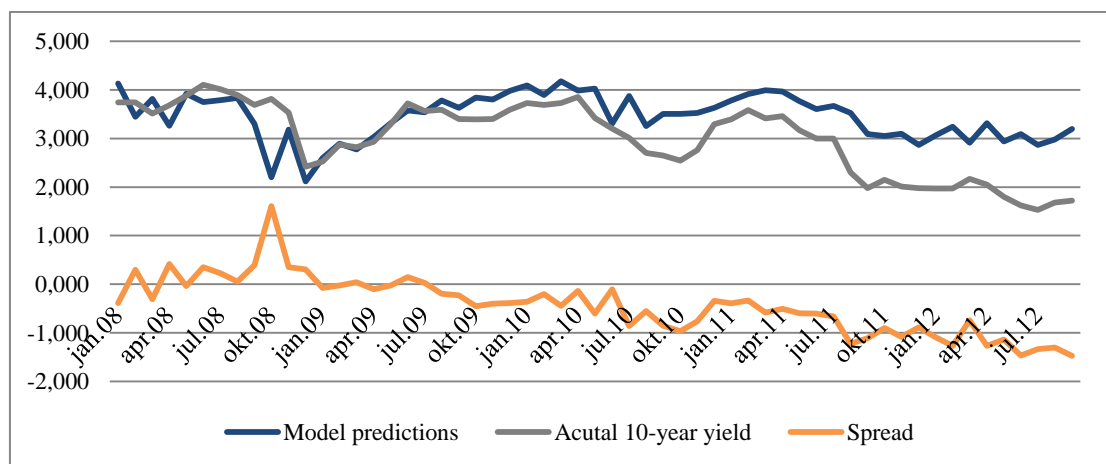
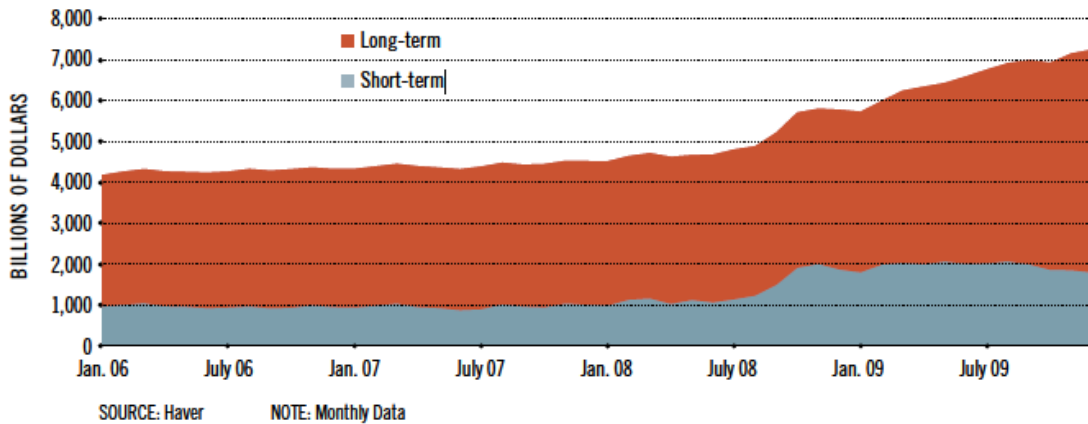


Figure 6-5 displays much of the same movements in the predicted interest rate as was the case when St. Louis financial stress index was not included. The average spread deviation in the entire prediction period is about 58 basis points and for September 2011 to September 2012 about 116 basis points, hence very close to the previous regression. The movement of the predicted 10-year yield is though a little bit different from the first regression.

In general, this model also predicts higher interest rates than seem to be case, but there are longer periods where the model now predicts lower yields than the actual yield. This is noticeable from approximately May 2008 to January 2009, where the highest positive spread (160bps) is in October 2008. It is plausible to say that the financial crisis officially started after the Lehman Brothers collapse in September 2008. Around this period the model cannot pick up some factors that increase the 10-year yields. One possible explanation can be that poor liquidity reduced the demand for U.S Treasuries. Many of the American financial institutions that had large holdings in Treasuries were the

ones hardest hit by a “liquidity squeeze” in the financial crisis. As was mentioned in section 2.2.9.1 regarding owners of U.S Treasuries, mutual funds-, depository institutions- and state- and local governments holdings of Treasuries were severely reduced during the financial crisis. As we know from asset demand theory, poor liquidity in the market reduces the demand and one can see an increase in the yields. Even though Treasuries under normal circumstances are not characterized with risk-and liquidity premiums, it can be the case that the increases in 10-year yields at this point in 2008 were also driven by investors’ demands for compensation for holding investments at all. The inclusion of St. Louis Financial stress index actually gave a higher spread between model and actual yield in October 2008 than was the case when it was not included. The index increased by 436 % in the period May 2008 to January 2009, indicating that there was a high level of financial stress in the economy, and this reduced the model predicted yield. A counterforce for reduced demand could be that the supply of Treasuries increased as the Fed had large financing needs for their rescue packages to credit- and financial institutions all over the U.S. Increased supply of Treasuries could have kept the actual 10-year yield over the level of the predicted yield, since supply of bonds is not a factor in the model. As figure 6-6 displays, the supply of Treasuries increased from roughly \$5,000 billion in mid-2008 to \$7,000 billion in a year.

Figure 6-6 Levels of Treasuries outstanding



Source: (Noeth & Sengupta, 2010)

The highest negative spread in this model is actually in September 2012. The model here predicts a 10-year yield 150 basis points higher than the actual yield. As noted above regarding the average spread deviation; including the St. Louis financial stress index does not seem to be able to explain the decline in the recent year more than the former model could.

### 6.1.2.2 REGRESSION WITH FEDERAL DEBT HELD BY FOREIGN-AND INTERNATIONAL INVESTORS

As was the case over, I did not manage to remove all auto correlation with the Cochrane-Orcutt method for this regression. There is therefore a chance that the residuals are not totally independent of each other in this model, hence; statistical inference about probabilities needs to be done with caution. The data for the variable federal debt held by foreign-and international investors (FDHBFIN) is gathered from FRED and is published each quarter. To include observations for each month I smoothed the data series by letting each quarterly published value be applicable for the two following months. That is the value for January 2000 is also applicable for February and March as well, before a new value is published in April who is applicable for May and June. The data is in billions of dollars and is published by the U.S department of Treasury.

$$10 - \text{year yield} = 1,06 + 0,000024 \text{ Trade} + 0,0742 \text{ Inflation} + 0,0373 \text{ PMI} + 0,244 \text{ Fed fund} \\ - 0,000210 \text{ Federal deb}$$

Predictor	t-value	P -value
Constant	5,55	0,000
Trade	2,83	0,006
Inflation	1,45	0,151
PMI	3,33	0,001
Effective Fed Fund	6,84	0,000
Federal debt	-0,90	0,371

The coefficient for federal debt held by foreign-and international investors is negative, meaning that when foreigners increase their holdings in U. S. Treasuries the 10-year yield should decline. This is also what to expect in the light of events like the bond yield “conundrum”, the “global savings glut”, “flight to quality” movements and the effects of a large trade deficit with China. But this variable has both insignificant t-and p-values, indicating that there is no meaningful relationship between this variable and the variation in the 10-year yield. This can be a result of multicollinearity. Even though the VIF and tolerance level disregarded this, the two variables might bring the same information to the model. A typical consequence of multicollinearity is that the regression can signal an insignificant relationship between variables that in fact have a significant relationship. My thoughts on multicollinearity steam from the fact that when doing a regression without trade the variable federal

debt held by foreign-and international investors becomes significant. However, if one trusts that the estimates are still unbiased one can use the model for prediction purposes.

The relationship between these five variables explain 42,3 % of the variation in the 10-year yield. In other words, the models explanatory powers can be said to be moderate and ranging within the same interval as the previous regressions (40-50%). The F-ratio signals that we can reject that all coefficients are zero. These measures might be however misleading since the model is not BLUE.

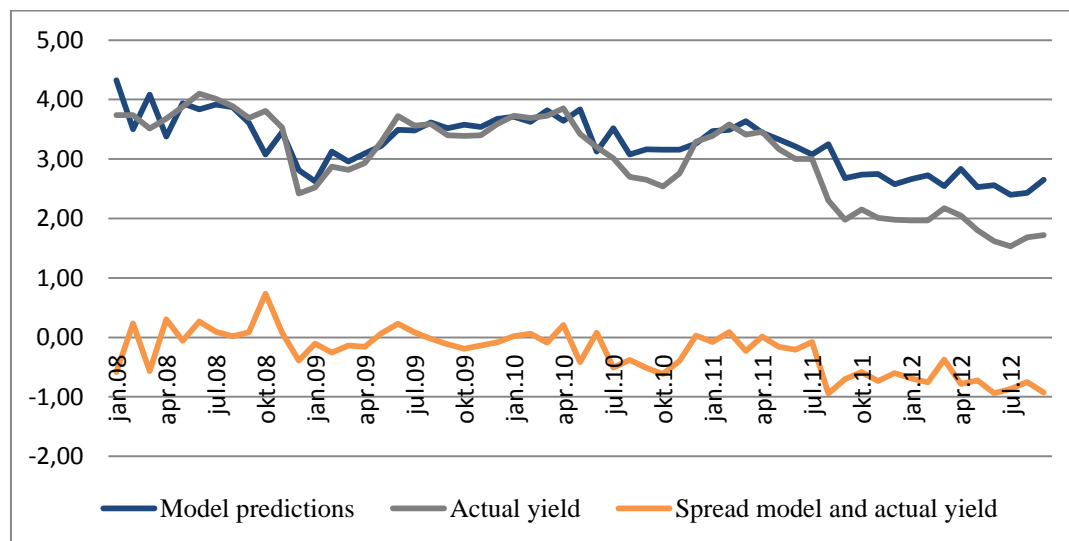
Analysis of Variance	Regression
R-Sq	45,4 %
R-Sq(adj)	42,3 %
F-ratio	14,78
P-value	0,000

### Predicting the 10-year yield

The next step is to see how the model explains the development of the 10-year yield from January 2008 to September 2012:

$$10 - year\ yield = 3,14 + 0,000024\ Trade + 0,0742\ Inflation + 0,0373\ PMI + 0,244\ Fed\ fund \\ - 0,000210\ Federal\ deb + 0,662\ \varepsilon_{t-1}$$

Figure 6-7 Predicting the 10-year yield with trade, inflation, PMI, the effective federal funds rate and federal debt held by foreign-and international investors



Including federal debt held by foreign-and international investors has clearly improved the models predictive abilities. The average spread deviation in the entire prediction period is now reduced to about 34 basis points. One can see from this figure that the predicted yield follow the movements of the actual yield in the entire prediction period with a much lower spread than the other models could manage. It is therefore plausible to suggest that for this period (2008-2012) foreign inflow of capital to treasuries has been an important determinant for the development in 10-year yields.

What is even more interesting is that by including this variable in the model the spread between model predicted yield and model yield in August 2012 is now narrowed down to - 75 basis points, whereas the previous models gave a spread of -122 basis points (section 6.1.1) and -132 basis points (section 6.1.2.1).The average spread deviation from September 2011 and September 2012 is now reduced to about 72 basis points. Hence, foreign inflow of capital could also be a determinant for the development in 10-year Treasury yields in the last couple of years. Studies mentioned in section 2.1.2.6, confirms this conclusion (Keinzler (2012), Craine & Martin (2009), Beltran et al (2012)). All though one might be closer in finding a model that can explain much of the variation in the 10-year yield from 2008-2012, I still want to experiment more to see if I can reduce the average spread deviation in the last year.

