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Finance

ANALYSIS OF EARNINGS, STOCK PRICES AND BOND YIELDS: THE FED MODEL APPROACH

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Helsinki, April 28, 2008

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ABSTRACT

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Title:	Analysis of Earnings, Stock Prices and Bond Yields: The Fed Model Approach
Faculty:	School of Business
Major:	Finance
Year:	2008
Master's Thesis:	Lappeenranta University of Technology
	71 Pages, 8 Tables, 7 Figures
Examiners:	Professor Mika Vaihekoski Professor Minna Martikainen
Key words:	stock prices, bond yields, market valuation, cointegration,market prediction, Fed Model

Prediction of the stock market valuation is a common interest to all market participants. Theoretically sound market valuation can be achieved by discounting future earnings of equities to present. Competing valuation models seek to find variables that affect the equity market valuation in a way that the market valuation can be explained and also variables that could be used to predict market valuation.

In this paper we test the contemporaneous relationship between stock prices, forward looking earnings and long-term government bond yields. We test this so-called Fed model in a long- and short-term time series analysis. In order to test the dynamics of the relationship, we use the cointegration framework. The data used in this study spans over four decades of various market conditions between 1964-2007, using data from United States.

The empirical results of our analysis do not give support for the Fed model. We are able to show that the long-term government bonds do not play statistically significant role in this relationship. The effect of forward earnings yield on the stock market prices is significant and thus we suggest the use of standard valuation ratios when trying to predict the future paths of equity prices. Also, changes in the long-term government bond yields do not have significant short-term impact on stock prices.

TIIVISTELMÄ

Tekijä:	Antti Helkala
Tutkielman nimi:	Osakemarkkinoiden arvostus suhteessa osake-, ja velkakirjamarkkinoiden tuottoihin: Fedin malli
Tiedekunta:	Kauppatieteellinen tiedekunta
Pääaine:	Rahoitus
Vuosi:	2008
Pro gradu-tutkielma	Lappeenrannan teknillinen yliopisto
	71 sivua, 8 taulukkoa, 7 kuvaajaa
Tarkastajat:	Professori Mika Vaihekoski Professori Minna Martikainen
Hakusanat:	osakkeet, velkakirjat, markkinoiden arvostus, yhteisintegraatio, markkinoiden ennustaminen, Fedin malli

Osakemarkkinoiden tulevan hintatason määrittäminen on yksi kaikkia markkinatoimijoita yhdistävä tekijä. Teoreettisen tarkastelun kestävä osakemarkkinoiden arvostustaso saadaan diskonttaamalla tulevaisuuden tuotot nykyhetkeen. Kilpailevat osakemarkkinoiden arvostusta mittaavat mallit pyrkivät määrittämään muuttujia, joiden avulla voidaan selittää markkinoiden arvostusta ja muutoksia, ja myös ennustaa tulevaa arvostusta.

Tässä tutkimuksessa tarkastelemme osakkeiden hintojen, tulevien tuottojen ja valtion pitkien velkakirjojen tuottojen välistä suhdetta. Testaamme näiden muuttujien välistä suhdetta, sekä pitkä - että lyhytkestoisten muutosten dynamiikkaa, aikasarja-analyysillä. Tutkimus suoritetaan yhteisintegraatiotesteillä, aineistolla joka tunnetaan myös nimellä Fedin malli. Tutkimuksessa käytetty aineisto koostuu yli neljän vuosikymmenen ajalta Yhdysvaltojen markkinoilta, aikaväliltä 1964-2007.

Tutkimuksen empiiriset tulokset eivät tue Fedin mallin käyttöä. Voimme todeta, ettei pitkien valtion velkakirjojen merkitys osakemarkkinoiden hintoihin ole tilastollisesti merkittävä. Tulevaisuuden tuottojen merkitys on havaittavissa, ja voidaankin todeta että markkinoita ennustettaessa perinteisten arvostusmittareiden käyttö on suositeltavaa. Lisäksi, lyhyellä aikavälillä pitkien valtion velkakirjojen muutoksella ei ole merkittävää vaikutusta osakkeiden hintoihin.

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1. INTRODUCTION

1.1 Background

Among academic researchers, conventional wisdom regarding the predictability of stock prices has changed dramatically over the past decades. Early empirical evidence favoured the random walk hypothesis for stock returns. However, the latest empirical evidence shows that stock returns are in fact, partly predictable. Evidence from researches such as Lo and MacKinley (1988) and Poterba and Summers (1988), has provided us with convincing evidence that accounting and financial variables seem to have power when trying to predict stock prices. It is clear that such evidence might provide important information for market timing and active asset allocation strategies.