### 6.1.2.3 MODEL WITH BOTH THE ST. LOUIS FINANCIAL STRESS INDEX AND FEDERAL DEBT HELD BY FOREIGN AND INTERNATIONAL INVESTORS

I wanted to see how the model predicted the 10-year yield when both the St. Louis Financial stress index and federal debt held by foreign-and international investors were incorporated in the model. This way one could model how “flight to quality” both international- and domestic- and foreign inflow of capital combined predicted the 10-year yields.

$$10 - \text{year yield} = 1,40 + 0,000028\text{Trade} + 0,0914\text{Inflation} + 0,0232 \text{PMI} + 0,197\text{Fed fund} \\ - 0,000287\text{Federal debt} - 0,314 \text{St. Louis Financial stress index}$$

Predictor	t-value	P –value
Constant	6,58	0,000
Trade	3,45	0,001
Inflation	1,86	0,067
PMI	2,00	0,048
Effective Fed Fund	5,28	0,000
Federal debt	-1,27	0,206
St. Louis index	-3,14	0,002

As one can assess from the table displaying the significance of the coefficients; inflation and federal debt held by foreign-and international investors are not significant in explaining variation in the 10-year Treasury yield in this model. I contribute some of this to multicollinearity between trade and federal debt held by foreign-and international investors as mentioned above, and that I not have managed to remove all auto correlation.

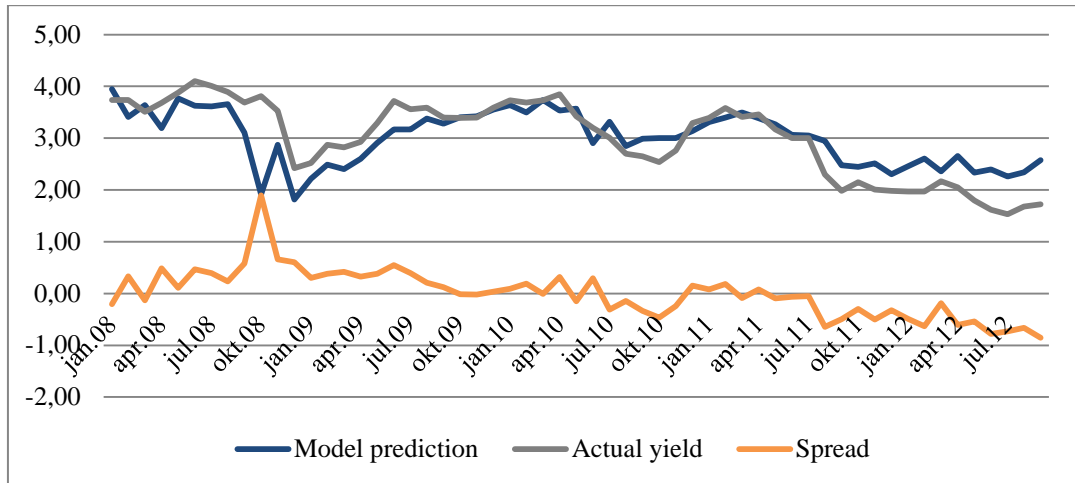
Analysis of Variance	Regression
R-Sq	49,9%
R-Sq(adj)	46,5%
F-ratio	14,60
P-value	0,000

In comparison with the two previous regressions which separated the effect from these two variables, the adjusted coefficient of determination has increased marginally from 42, 3 %- and 45, 8 % to 46, 5 %. However, this measure of explanatory power might be misleading when the assumptions above are violated.

### **Predictions of the 10-year yield**

$$10 - \text{year yield} = 4,23 + 0,000028\text{Trade} + 0,0914\text{Inflation} + 0,0232 \text{ PMI} + 0,197\text{Fed fund} \\ - 0,000287\text{Federal debt} - 0,314 \text{ St. Louis Financial stress index} + 0,669\epsilon_{t-1}$$

Figure 6-8 Predicting the 10-year yield with trade, inflation, PMI, the effective federal funds rate, St. Louis financial stress index and federal debt held by foreign-and international investors



By viewing figure 6-8 it seems like the general prediction abilities have remained roughly the same when including both these two variables in the model. This is also confirmed when calculating the average deviation spread in the prediction period; it is lower (35,7bps) than the regression with only the St. Louis Financial Stress index (57,9bps) but higher than the regression that only included federal debt held by foreign-and international investors (34,3bps). However, the average spread deviation from September 2011 to September 2012 is about 55bps, i.e. this model seems to be better at explaining last year's movements in the 10-year Treasury yield. The model combining the effects of foreign inflow of capital- and "flight to quality" seems to have stronger predictive powers in explaining variation in the 10-year yield in the last year than the two models separating these effects.

### 6.1.3 EXPERIMENTING WITH THE MODEL

Because of possible multicollinearity between trade- and federal debt held by foreign-and international investors, I wanted to see how the model developed without trade as a variable. In addition, inflation proved to be variable that showed different levels of significance. I therefore used a model incorporating approximate inflation expectations instead of the monthly inflation rate. According to bond theory, inflation expectations are the factors that really matters for financing-and investment decisions. A brief review of only the prediction results from these analyses can be interesting. These models are also adjusted for auto correlation by the Cochrane-Orcutt method, and the remaining assumptions are also investigated but conferred less concern. As mentioned in section 6.1.2.2, when



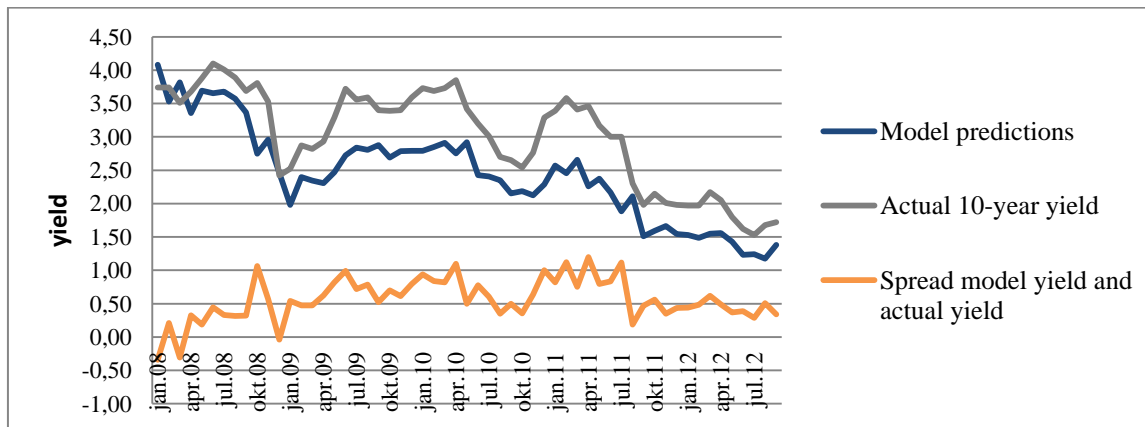
removing trade from the model, federal debt held by foreign-and international investors becomes significant.

### 6.1.3.1 MODEL SUBSTITUTING TRADE WITH FEDERAL DEBT HELD BY FOREIGN- AND INTERNATIONAL INVESTORS

This model consists of the trade balance, PMI, inflation, the effective federal funds rate and federal debt held by foreign-and international investors.

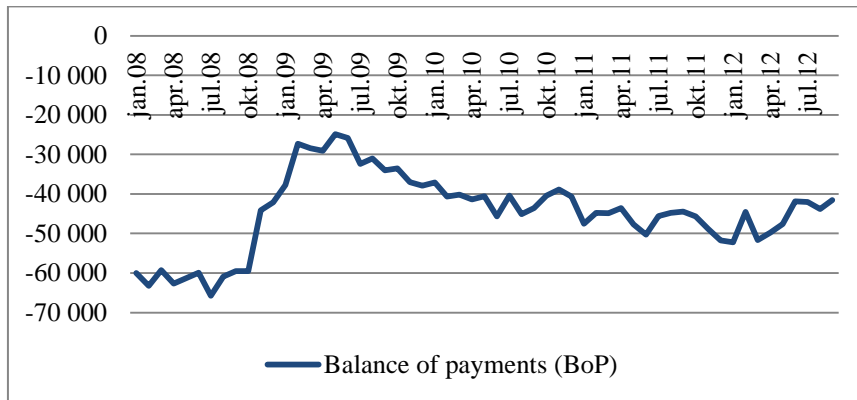
$$10 - \text{year yield} = 3,296 + 0,0173 \text{ Inflation} + 0,0320 \text{ PMI} + 0,248 \text{ Fed fund} - 0,000749 \text{ Federal deb} + 0,645 \varepsilon_{t-1}$$

Figure 6-9 Predicting the 10-year yield with inflation, PMI, the effective federal funds rate and federal debt held by foreign-and international investors



When viewing the entire prediction period, the model seems to be a poorer fit in terms of prediction accuracy. However, the average spread deviation is roughly the same as the regression representing fundamental conditions in the economy in section 6.1.1 (about 59bps). Regardless of this, the model consistently predicts lower yields than the actual 10-year yield. So the question becomes; what does the trade variable incorporate in the model that federal debt held by foreign-and international investors does not? When viewing the development in balance of payments one can perhaps see why.

Figure 6-10 Balance of payments (BoP) 2008-2012



Source: (United States Census Bureau)

Approximately when the model starts predicting lower 10-year yields than actual yields the balance of payments improves (July 2008 to January 2009). An improved trade balance should in theory increase the yields if U.S trading partners have fewer proceeds to position in Treasuries. Since this model excludes the balance of payment, it cannot pick up the decreased demand for Treasuries and therefore the increase in 10-year yield as the balance of payment improves. Federal debt held by foreign-and international investors should perhaps have picked up this reduced demand for Treasuries, but this variable can still be large, i.e. reducing the yields, for other reasons like “flight to quality” or a “global savings glut”. Federal debt held by foreign-and international investors actually increased from the third quarter of 2008 to the first quarter of 2009 by about 16%, signaling that the yields should decrease. In comparison, the balance of payments improved by reducing the deficit by about 43% in the same period. For the remaining prediction period the trade deficit increases again, which would have induced reduced yields in the model. One can therefore from this observation infer that trade could be very important in explaining 10-year yields for the time period investigated.

It is safe to conclude that this model did not prove to be a better model in predicting yields for the entire period analyzed. However, the predictions in the last year narrow the spread between the actual yield and the predicted yield. The average spread deviation from September 2011 to September 2012 is only 44 basis points. For July 2012 the spread is positive 29 basis points, i.e. the model predicts that the 10-year yields should have been lower than is the case. In difference from the previous models, there are no large negative spreads in or between August 2011 and now. In other words this model suggests that the variables used warrants lower yields than is the case. Could it be the case that the

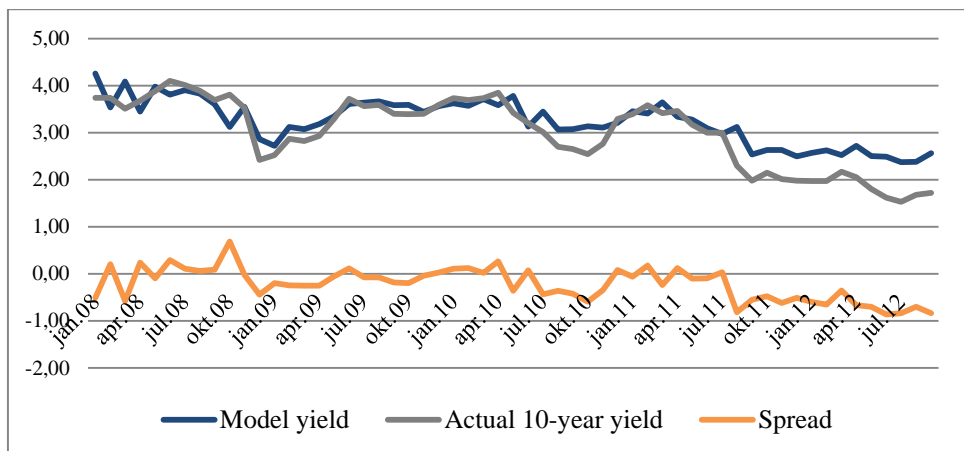
foreign demand for Treasuries has been so high that if the FOMC had not reduced the amount of Treasuries available for the public, the yields would have been even lower?

### 6.1.3.2 MODEL USING APPROXIMATE INFLATION EXPECTATIONS AS A VARIABLE IN THE MODEL

The University of Michigan publishes their measurements of inflation expectations as a median expected price change for the next 12 months, calculated from consumer surveys. This variable is collected from the FRED data base (MICH). I also chose to include federal debt held by foreign-and international investors in the model since this variable showed to be important for the variation in the 10-year yield in recent years.

$$10 - \text{year yield} = 3,13 - 0,000255 \text{ Federal debt} + 0,000021 \text{ Trade} + 0,0767 \text{ InflationEX} + 0,0321 \text{ PMI} \\ + 0,245 \text{ Fed fund} + 0,671 \varepsilon_{t-1}$$

Figure 6-11 Predicting the 10-year yield with the trade balance, inflation expectations, PMI, the effective federal funds rate and federal debt held by foreign-and international investors



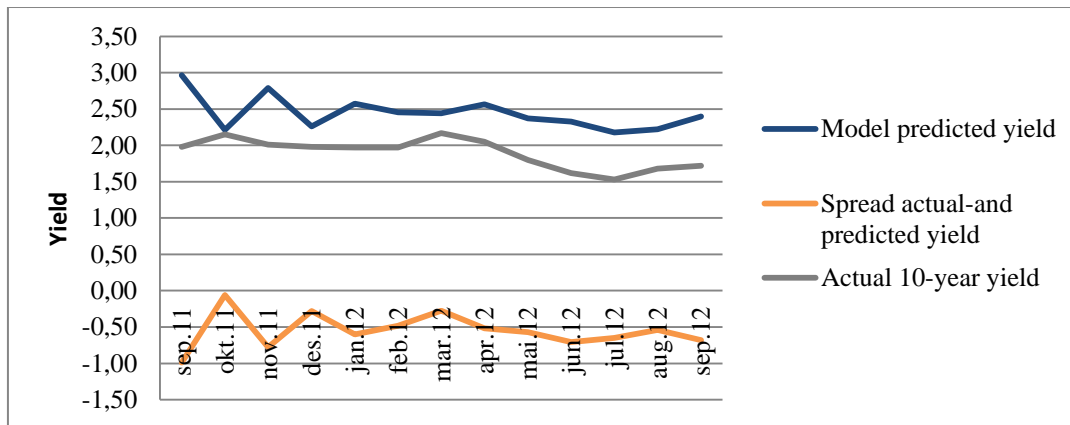
Using approximate inflation expectations does seem to improve the models predictive abilities. The average spread deviation for the entire prediction period is 32 basis points, which is the lowest spread compared to the other models. However, the average spread deviation from September 2011 to September 2012 is about 65 basis points; hence this model cannot explain more on the last years` development than the other models with similar variables could. As a general model however, these five variables seem suitable in explaining variation in the 10-year yield between 2008 and 2012.

#### 6.1.4 EXTENDING ESTIMATION-AND PREDICTION PERIOD

A weakness with the previous models analyzed in is that due to the estimation-and prediction period, I might have incorporated possible effects of other large-scale-asset purchase programs conducted by the Fed from 2008 to 2010. As a concluding remark for the MEP analysis I will therefore discuss results when expanding the estimation-and prediction period for the model that showed best accuracy in explaining the reduction in the 10-year yield in the last year. This is the model including both the St. Louis financial stress index and federal debt held by foreign-and international investors along with the four variables representing fundamental conditions in the economy. The estimation period now extended from February 2000 to August 2011, and the prediction period September 2011 to September 2012. This model is also adjusted according to Cochrane-Orcutt method but the rest of the assumptions to achieve BLUE results are conferred less concern.

$$10 - \text{year yield} = 3,78 + 0,000016\text{Trade} + 0,0617\text{Inflation} + 0,0245\text{PMI} + 0,209\text{Fed fund} \\ - 0,000327 \text{ Federal debt} - 0,0452\text{St. Louis stress index} + 0,669\varepsilon_{t-1}$$

Figure 6-12 Extending the estimation-and prediction period



The first interesting result with this model was that the coefficient of determination increased to about 58 % when only modeling last year's 10-year yield. That confirms that the variables used are more suited to explain variation in the 10-year yield in the last year, more so than in general. The average spread deviation is approximately the same as in section 6.1.2.3, namely 54, 8 bps. As the figure displays, the model cannot catch the entire decline in the 10-year yield in the last year, and for this model it cannot be the quantitative easing programs that is solely responsible for the decline, as they

were completed in 2010. Including the financial crisis-and quantitative easing years in the estimation period did not significantly change the prediction results.

### 6.1.5 CONCLUSION

As mentioned initially, the results from the analysis of MEP have lead one in two different directions. Some of the models give on average good prediction accuracy but cannot seem to explain last year's development. Other regressions seem to be better suited to explain last year's movement in the 10-year yield, but not general variations in the yield over the time period analyzed. I therefore review which variables that stood out as the most significant throughout the analysis and which regressions gave the most accurate predictions.

Table 6-1 The variables significance in the analysis of MEP

Trade	Inflation	PMI	Fed fund	St. Louis	Federal debt	Inflation expectations.
√	0,082	√	√	-	-	-
√	√	0,055	√	√	-	-
√	0,151	√	√	-	0,371	-
√	0,067	√	√	√	0,206	-
-	0,726	√	√	-	√	-
0,010	-	√	√	-	0,270	0,223

\*√ Signals that the coefficient was significant at a 5% significance level

- Signals that the variable was not included in the regression

The effective federal funds rate is clearly the variable that consistently throughout the analysis proofs to be significant in explaining variation in the 10-year yield. This is not surprising result, as the federal funds target explicitly communicates the course of the monetary policy to the market participants and therefore the future short-term interest rate level. Basis calculations in expectations-, liquidity-premium-and bond theory all regard expectations as essential for the development of longer-term interest rates. The second overall most significant variable is the PMI index. Bond theory can explain this by attributing changes in supply-and demand to economic expansions; certain levels of PMI can signal GDP growth. Federal debt held by foreign-.and international investors is not significant when regressed with the trade, but highly significant when trade is removed and seem to improve the models predicting abilities as well. Trade on the other hand is strongly significant in the regressions, but has

lower prediction abilities than federal debt held by foreign-and international investors. Another point of interest is that the St. Louis Financial stress has proved to be significant in both regressions where it was used as a variable.

Table 6-2 Average spread deviations in the analysis of MEP

Model used	Av. spread deviation	Av. spread deviation Sep. 2011-Sep. 2012
Section.6.1.1	59,48 bps	116bps
Section.6.1.2.1	57,9bps	116bps
Section. 6.1.2.2.	34,3bps	72bps
Section. 6.1.2.3	35,7bps	<b>54,6bps</b>
Section 6.1.3.1	58,8bps	44bps
Section 6.1.3.2	<b>32bps</b>	65bps

The regression equation that yields the lowest average spread deviation (32bps) for the entire prediction period is the regression with inflation expectations, trade, PMI, effective federal funds rate and federal debt held by foreign-and international investors as independent variables. This highlights that it might not be the current inflation itself that affect the treasury yields, but the future expectations regarding inflation- and its effect on the real rate of return. In addition, this model suggest that the combination of trade and federal debt held by foreign-and international investors can account for variation in the 10-year yield.

The regression that seems to explain most of last year`s development in the 10-year yields is the regression using federal debt held by foreign-and international investors, inflation, PMI and effective federal funds rate as independent variables. This model suggests that the 10-year yield should be, on average, 44 basis points lower than realized. The regression in second place includes both the St. Louis Financial stress index and federal debt held by foreign-and international investors, with an average spread deviation of about 55 basis points. The common feature between the regression that yields good prediction abilities overall and in the last year is the inclusion of federal debt held by foreign-and international investors. In addition, the inclusion of St. Louis financial stress index has contributed to this increased prediction accuracy. This result highlight that a combination of foreign inflow of capital- as, well as both domestic-and international financial stress, could be important when explaining last years` variation in the 10-year yield. However, there is still on average a 55 basis points spread

between the model-predicted yield and the actual yield that the variables cannot explain. In other words, there has to be some omitted variable, demand pressuring effects-or economic factor that has brought the 10-year yield to its current low level.

## 6.2 OPERATION TWIST

### 6.2.1 REGRESSION WITH FOUR VARIABLES REPRESENTING FUNDAMENTAL CONDITIONS

When analyzing Operation Twist in 1961, data collection gave me a bit of a challenge. I initially wanted to use the same four variables, described for MEP, as representatives for fundamental conditions in the economy. However, lack of sorted data on international trade made this difficult. As a solution I decided to use U.S. marketable public debt; the share of the marketable Federal debt held by the public. Since Operation Twist essentially relies on the assumption that a reduction in the public's holdings of Treasuries can stimulate the economy through the portfolio rebalancing channel, this variable could be used to investigate if there is a significant relationship between amount of public debt and the 10-year Treasury yield in the 60`s. Data for this variable is gathered from the Federal Reserve Bulletin published December 1954 to January 1965 on a monthly basis in millions of dollars (See FRASER, Federal Reserve Bulletin). Data from July 1954 to December 1964 is used. The remaining variables are gathered from the same sources as discussed in section 4. Because of auto correlation adjustments the sample in the regression is lagged one period, i.e. from August 1954 to December 1959.

$$10 - \text{year yield} = -1,04 + 0,0274 \text{ Public held debt} + 0,121 \text{ Inflation} + 0,0137 \text{ PMI} + 0,314 \text{ Fed fund}$$

Predictor	t-value	P -value
Constant	-3,58	0,001
Public held debt	5,38	0,000
Inflation	2,82	0,006
PMI	2,25	0,028
Effective Fed Fund	5,83	0,000

As I have given a fairly thoroughly review of the independent variables when discussing MEP, I will limit myself to discussing the how results differ from the first regression conducted (Section: 6.1.1).

Firstly, inflation is now significant in explaining variance in the 10-year yield. Both t- and p-values assures of this. A unit increase in inflation will, according to this model, increase the 10-year yield with 0,121. Secondly, the variable marketable public debt is significant. The positive coefficient of 0,0274 signals that a unit increase in public held marketable federal debt increases the 10-year yield. According to this model, the amount of Treasuries held by the public is positively connected to the 10-year yield so when this size reduces the 10-year yield will increase less, as is the intended effect of Operation Twist. The connection could also be that the amount of public held debt increases when the Treasury auctions new debt, increased supply should in theory increase the yields.

Analyze of variance	Regression
R <sup>2</sup>	68,7%
R (adj)	66,6 %
F-value	32,86
P-value	0,000

Analysis of variance shows a significant larger coefficient of determination than was the case for the first regression analyzing MEP. This model can explain 66, 6 % of the variance in the 10-year yield from the time series analyzed. A possible explanation for this increase in explanatory power can be due to inflation and its alleged significance in this model as suppose to regressions analyzing MEP. Secondly, because it can be plausible to say that the financial markets in the 60`s were smaller and less complex, therefore it is possible that there is less “noise” in the variation. The F-value and corresponding p-value assures that at least one of the independent variables has explanatory power. These variance measures can be misleading, as the Glesjer`s test in this model showed traces of heteroscedasticity for the PMI index.