It is easy to say that predicting future returns and stock market valuation is difficult. Even though efficient market theory suggests that market prices are always right, there is still need to analyse and forecast future returns. Two most common quantitative analysis methods are the calculation of intrinsic value (such as the dividend discount model) in order to compute a "fair" price at a certain time. Another approach is to search for stable relationships between the market and the variables that are assumed to affect the market valuation.

The calculation of an intrinsic value has a strong theoretical background but also stricter theoretical assumptions that usually do not fit into the real world. Also, the calculation of the fair price in a given time does not answer the question or give information of the future path of the market. The competing valuation methods that seek to find relationships within the market and the variables that might affect it are generally based on weaker theoretical grounding, or the theoretical assumptions must be adjusted to fit the reality. This competing method has found to be a success, however, in the sense that market movements can be explained by, and forecasted on the basis of variables that drive market valuations.

In this study, we will research the predictability of future stock market valuation by studying the fluctuations around the market value by using the expected earnings yield and the 10 year Treasury bond yield – also commonly known as the Fed model - which can be interpreted as a long term yield spread of stocks relative to bonds. [1] The very basic idea behind the Fed model is that stocks and bonds are substitutes. Why invest in stocks if bond yields are better? Rational investor must choose the more profitable investment also considering the amount of risk involved.

1.2 Objectives and methodology

The purpose of this study is the historical analysis of the relationship between stock prices, expected earnings and long term government bond yields in the United States. We use the cointegration framework in the time period of March 1964 to March 2007 in order to test the following research questions:

Q1 Is there a long-run relationship between earnings, stock prices and government bond yields?

Q2 How does deviation from this possible equilibrium impact stock prices in the short-run?

Q3 Do government bond yields play a significant role in the relationship?

[1] The use of the name Fed model in this paper refers to the earnings yield relation to a 10-year Treasury bond. The name of the model refers to a Federal Reserve System, i.e. the central banking system of the United States, which is believed to use the model for stock market valuation.

In this thesis we will test the conventional economic theory by trying to explain the long-run trend and valuation of the stock market. Earlier studies by authors such as Fama and French (1988), Cambell and Shiller (1988), Cambell and Vuolteenaho (2004) and Maio (2005) have found proof that the fundamental analysis is indeed the best way for determining long run trend and market earnings. However, there are also authors such as Brooks et al. (2001) and Tse (1995) who show that it is possible to model changes in the stock index.[2] Obvious question to ask is whether such a model can be used to forecast the future value of a stock index. On the other hand there is also proof that economic theory is not always best when trying to forecast market fluctuations in the short-run. Asness (2003), Clemens (2007) and Durré and Giot (2007), among other authors have concluded that Fed model is found to have explanatory power over short-term market fluctuations. We will use the Fed model to determine the short term adjustment process which acts to restore deviations from the equilibrium relationship and the fair market value.

In order to test the research question one, we use a cointegration framework. Before testing for cointegration we run a unit root testing that is necessary to assure the non-stationary of the time series for the cointegration to be used. The research questions two and three are also studied in the cointegration related variance decomposition, and Granger causality framework.

1.3 Limitations and structure

The empirical part of this paper concentrates on testing the Fed model in the cointegration framework. When keeping in mind the research questions that we stated above, it is preferred to study a substantially long dataset that can be used for the methodological part of this paper. We

[2] In particular, by error correction formulation to model changes in the log of a stock index.

prefer to work with the data from United States market, as there is reliable data for long enough time range. In addition to empirical analysis, we also provide the theoretical critique against the Fed model and possible problems with the methodology used to study the Fed model. To our knowledge, full cointegration analysis of both short-and long term analysis has only been conducted by Durré and Giot (2007). We want to contribute to this field of study by providing empirically sound analysis of the Fed model with a long dataset and also with the most recent data included.

Rest of the paper is constructed as follows, after the introduction we describe the origins of the Fed model and the earlier research that has contributed to this field of study. The earlier research part of the paper also explains the theoretical assumptions that are built inside the Fed model as it is very important to understand the possible problems when using relative valuation models such as the Fed model. After explaining the methodology we describe the data used in this study. In the fifth part we go through the results and explain the answers to the research questions. Finally, the sixth part concludes this thesis and presents ideas for further study.