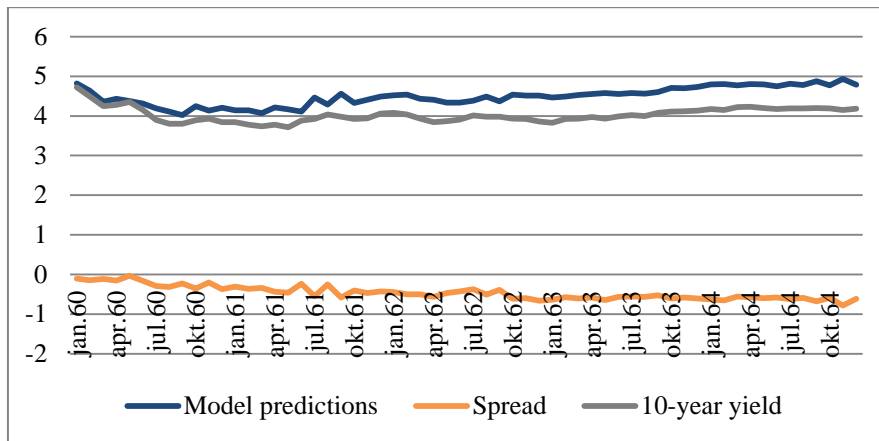
### **Prediction of the 10-year yield**

The equation used in predictions is modified according to Cochrane-Orcutt method, and the prediction period is January 1960 to December 1964:

$$10 - \text{year yield} = -2,826 + 0,0274 \text{ Public held debt} + 0,121 \text{ Inflation} + 0,0137\text{PMI} + 0,314 \text{ Fed fund} \\ + 0,632\varepsilon_{t-1}$$



Figure 6-13 Predicting the 10-year yield with inflation, PMI, the effective federal funds rate and U.S. marketable debt held by the public, 1960-1964



From January 1960 to July 1960 the negative spread is very small; ranging from 3 to 29 basis points. In May 1960, the model actually predicts the approximately same interest rate as turned out to be the case, only differing with -3 basis points. For the remaining part of the prediction period the model predicts about 20-78 basis points higher yields than realized. For the entire prediction period the average spread deviation is 46bps. Compared to the first regression in section 6.1.1(59,5bps) this is a lower spread. One must however keep in mind that the variable trade is substituted for federal marketable debt held by the public. Better prediction abilities for could be related to the fact that characteristics of the Treasury debt management conducted in Operation Twist is incorporated in the model directly. From February 1961 to December 1961 the average spread deviation is about 41 basis points. Similar conclusions regarding explanatory power of the model for MEP can therefore also be made here. What is interesting is that the actual 10-year yield only declines marginally between February 1961 and May 1961 (3,78 % February, 3,74% March, 3,78 % April, 3,88% May). In addition, the variable federal marketable debt held by the public also decrease marginally, leaving me to believe that the supply of treasuries must have increased to some extent in the period as well. We know that even though Operation Twist was not officially abandoned as a monetary policy before 1965, the purchases were of limited size in the years following 1961. The marginal decline in the actual 10-year yield in 1961, and increasing 10-year yields after May 1961 could be a result of this.

### 6.2.2 EXPANDING THE MODEL

When analyzing Operation Twist I also wanted to expand the model to see if any added components could increase the model's explanatory and predictive abilities. Foreign government involvement in Treasuries during the 1960's was very limited (Swanson, 2011), therefore this factor could be ignored. However, we know that there was a recession in the American economy in the beginning of the 1960's, I therefore wanted to incorporate the "market sentiment" at this time and if some form of "flight to quality" was present.

In trying to model this I decided to use the Dow Jones industrial average. This index was created in 1896 to give a "clear view of the American stock market and in extension; the U.S. economy" (S&P Dow Jones Indices, 2012). The average can be used as a benchmark when comparing individual stocks with the course of the market, and to compare the stock market with other economic indicators to review the economic conditions (S&P Dow Jones Indices, 2012). The average is computed by totaling the component prices of stocks of the thirty largest companies in the U.S. The divisor is today continuously adjusted to in reality becoming a multiplier, while in 1950's and 60's the divisor was simply the number of stocks (S&P Dow Jones Indices, 2012). This means that the data used in this part of the analysis might not be very sophisticatedly calculated, but the movement in the index, regardless of divisors, can give the same economic interpretation today as it could 50 years ago. The index is published daily by Dow Jones & Company and the data is collected from the FRED data base (DJIA). A monthly average is used.

I have chosen to include this variable as a description of the market's sentiment and general economic outlook. The PMI gives a view of the manufacturing sector, while the Dow Jones can give an indication whether market participants expect profitable investments, or if they are pulling their investments to safer placements such as Treasuries. It is basic supply and demand, a high Dow signals that more investors are buying than selling shares; an optimistic market where demand for Treasuries should be lower.

### 6.2.2.1 REGRESSION WITH DOW JONES INDUSTRIAL AVERAGE

The variables used in this regression are U.S marketable debt held by the public, inflation, PMI, effective federal funds rate and the Dow Jones Industrial Average from August 1954 to December 1959.

$$10 - \text{year yield} = -0,225 + 0,00642 \text{ Public held debt} + 0,0783 \text{ Inflation} + 0,00653 \text{ PMI} + 0,199 \text{ Fed fund} \\ + 0,00429 \text{ Dow Jones}$$

Predictor	t-value	P -value
Constant	-0,94	0,350
Public held debt	1,06	0,292
Inflation	1,97	0,053
PMI	1,20	0,237
Effective Fed Fund	3,68	0,001
Dow Jones	4,85	0,000

When including the Dow Jones Industrial Average, many of the independent variables becomes insignificant at a 5 % significance level (the intercept, inflation, public held debt and PMI). The variable Dow Jones industrial average is, however, statistically significant, and the positive coefficient of 0, 00429 imply that when the Dow is high the 10-year yields increase. From theory this is plausible; optimism in the stock market gives incentive to invest where the relative return is higher, this might reduce demand for Treasuries.

Analysis of Variance	Regression
R-Sq	70,5 %
R-Sq(adj)	68 %
F-ratio	28,15
P-value	0,000

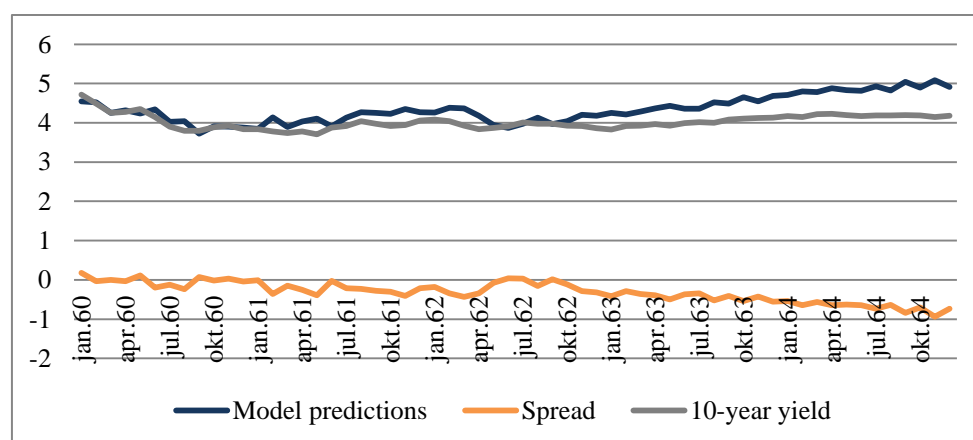
When including the Dow Jones industrial average the explanatory power of the model increases to 68 %. This strikes one as odd, since only the effective fed funds rate- and Dow Jones, and to some extent inflation, has significant t-and p-values. All though the VIF calculations did not indicate multicollinearity for this model, I suspect that there might be traces of this since the typical consequence of multicollinearity, since the F-value shows that all coefficients cannot be zero.

## Prediction of the 10-year yield

The prediction is, in similarity with the previous model, done from January 1960 to December 1964.

$$10\text{-year yield} = -0,760 + 0,00642 \text{ Public held debt} + 0,0783 \text{ Inflation} + 0,00653 \text{ PMI} + 0,199 \text{ Fed fund} \\ + 0,00429 \text{ Dow Jones} + 0,704 \varepsilon_{t-1}$$

Figure 6-14 Predicting the 10-year yield with inflation, PMI, the effective federal funds rate, U.S. marketable federal debt held by the public and Dow Jones Industrial Average, 1960-1964



This model has an average spread deviations of 32, 8 basis points, which is about 13 basis points lower than when the Dow Jones Industrial Average was not included. From the beginning of the prediction period to May 1961 the average spread deviation is only 13 basis points, indicating that the five variables used here, even though all were not significant in the regression, seem to explain the movements in the 10-year yield from 1960-1961 fairly good. From February 1961 to December 1961 the average spread deviation is about 26 basis points, this is lower than the model without Dow Jones (41bps). In the same time era the Dow Jones Industrial average was actually increasing, starting at 650 in February 1961 and ending on 728,44 in December 1961. One can therefore not attribute the marginal declining 10-year yields to a decline in the Dow.

### 6.2.3 CONCLUSION OPERATION TWIST

The models used to predict the 10-year yield for 1960-1964 has lower average spread deviations than the models in section 6.1. One reason for this could simply be that Operation Twist had little effect. In that event, fundamental conditions can perhaps give a fairly good indication of the movements of the

10-year yield. In addition, other claims that the Treasury had large borrowing needs in the period and therefore supplied Treasuries, counteracting the effect of Operation Twist. Bank of International Settlements (2009) claim that the Treasury's extension of maturities counteracted the Federal Reserve's purchases of longer-term bonds. Meaning & Zhu (2011) also suggest that lack of success for this program could be partly attributed to the Treasury raising the average maturity on marketable debt in 1960 to 1963.

The signaling effect from the Federal Reserve could also have been smaller under this program, as they were probably less effective in reaching the entire market with the communication tools one had in the 60's. Just viewing the actual 10-year yields in 1961 give the impression that the program was not effective in reducing them; the 10-year yield only fell 4 basis points from February 1961 to March 1961. The model including Dow Jones industrial average has an average spread deviation of 26 basis points, so the variables used cannot warrant the level of the 10-year yield in 1961. It could be that the 10-year yield would have been higher, due to some omitted variable, had the Fed not conducted Operation Twist. The program might therefore have stabilized-more than reduced the 10-year yield.

Studies by Modigliani & Sutch (1966) and Swanson (2011) both conclude that the effect on longer-term treasuries was about 12-20 basis points. But these authors measure accumulated effect on several treasury yields. My findings could be direct result of the fact Fed's balance sheet in 1961 was increased mostly by Treasury notes and to a less extent bonds (Table 1-1). The purchases might therefore not have influenced the 10-year yield more than possible 4 basis points. For the purpose of this analysis, it could be plausible to say that any effects of Operation Twist on the 10-year yield might have been small- and short-lived.

### 6.3 TESTING THE MODEL'S EXPLANATORY-AND PREDICTIVE ABILITIES

All though many of the same variables have been used in all the conducted regressions, their significance- and explanatory power differ. This has especially been apparent for inflation. I therefore wanted to test a random data series where monetary policy- and to some extent financial structure can be said to be different from the 60's and recent years. It can seem logical that monetary regime shifts and the market participant's confidence in these shifts can alter the information in the term structure. For instance Kloster (2000) claims that when there is a high degree of confidence in the central bank maintaining a low and stable inflation, the term structure contains less information about inflation

expectations. In addition, the development of financial markets- and the degree of regulation can also influence the information in the term structure (Kloster, 2000). I have therefore chosen to do an estimation with data series from 1992-1999 and prediction with data series for 2000-2003.

The 1990`s was according to Goodfriend (2002) the longest cyclical expansion in history, due to what Mankiw (2001) describes as a “good macroeconomic performance”. Mankiw (2001) attribute some of the credit to the policymakers for making interest rates more responsive to inflation. Goodfriend (2002) agrees with this view, and states that the 1990`s was a period characterized with full credibility in the central bank in achieving low inflation. High confidence in the central bank could imply that the concern for inflation was less important for demand- and supply in the bond market.

In difference from the central bank policy practice we see today, the beginning of the 1990`s were days of discretionary monetary policy, meaning less explicit communication to the market regarding future monetary policy (Mankiw, 2001). This could imply that the longer-term interest rates were less affected about expectations of future short-term interest rates levels because they were partly unknown. However, in February 1995 the FOMC started explicitly announcing their target for the federal funds rate, making monetary policy more transparent and time consistent. One could also be tempted to say that the American bond market was more influenced by domestic conditions in the 1990`s, as technology, deregulation and the age of “globalization” had not yet developed to the extent we see today. This means that foreign inflow of capital, international influence on the PMI and international “flight to quality” could have less significance in explaining the longer-term yields at the 90`s and beginning of the 20<sup>th</sup> century.

### 6.3.1 MODELING THE TEST ROUND

If the information in the term structure- and therefore the determinants for longer-term interest rates changes over time, using the same model to predict the 10-year yield can give various results. Finding which variables are best at explaining variation in the 10-year yield can differ according to which time series one analyses. I therefore tested the model on data series for trade, inflation, PMI and effective federal funds rate from January 1992 to December 2003. The data is collected from the same sources as discussed in section 4. Due to auto correlation, the estimation period is lagged one period and is therefore from February 1992 to November 1999.

$$10 - \text{year yield} = 0,248 + 0,000034\text{Trade} + 0,475 \text{Inflation} + 0,0669 \text{PMI} + 0,227 \text{Fed fund}$$

Predictor	t-value	P-value
Constant	0,82	0,417
Trade balance	2,52	0,013
Inflation	3,72	0,000
PMI	4,90	0,000
Effective Fed Fund	2,79	0,006

In this model the constant is not significant. An interpretation of this is that when all coefficients are zero, the response variable is zero, i.e. the mean of the response variable is zero. With allowance of some subjective judgment, this is less likely. Problems like these can be attributed to the fact that I did not manage to remove all auto correlation by the Cochrane-Orcutt method for this regression. All the independent variables seem significant in explaining the variation in 10-year yield.

Analysis of Variance	Regression
R-Sq	36 %
R-Sq(adj)	33,2%
F-ratio	12,53
P-value	0,000

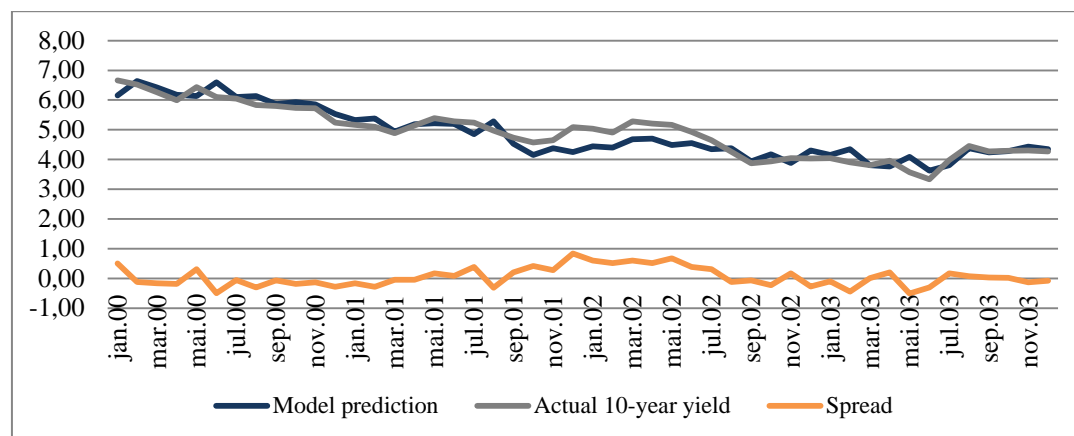
The model had an adjusted coefficient of determination of 33, 2 %, meaning that for this data sample the four independent variables can explain about 33 % of the variation in the 10-year yield. The rest is of the variation is made out of “noise”. The F-value confirms that not *all* coefficients are zero.

### **Prediction the 10-year yield**

The following equation was used to predict the 10-year Treasury yields for January 2000 to December 2003. I chose to steer away from years after 2003 to avoid incorporating “the bond yield conundrum” of 2004-2007.

$$10 - \text{year yield} = 0,77 + 0,000034\text{Trade} + 0,475 \text{Inflation} + 0,0669 \text{PMI} + 0,227 \text{Fed fund} + 0,679\varepsilon_{t-1}$$

Figure 6-15 Predicting the 10-year yield with the trade balance, inflation, PMI and the effective federal funds rate, 2000-2003



The actual-and predicted yield declines in almost the entire prediction period. Factors like the dot.com bubble in 2001 and the economic impact of 9/11, influenced the economic outlook of the beginning of the 2000's, and therefore the 10-year yields. While the dot.com bubble-burst lead to extensive reductions in large U.S based company's market capitalization, the 9/11 attack caused the Dow Jones to drop 600 points, worsened the 2001 recession, and initiated extensive need for government spending for the "war on terror"(Amadeo, 2012).

The variables in the model seem to incorporate this downward development in the 10-year yield. Firstly, low levels of PMI can indicate lower GDP growth. In 2001, GDP growth fell to 1, 3 % in Q1, 0, 3 % in Q2 to -1,3 % in Q3, and 9/11 also induced a contraction in the manufacturing sector (Goodfriend, 2002). Secondly, the federal funds target was cut in 11 steps in 2001, from 6, 5 % in the beginning of the year to 1, 75 % in December (Goodfriend, 2002). In addition, inflation started falling mid-2001 and did not significantly increase until about October 2002. According to theory, both expectations of lower short-term interest rates-and inflation increases demand for bonds and lower yields. A lower PMI will also keep the 10-year yield down.

This model actually predicts the 10-year yield quite accurate. One can see this graphical but also by the average spread deviation of 26 basis points for the entire prediction period. From the conclusion in section 6.1.4 we can infer that this is indeed a very low average deviation.



### 6.3.2 CONCLUSION TEST ROUND

The results from the prediction brings me to assume the following; firstly, the model seems to be a better fit to explain movements in the 10-year yield in the beginning of the 20<sup>th</sup> century than later on. Secondly that there might be the differences in the monetary policies- and financial structures that gives me this result. The beginning of the 20<sup>th</sup> century was not, at least not to the same extent, characterized with several accommodation policies from the central bank. And in particular, large-scale-asset purchases were not used to stimulate the economy to the same extent. It is possible that some of the recent year's accommodations policies have partly impaired the monetary transmission channels, making it difficult to model how programs like MEP should affect the economy. In addition, the increased accuracy can come from the fact that the possible effect of MEP is not in this model. Actually, this test round have signaled that the four variables representing fundamental conditions in the economy can be quite accurate in predicting yields, only not to the same extent in 2011-2012 because other factors might have influenced the yields at this point. If any plausible conclusion can be made here, it has to be that models describing macroeconomic outlook needs subjective judgment and knowledge of omitted factors that impair the response variable from behaving like "normal".

### 6.4 CONCLUSION ANALYSIS

All the models analyzed have some common features. Firstly, the coefficient of determination has been relatively low for all regressions. This highlights the amount of "noise" in the financial markets and therefore the difficulties in modeling-and working with financial data. In addition, for both MEP and Operation Twist the four variables representing fundamental conditions in the economy follow the movements of the 10-year fairly well, but there is consistently a large negative spread between the predicted-and actual yield. The model almost always predicts higher interest rates than realized.

The results from the analysis of MEP leads me to believe that either all the models lack a variable that should reduce the 10-year yield, or that programs like MEP- or quantitative easing have in fact had some downward pressure on the 10-year yield. It is also of interest that the variables representing economic variables cannot warrant the low levels of the 10-year yield. I find it especially interesting that the large-and persistent fall in the effective federal funds rate did not induce a similar large

reduction in the 10-year yield until last year. This could indicate elasticity in the demand for longer-term treasuries.

When only including federal debt held by foreign-and international investors the overall spread was reduced, but was not until I included the St. Louis financial stress index that the spread in the last year narrowed to 55 bps. As noted above, the prediction accuracy increased when the model combined these effects. These results indicate that world-wide credit movement, as well as market expectations-and sentiment regarding economic outlook could be important determinants for the 10-year Treasury yield in the last year. When expanding the estimation-and prediction period for the same model, the average spread deviation for the last year is still about 55 bps but the coefficient of determination increases to almost 60%. The prediction does in other words not change when the financial crisis-and quantitative easing programs are included in the estimation period, but the coefficient of determination confirms the explanatory power the variables used. As Beltran et al (2012) noted, this means that the central banks might have less leverage over the longer-term government yields as they are also influenced by the international capital market.

The models for Operation Twist had relatively good explanatory-and predictive power, but I concluded that any effects were small-and short lived. This conclusion was mainly based on marginal decline in the actual 10-year yield, but the accumulated effect when looking at several treasury yields could have given more favorable results. In the models there was about 26-41 basis points unexplained difference between the model yield and the actual yield, but because the 10-year yield stayed roughly unchanged, I cannot infer that this spread is due to Operation Twist. The “test” model reveals that the four variables representing fundamental conditions in the economy can in fact predict the 10-year yield fairly well, only with an average spread deviation of 26 basis points. This could indicate that the term structure of interest rates-and the information in it, is subject for alteration as monetary policy-and financial structure changes. It also brings me to believe that MEP-or other demand pressuring effects in the longer-term end of the Treasury market has given a downward pressure on the 10-year yield.

## 7. REFLECTIONS

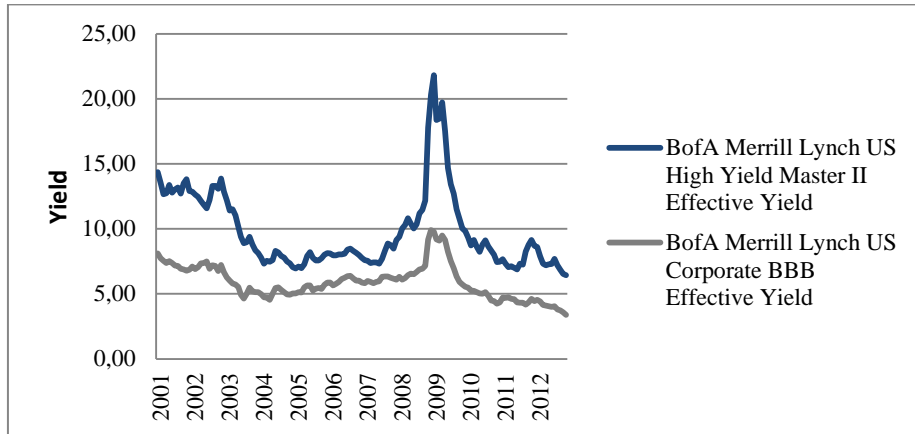
### 7.1 ECONOMIC STIMULI; THE PORTFOLIO REBALANCING CHANNEL

By viewing the development in 10-year yield one can safely establish that the yield is at currently low levels. But the superior objective of MEP is economic stimuli by transferring effects of lower longer-term yields through the portfolio rebalancing channel. The key assumption for the portfolio rebalancing channel is that different classes of assets in an investors' portfolio are not perfect substitutes. This can be due to transaction cost, risk characteristics or regulation; the point is that when the supply of various assets available for private investors changes, this can have effect on the yields and prices of those assets (Bernanke, 2012). The portfolio rebalancing channel will therefore not work in an environment where expectations theory is the only way one can explain the term structure of interest rates. There has to be investors who prefer certain maturities over others; hence elasticity in demand. According to Ehlers (2012) the strength of the portfolio rebalancing channel is determined by how much of the outstanding debt the Fed absorbs; hence the strength of the wish from private investors to substitute to other securities. The hope is that when Fed purchases Treasuries from the public, the private investors substitute these Treasuries with other securities with similar maturities. These assets can in turn experience a reduction in yields and increases in prices (Bernanke, 2012). Increased prices can thereby improve economic conditions by easing the access to external capital and improve the credit flow (Ehlers, 2012).

In the event that the declines in Treasury yields spin-off to other interest rates in the economy: will lower interest rates stimulate a public who are still deleveraging? Businesses already have much cash, and banks keep their reserves in the Fed (Lockhart, 2011). Will MEP make a difference when the 10-year yield has already been lower than 2 % since September 2011? In trying to answer some of these questions I have viewed some financial indicators that might reveal if the envisioned transmission channels are in effect.

Viewing the development of effective yields on corporate bonds one can perhaps get an indication whether investors are substituting Treasuries with similar debt securities; hence creating a lower yield and price increase in these markets. It is likely that the investors favoring Treasuries would substitute these with bonds with a similar risk-or default profile, therefore viewing corporate bonds rated BBB seems logical.

Figure 7-1 Development in the effective yield on Corporate bonds



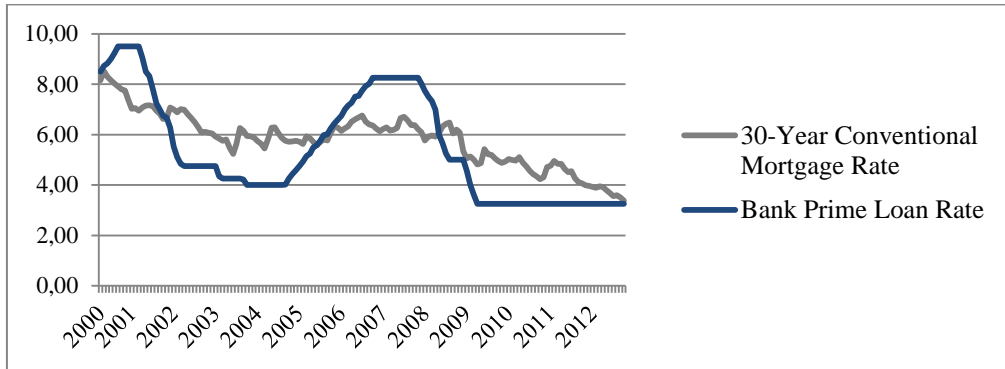
Source: (FRED, Data: High Yield Master II (BAMLH0A0HYM2EY), Corporate BBB (BAMLC0A4CBBBEY)).

Since September 2011 the effective yield on Corporate BBB has declined by about 2,33 %. For the purpose of diversity I also included the High yield Master. In comparison, this yield has only fallen with about 0,95 % since September 2011.

10-year Treasury yields are also believed to be important benchmarks for house loan-and mortgage rates, and we know that consumption-and investment decisions are often made on the basis of longer-term yields. As the main objective for MEP is economic stimuli, an important part of the goal is to increase private consumption. The Chairman of the FDIC (Federal Deposit Insurance Corp) Martin Gruenberg highlights this by stating: “The real key in going forward is going to have to be a pick-up in lending” (McGraine, 2012).

In trying to see if there have been eased-and increased credit flows I viewed the development of the bank prime rate and the 30-year Conventional mortgage rate. The bank prime rate is the rate commercial banks charge their most credit-worthy costumers (Klovland, 2011c), but it could also serve as a benchmark for other commercial-and personal loan rates. The 30-year Conventional mortgage rate represents the contract interest rate from fixed-rate first mortgages and is issued by Freddie Mac (FRED).

Figure 7-2 Eased credit conditions?

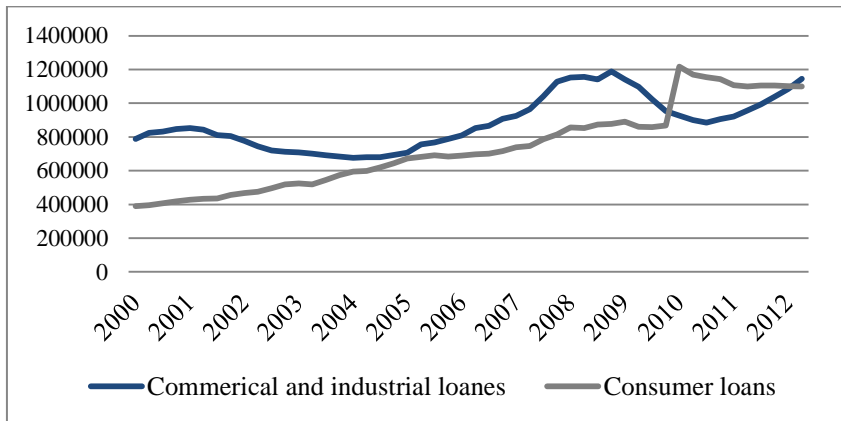


Source: (FRED, Data: 30-year Conventional Mortgage rate (MORTG), Bank Prime Loan Rate (MPRIME)).

The bank prime loan rate fell from 8, 25 % in November 2007 to 3, 25 % in April 2009, and has not changed since. The 30-year Conventional mortgage rate, on the other hand, has seen a decrease in the last year. Since September 2011, this rate has gone down by 0, 73 %. Only in 2012, the rate has fallen with about 0, 54 %.

A view of the amount of commercial- and customers lending could also be useful, to see if the will to lend- and borrow has increased in the last year.

Figure 7-3 Commercial-, industrial-and consumer loans among the 100 largest banks



Source: (FRED, Data: Commercial-and industrial loans (ACILT100), Consumer loans (ACLT100)).

For commercial-and industrial lending a fall in borrowing occurs in the end of 2008. From the fourth quarter in 2011 to second quarter of 2012 the approximate percentage increase in lending has been

about 10 %. In contrast, consumer lending seems to have been relatively stable since the second quarter of 2010. This could indicate that the consumers are still deleveraging, while the businesses are now starting to view investment opportunities more profitable-and safe.

Viewing these graphs might give a stylized picture of the actual development in credit markets, but it can function as a guide for general development in lending- and incentives. The graphs signal that the commercial segment has increased their borrowing more than seems to be the case for private consumers. SunTrust Banks Inc. Atlanta reported that their portfolio had increased by \$5, 5 billion in the course of 2011. Roughly half of this increase came from the commercial segment (McGraine, 2012). McGraine (2012), states that the demand increase in the second half of 2011 has mainly been from the large corporate segment. Banks reported that loan balances grew with \$130 billion in the last three months of 2011. And as noted, this growth was driven by loans to the commercial-and industrial segments (McGraine, 2012).

According to Fox Business (2012) the Feds quarterly survey of bank`s senior lending officers` state that U.S Banks reported stronger demand for home-, auto-and credit-card loans in the third quarter of 2012, stronger compared to the second quarter of 2012. 40 % of the survey participants stated that the demand for traditional home loans was either “substantially stronger” or moderately stronger in the third quarter, while 92% said credit standers were unchanged. The survey also stated that 89% of banks surveyed said lending to small-and large firms was unchanged in the last quarter (Fox Business, 2012). These numbers give the indication that perhaps credit conditions have eased in the last half of 2011, as well as in the third quarter of 2012.

## 7. 2 FACTORS CONTRIBUTING TO THE DECLINING 10-YEAR YIELDS

The 10-year yield is affected by a myriad of factors and a simple multiple regression cannot explain all variance there is. Therefore I cannot be sure that even though the model cannot explain the entire decline in the yields in the recent year, the spread is due to MEP. In addition, possible eased credit conditions can be a result of other monetary easing policies by the Fed. In this section I therefore reflect upon other factors that could potentially be a significant driver for the reduction in the 10-year yields.

## 7.2.1 QUANTITATIVE EASING

Quantitative easing is a policy where the central bank conduct open market purchases to such a great extent that they achieve a policy rate of zero (Bernanke, Reinhart & Sack 2004 ).The Fed and FOMC started using its balance sheet as a tool for monetary policy already in 2008. What is often referred to as large-scale-asset purchases or quantitative easing was the first sign of the Fed expanding their balance sheet to provide liquidity to ease credit conditions- and to lower longer-term yields.

Quantitative easing is conducted by increasing Fed`s balance sheet. In practice, Fed is buying securities from the banks and pay for these by crediting the banks accounts in the Fed thereby increasing the bank`s deposits in Fed. As a result, the monetary base (M0) increases (Klovland, 2011b). In total the Federal Reserve has done purchases worth about \$2,950 billion between 2008 and 2010 (Bernanke, 2012).

Table 7-1 Quantitative easing purchases 2008-2010

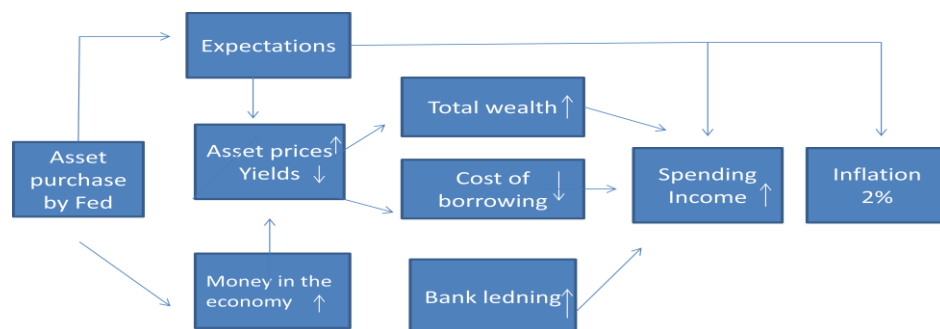
Time	Amount	Type of purchases
November 2008	\$600 billion	Agency MBS and agency debt
March 2009	\$1,25 trillion	Agency MBS
	\$ 200 billion	Agency debt
	\$ 300 billion	Longer-term Treasury debt
November 2010	\$600 billion	Longer-term Treasury debt

Source: (Bernanke, 2012)

While MEP is designed to be balance sheet neutral, quantitative easing involves a significant expansion of Fed`s asset holdings (Ehlers, 2012). MEP is expected to increase the duration of Fed`s portfolio from 5 to 8 years, QE2 on the other hand entailed purchases with an average duration of 5, 5 years. Since these purchases was spread along a wide range of maturities, the average effect on the Federal Reserve`s portfolio duration was roughly unchanged for 5 years (Federal Reserve Bank of New York, 2012b). Quantitative easing should in similarity to MEP work through transmission channels where the direct effects are in the yields and prices in the markets where the transactions take place. In difference from MEP, there is an additional liquidity effect in the markets where the purchases are made that can lead to increased trading activity. Because of this excess supply of money investors will adjust their portfolios (Klovland, 2011b). In addition, the banks increased deposits in

the fed should increase the banks` lending to the public and this way stimulate aggregate demand. Because of higher prices, demand- and credit flows should be stimulated through the wealth-and lending transmission channels (Klovland, 2011b).

Figure 7-4 Stylized transmission mechanism for asset purchases



Source: (Benford et al, 2009)

The intended effect from MEP, QE1 and QE2 is the same; reduction in the longer-term yields. Studies suggest that approximately the same amount of duration risk is removed from the public with both programs (Ehlers, 2012). The intended effect on shorter-term yields also differ between the two programs since also purchases are made in the short end of the market in QE programs. However, the effect is likely small for both programs due to FOMC`s announcements. Ehlers (2012) however, claim that because QE programs expand the amount of cash in the economy, the impact on the real economy will be larger than what MEP provides.

### Empirical studies show...

It was doubted if there would be any effect in 10-year yields in the second round of quantitative easing. Thornton (2010) suggests two reasons for this doubt. Firstly, the financial markets functioned a lot better in 2010 than in the spring of 2009. Secondly, the banks held in 2010 about \$1 trillion in excess reserve in the Fed, rather than increasing lending to the public. Low willingness to lend- and borrow resulted in M2 remaining roughly unchanged. Many analysts believed that reducing already low yields was unlikely to stimulate aggregate demand. Thornton (2010) explains this by stating that investment spending is not only depending on interest rate levels but more on the economic outlook.

There has now been four years since the beginning of Fed`s large-scale asset purchases, therefore many empirical studies have measures its effect. Ben Bernanke (2012) states that the \$1, 75 trillion purchase program in March 2009 (QE1) lowered the 10-year Treasury yields by between 40 and 110



basis points. The extension of LSAP in November 2010 (QE2) by \$ 600 billion reduced the 10-year yields further by 15-45 basis points (Bernanke, 2012). Gagnon et al (2011) find that large-scale asset purchases have induced long-lasting reductions in longer-term interest rates on several debt securities, not only the ones included in the program. The authors claim that the interest rate reduction on MBS's and agency debt has been very powerful, mainly due to improved liquidity. Furthermore the authors claim that these declines are a result of lower risk-and term premiums rather than lower expectations regarding the future level of short-term rates. The study by D`Amico & King (2010) also conclude that QE1 contributed to a downward shift in the Treasury yield curve with about 50bps.

These results lead to the conclusion that the effects from quantitative easing purchases might still be in effect, reducing the 10-year yields or keeping them at lower levels than normal.

### 7.2.2 FORWARD GUIDANCE

Forward guidance has been used by many central banks around the world as an important tool in trying to influence the market expectations. The central bank can have some leverage over the longer-term interest rates if communication affects expectations of future policy (Bernanke, Reinhart & Sack, 2004). In a time of crisis this can be particularly important since communication can lower the private sectors expectations of future short-term interest-rate levels and therefore the longer-term interest rates (Bernanke, 2012). Even when the shortest interests in the market are zero, the possible stimuli from lower longer-term interest rates can be intact. Fed's forward guidance can therefore be another determinant for the current low level of the longer-term interest rates.

Gürkaynak, Sack & Swanson (2005) does a high-frequency even-study where they assess the effect of U.S monetary policy on asset prices. They have two important findings. Firstly, they suggest that effects on asset prices are not adequately captured by changes in the federal funds rate. Secondly, they find that two factors are required; the current level of the federal funds target and the expectations of the future path of policy. Using data from 1990-2005 the authors find that FOMC's statements accounted for more than 75 percent of the explainable variation in 5-and 10-year Treasury yields around FOMC meetings.

To influence the market expectations, the FOMC has been very explicit regarding the future federal funds rate in their post meeting statements. In March 2009, the statement noted that economic

conditions “are likely to warrant exceptionally low levels of the federal fund rate for an extended period” (Board of Governors of the Federal Reserve System, 2009). In August 2011, the FOMC communicated that the economic conditions warranted low levels of the federal funds rate “at least through mid-2013” (Board of Governors of the Federal Reserve System, 2011a). After the FOMC meeting in August 2012, the statement noted that the federal funds rate would be held at exceptionally low levels “at least through late 2014” (Board of Governors of the Federal Reserve System, 2012a). In September, it was further extended to mid-2015 (Boards of Governors of the Federal Reserve System, 2012b). By making these announcements periodically after meetings, the FOMC has not only verified its objective for economic recovery, but have periodically reminded the market of the future course and level of the federal funds rate. However, the success in this form of policy relies on the markets confidence in the central bank’s independence in interest-rate setting (Thøgersen & Klovland, 2011). Bernanke (2012) claim that private forecasters have pushed out their date for expected increases in the federal funds target, i.e. that the markets policy expectations seem to align well with FOMC’s communication.

Forward guidance and its possible effect on the private sectors expectations, is a somewhat abstract variable to incorporate in the model. One could say that communication is represented in the model through the effective federal funds rate, if in fact the markets policy expectations align with those of the FOMC. Otherwise, I have to conclude that forward guidance can influence the longer-term yields through expectations theory in its simplest, but significant form, as an omitted variable.

### 7.2.3 LOW INTEREST RATES AFTER A DEBT CRISIS

The current low levels of the longer-term Treasury yields can also give rise to a new hypothesis. One possibility is that the current low levels of the longer-term Treasury yields cannot be explained by fundamental conditions in the American economy, but that a program like MEP and the euro-crisis has reduced the longer-term Treasury yields. In that event, it is likely that the longer-term interest rates will increase when the American economy recovers-, the fiscal situation in Europe improves and Fed terminate their LSAP’s programs (DNB Økonomiske utsikter, 2012). DNB Økonomiske utsikter (2012) suggest a different hypothesis, namely that the longer-term interest rates can remain low or fall further for an extended period to a new-and lower normal level for the real interest rates.

Reinhart, Reinhart & Rogoff (2012) investigate debt crises in several countries since the 1800`s. The authors find that when government debt exceeds 90 percent of GDP the economic growth is impaired. The period of slow economic growth has been long for the 26 episodes studied; 23 years in average for the observed periods. Checherita & Rother (2010) also find there is a negative connection between high government debt and economic growth. In addition, the authors find a negative connection between government leverage and long-term real interest rates. The Great Depression in 1929 is an example of government debt accumulation where the government yields stayed low for an extended period. In similarity with today, these post-recession periods were characterized with low incentives to borrow-and make new investments (DNB Økonomiske utsikter, 2012).

These factors suggest that it is not programs like MEP- and quantitative easing that reduce and keep the longer-term interest rates low, but rather that the leverage effect on economic growth that give the longer-term interest rates new reduced normal levels.

### 7.3 OTHER EMPIRICAL FINDINGS

In the American financial community there was a tepid enthusiasm for MEP. According to Kenny (2012d), Bloomberg conducted a survey of 42 economists on the likely effect of MEP. Of the participants, 61 % said the program would have no effect and 15 % actually answered that it would impair an economic recovery. A review of other empirical studies therefore seems suitable.

The majority if the studies examine the accumulated effects of large-scale asset purchases (QE1, QE2 and MEP). Extracting the isolated effect from MEP is therefore difficult. Regardless of this, empirical studies can establish if there is an environment in the term structure that comply with the assumptions necessary for these programs achieve their objectives.

#### 7.3.1 MEP

Ben Bernanke himself states that in general, the large-scale asset purchases by the Fed have significantly lowered longer-term yields (Bernanke 2012). Li & Wei (2012) evaluate the effect of LSAP`s on the term premium of longer-term securities by using an arbitrage-free term structure. The authors find evidence that private holdings of Treasuries- and agency MBS have explanatory power over the variance in Treasury yields. Li & Wei (2012) also find that LSAP one-and two, and MEP

combined gives a 100bps lowering effect on the 10-year Treasury yield. Hamilton & Wu (2011) investigate the monetary policy options when nominal interest rates are limited to a zero lower bound. They display empirical measures of how “the maturity structure of publicly held debt affects the term structure of interest rates”. Hamilton & Wu (2011) estimates suggest that if the Fed in 2006 had purchased \$ 400 billion in longer-term maturities and selling Treasuries for the same amount, the 10-year yield would have dropped 14 basis points and the 6-month rate increased with 11 basis points. Meaning & Zhu (2012) on the other hand, find that the effectiveness of MEP could be limited by the Treasury debt management policy. Their estimates indicate that Fed’s maturity structure -and the size of their holdings affects the bond yields. If the stock- and maturity of the outstanding debt remains unchanged, Meaning & Zhu (2012) suggest that the planned 25 month extension of the average maturity could lower the 10-year yield by 85 basis points. However, due to possible conflict of interest between the Treasury’s borrowing needs and the Fed’s wish to reduce the yields, effects might be limited.

All though the direct objective of MEP is a reduction in longer-term interest rates , there has been much skepticism whether the purchasing programs would transmit to other interest rates- and asset prices (Bernanke, 2012). However, various studies find that the portfolio rebalancing channel has given effects on other yields and asset prices. Krishnamutry & Vissing-Jørgensen (2011) for instance claim that both rounds of quantitative easing gave significant effects on medium-and longer-term Treasury yields, highly rated corporate bonds, and agency bonds. They also conclude that one cannot view Treasury yields as the only policy target, because the quantitative easing programs work through different channels that affect particular assets different. Secondly, they establish that the effect on yields differ from each program-, which assets were purchased- and maturities of the assets.

Wright (2011) suggest that monetary shocks are heteroscedastic, i.e. the monetary policy shocks have high variance around FOMC meetings and announcements. Using a high-frequency event-study and structural VAR, Wright (2011) finds that stimulating monetary shocks have had a lowering effect on longer-term Treasury-and corporate yields but that these effects are short-lived.

Fuster & Willen (2010) uses an event-study to assess the effect of large-scale asset purchases (excluding MEP) on U.S mortgage prices- and quantities. The authors’ finds that the quantitative easing programs boosted market activity, but that the most creditworthy customers benefited the most. In addition, effect on stock prices is seen to be an important signal of economic recovery, since these

asset prices affect both consumption and investments. Large-scale asset purchases have notable boosted stock prices, both by lowering discount rates and improving economic outlook (Bernanke, 2012).

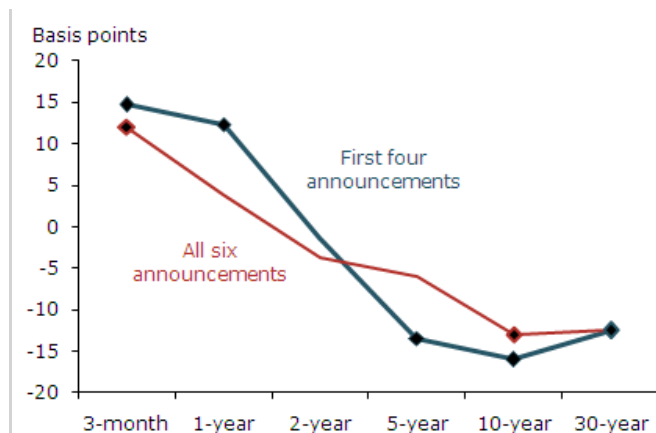
### 7.3.2 OPERATION TWIST

Modigliani & Sutch (1966) regard Operation Twist as somewhat of a failure. Firstly, they claim that the spread between shorter-and long-term rates that prevailed between 1961 and 1965 narrowed because of economic recovery- and rising short-term interest rates. Modigliani & Sutch (1966) indicate that the success of Operation Twist was not due to debt management by the Fed- or the Treasury but rather that the alleged twist in the yield curve could be attributed to Regulation Q, a policy tool adopted in 1961. Regulation Q was a Federal Reserve Board regulation that imposed ceiling rates on time deposits (Gilbert, 1986). One objective with this regulation was to limit destructive competition for deposits. The competition had influenced banks to acquiring riskier assets with higher return. This destructive competition could threaten the banking system solvency and stability (Gilbert, 1986). Modigliani & Sutch (1966) also suggest that a raising of the ceiling rates under Regulation Q solely twisted the yield curve by allowing for the innovation of negotiable time certificates of deposits (CD`s). CD`s made it possible for commercial banks to attract short-term funds to competitive rates. Modigliani & Sutch (1966) conclude that Operation Twist attempt in narrowing the long-short spread had moderate effects, maximum 10-20 basis points.

Swanson (2011) does an event-study by viewing different government yields (3month, 1-, 3-, 5-,10- and 20 year yields) following six announcements from the Fed in 1961. By viewing the government yields in a narrow time window, the author keeps all macroeconomic factors that would otherwise influence the yields directly constant. Alon & Swanson (2011) describes these six announcements and the following cumulative effect on the yields. On February 2<sup>nd</sup> 1961, the Kennedy administration first announced the program. When market closed that day the Treasury announced an auction of \$6, 9 billion of new debt for at 18 months maturities. February 9<sup>th</sup>, the Federal Statistics release showed a rare purchase of longer-term securities which demonstrated some support for Operation Twist. The 20<sup>th</sup> of that same month the Fed explicitly endorsed the program and announced new purchases of Treasuries with maturities of five years or longer. However, on March 15<sup>th</sup>, the Fed backtracked some of their previous support by announcing refunding of Treasuries with longer maturities than expected.

April that same year, statistic releases showed purchases of longer-term Treasuries by the Fed for maturities over ten years (Alon & Swanson, 2011).

Figure 7-5 Cumulative responses in the yield curve to Operation Twist



Source: Data from Swanson (2011).

Note: Black nodes are statistically significant movements.

Source: (Alon & Swanson, 2011)

Of the six announcements, Swanson (2011) finds that four of them had statistically significant effect on the financial markets by reducing the yields from February 1961 to May 1961. His analysis therefore indicates that the effect of Operation Twist was limited to a short period of time. Consistent with Modigliani & Sutch (1966) findings, Swanson (2011) conclude that the cumulative effect on Operation Twist on longer-term Treasuries was limited to approximately 15 basis points but that it could have been larger had the Fed and FOMC been more consistent in their communication to the market. Alon & Swanson (2011) refer to subsequent research (Swanson, spring of 2011), where possible spillovers from Operation Twist to other debt securities and credit markets is investigated. The authors claim that the yield on government agency securities declined in similar magnitude as the longer-term Treasury yields while yields on corporate bonds were affected less.

## 7.4 COST-BENEFIT ANALYSIS OF MEP

### 7.4.1 EXIT STRATEGIES

“It would be an extension of something we have in place, so it would be more seamless, and it doesn’t complicate exit strategies as much because it’s not expanding the balance sheet”, these are the words of former senior economist for the Federal Reserve Board, Josh Feinman (Matthews & Kearns, 2012).

As we know, MEP has not given a net liquidity increase, therefore threat of higher inflation when the programs terminate is of less importance. The Fed balance sheet was, however, in 2011 2,5 times larger than before the Lehman collapse, indicating that accumulated effect of all accommodation programs might create challenges when the Fed exit them (DNB Økonomiske utsikter, 2011). When conducting quantitative easing programs the Fed has increased their short-term liabilities, i.e. they have printed more money. Increased inflation has not been the case yet, since the banks have not put the money in circulation but left it as deposits- or reserves in the Federal Reserve (DNB Økonomiske utsikter, 2011). There has therefore been a concern whether the excess reserves in Fed will induce an explosive lending to the public, and with that higher inflation, when the economy sees signs of recovery. Low willingness to lend-and borrow is probably not a permanent situation (DNB Økonomiske utsikter, 2011). In the event that inflation expectations are unanchored the fed can increase the depositary rate on reserves in the Fed to put upward pressure on money market-rates (Blinder, 2010). The Fed could also communicate to the market that the increased monetary base would be reduced systematically if the economy shows signs of recovery (Thornton , 2009).

The minutes from the FOMC meeting in June 2011 mention three important steps in an exit strategy for, in reality, all accommodation policies since the financial crisis. The first step is to refrain from reinvesting some or all principal payments in SOMA (System Open Market Account). The second, and perhaps most important step, is to normalize the use of the federal funds target as a tool for monetary policy. As discussed in 4.4, controlling the reserves in the banking system through open market operations will bring the fed fund towards its target. The timing- and speed, in which the target starts increasing, will be considered with what the economy warrant. Finally, the FOMC states that they will sell securities from SOMA to the extent that the portfolio has a minimum effect on credit allocation. This is anticipated to take between two and three years (Board of Governors of the Federal Reserve System, 2011b).

The exit strategies seem fairly straight forward, but is it possible that the monetary transmission channels are damaged or at least disrupted after such a long period of accommodation policies? Using the federal funds target to influence expectations regarding future monetary policy works under the assumption of credibility. If the Fed does not manage to exit without creating financial instability- or a new recession, will the market still have confidence in the Fed?

## 7.4.2 POTENTIAL COSTS OF MEP

Ben Bernanke states himself that the hurdle for using non-traditional monetary policies should be higher than for using traditional policies (Ben Bernanke, 2012). Not only are the policy makers more experienced with the traditional policies; its long-lasting effects are easier to measure. As previously mentioned, the long-lasting effects of monetary policies like QE- and MEP are difficult to quantify since it is difficult to measure how the economy would have performed without these actions (Bernanke, 2012). The same uncertainty can be said to be present when it comes to potential costs and consequences for the well-functioning of the financial markets when the Fed exits these programs. Economic conditions, prior asset purchases by the Fed and the health of the global financial system are factors that will affect the potential disruptions (Bernanke, 2012).

One potential cost can be the disruption of the market where the asset purchases have taken place; the market of Treasuries and agency securities. FOMC's dominating trading activity in these markets could potentially have damaged liquidity and thereby increasing risk premiums; counteracting the goal of lower longer-term yields (Bernanke, 2012). If trading among private agents dries up, this is not only costly, but a less functional American Treasury market could impede the effects of the most important tool in monetary policy; open market operations (Bernanke, 2012). According to Bernanke (2012) the transmission channels of monetary policy are not impaired to this point, as public holdings and trading of Treasuries remain large.

The Federal Reserve also stands in a vulnerable position when it comes to interest-rate risk with such large holdings of securities from both QE- and MEP. If the interest rates level increases, the Fed could potentially face substantial capital losses. As of today, a large unexpected rise in the interest level is unrealistic, but it is a large latent and potential cost.

Another point of concern is that of financial stability. When the FOMC makes open market operations with the objective to reduce longer-term yields, there is a chance that some investors will search for return in a less productive risk-taking manner and with high leverage (Bernanke, 2012). If search for high-risk yields emerges among many private investors, this could lead to instability in financial markets. The Fed along with the Financial Stability Oversight Council, claim measures have been made for extraordinary monitoring of the financial system, so that unsafe risk-seeking behavior is detected (Bernanke, 2012).



Lastly, public confidence could be lost if the Fed does not manage to exit these programs in a timely manner without creating a new recession.

## 7.5 THE ROAD AHEAD FOR FOMC AND BERNANKE

What will happen with the American economy if MEP fails in its mission? The fragile upturn in American economy can be shattered if a new shock from the Euro zone hits the American market (DNB Økonomiske utsikter, 2012). Has the Fed run out of ammunition?

Further extension of MEP in its originated form is not possible, as there are no more short-term securities to sell (DNB Økonomiske utsikter, 2012). The alternative could therefore be to continue purchasing longer-term securities (ref. quantitative easing) and therefore attempt to ease financial conditions by injecting liquidity in the economy. On September 3<sup>rd</sup>, the FOMC decided to further extend accommodation policies by purchasing agency mortgage-backed securities worth \$40 billion each month (Board of Governors of the Federal Reserve System, 2012b). In addition, the FOMC directed the Federal Reserve Bank to continue purchases of longer-term Treasuries after MEP is completed in December 2012. Initial pace is at \$45 billion each month (Federal Reserve Bank of New York, 2012c). But as reviewed over, the potential loss of central bank confidence in managing to exit these strategies in a timely manner can potentially grow.

Another option for the Fed could be to reduce the interest paid on reserves from 0,25 to 0 percent for the banks in the Federal Reserve System (DNB Økonomiske utsikter, 2012). This could leave the banks with less incentive, other than security, to leave the funds in the Federal Reserve and motivate them to place these in the money market. As a result lending to the public could increase. Lastly, they could follow a similar regime like the Bank of England's Funding for Lending scheme (FLS) that seeks to increase lending (DNB Økonomiske utsikter, 2012). The banks who increase their lending can borrow more from this program to a lower interest than the banks who reduce their lending (DNB Økonomiske utsikter, 2012). This could perhaps also stimulate to increased private consumption.

## 8 CONCLUSION

Many models-and factors have been thoroughly discussed in this study, and the results does not necessarily lead in one direction. Firstly, the analysis showed differing results on the effect of MEP- and Operation Twist. The success of a monetary policy like MEP and Operation Twist might therefore rely on when it is conducted, which communication tools the central bank have, what economic state the rest of the world faces and the degree of cooperation between the Treasury and the Federal Reserve. Secondly, section 7.2 described that one cannot necessarily contribute declining yields to MEP. It is perhaps more likely that a combined effect of several monetary policies has led to the current low level of the 10-year Treasury yield. The results can therefore not be summed up in one sentence. As a final remark, I will therefore review the most central conclusions made for each section of the analysis.

The most accurate model in the analysis of MEP gave on average -55 basis points, unexplained reduction in the 10-year yield from September 2011 to September 2012. 55 bps was the lowest spread in the analysis of MEP, and this was achieved by letting St. Louis Financial stress index and federal debt held by foreign-and international investors explain parts of the variation in the 10-year yield. Foreign inflow of capital-and the market sentiment regarding volatility in returns, therefore seems to have been important determinants for last years` development in the 10-year yield.

The analysis of Operation Twist leaved on average - 26 basis points unexplained from February 1961 to December 1961. However, knowing that the 10-year yield only declined 4 basis points from February 1961 to May 1961, leaves me to conclude that the 10-year yield was marginally affected by Operation Twist. There might rather be other characteristic regarding the 10-year yield, omitted from the model that makes the predicted yield higher than the actual 10-year yield. Possible inadequate cooperation between the Treasury and Federal Reserve, along with purchases in markets where the 10-year yield was less affected are possible reasons for my unfavorable results in the analysis of Operation Twist.

When testing the model by predicting the 10-year yield from 2000 to 2003, the average spread deviation is only 26 basis points. The results indicate that the trade balance, PMI, inflation and the effective federal funds rate could be quite accurate in predicting the 10-year yield under “normal” circumstances. The need for a hybrid of theories also surfaces here; different time series have given

variables differing significance-and predicting abilities, indicating that the course of the 10-year yield is influenced by time specific factors like world-wide capital movements and monetary policies. Using the word “normal” is somewhat ambiguous in itself; if anything, theories of the term structure of interest rates-and studies trying to establish the best explanations for movements in the longer-term government yield show that there is no straightforward answer.

Whether MEP has achieved its envisioned effects through the portfolio rebalancing channel remains to see as the program is not completed. However, it can seem like credit flows have eased for the commercial-and industrial segment in the last half of 2011-and 2012. The same conclusion cannot be made for the consumer segment of the bank market, although bank lending officials state that there has been increased demand from also this segment in the last quarter of 2012.

Other studies on the effect of MEP-and other large-scale asset purchases, find a significant downward effect on the 10-year yield. As noted in section 7.3.1, studies suggest that the accumulated effect of MEP-and other large-scale asset purchases could at most have given a 85-100 reduction in the 10-year Treasury yield. Studies of quantitative easing also show that there has been a significant price-and yield effect on other debt securities, as envisioned through the portfolio rebalancing. For Operation Twist, Modigliani & Sutch (1966) and Swanson (2011), conclude that the accumulated effect on longer-term treasuries was at best 10-20 basis points.

Fed`s-and the FOMC`s forward guidance and quantitative easing programs are additional variables that could have induced the decline in the 10-year yield in the last years. The current low interest rate levels could also be a new, lower normal level if long periods of government debt accumulation has effect on the term structure of interest rates. Whether one can contribute the current low level of longer-term interest rates to MEP is therefore unclear.

There is still uncertainty regarding exit options for the Fed- and possible economical costs after years of accommodation policy. The same can be said when it comes to further options for the Fed in stimulating the economy, if the envisioned-and much needed economic recovery stagnate.

Whether Chubby Checkers prophecy; “more money to everybody”, comes true remains to see. Operation Twist-and MEP will certainly be a “learning by doing process” for the Fed.

As it turned out, Operation Twist was not at easy to do as the twist. Neither became it as popular.

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