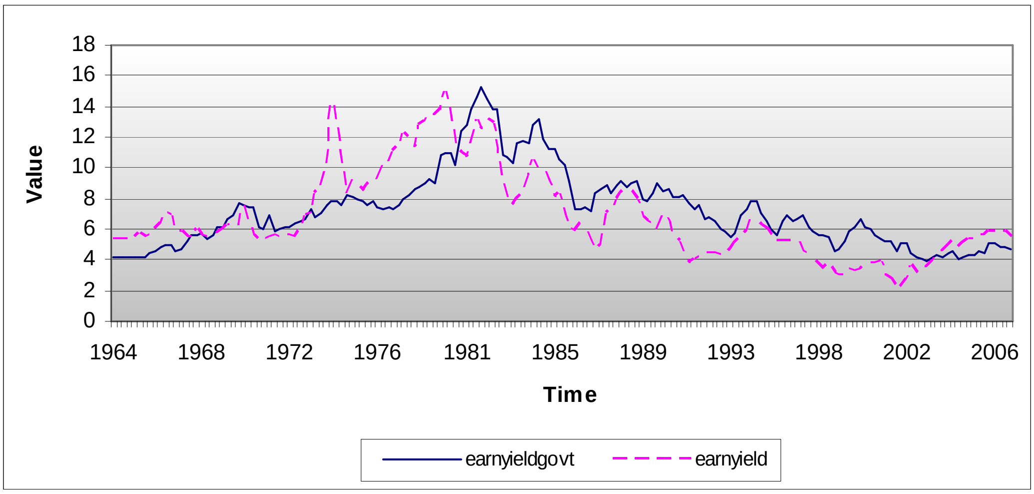
2. FED MODEL

2.1 The history of the Fed model

The origins of the Fed model date back to 1997 when the Federal Reserve Board of The United States broadcasted its Humphrey-Hawkins[3] report of July 22, 1997. The Fed noted in a speech of then a chairman Alan Greenspan that the ratio of prices in the S&P500[4] to consensus estimates of earnings over the coming twelve months had risen even further from levels that were already unusually high. In this speech Alan Greenspan also concluded that the changes in this ratio have been inversely related to the changes in long term Treasury yields.

Figure 1

The S&P500 Composite Index 12-month expected E/P ratio compared to a 10-year Treasury bond yield.



[3] Humphrey-Hawkins is an act of federal legislation by the United States Government. The act aims to full employment and balanced growth. It is designated to mandate such national economic policies and programs that are necessary to achieve full employment, production, and purchasing power; to restrain inflation; and to provide the development and implementation of such economic policies and programs. www.federalreserve.com

[4] Widely regarded as the best single gauge of the U.S. equities market, this world-renowned index includes 500 leading companies in leading industries of the U.S. economy. Although the S&P500 focuses on the large cap segment of the market, with approximately 75% coverage of U.S. equities, it is also an ideal proxy for the total market. www2.standardandpoors.com

Figure 1 shows the 12-month ahead E/P ratio and the 10-year Treasury bond yield gives a rough idea of why this relation has been widely used by market practitioners and media to try and explain the stock market movements by the changes in bond yields. Over the last 43 years the E/P ratio of S&P500 index has quite obviously tracked the Treasury bond yield. The following is shortened version of the Alan Greenspan's speech in the 1997 Humphrey-Hawkins report which gives a better insight of how The Federal Reserve of United States at least seemed to value the equity markets back in 1997:

> Equity markets have advanced dramatically again this year. Through mid-July, most broad measures of U.S. stock prices had climbed between 20 percent and 25 percent since year-end. Stocks began the year strongly, with the major indexes reaching then-record levels in late January or February. Significant sell-offs ensued, partly occasioned by the backup in interest rates, and by early April the NASDAQ index was well below its year-end mark and the S&P 500 composite index was barely above its. Equity prices began rebounding in late April, however, soon pushing these indexes to new highs. Stock prices have been somewhat more volatile this year than last. The run-up in stock prices in the spring was bolstered by unexpectedly strong corporate profits for the first quarter. Still, the ratio of prices in the S&P 500 to consensus estimates of earnings over the coming twelve months has risen further from levels that were already unusually high. Changes in this ratio have often been inversely related to changes in long-term Treasury yields, but this year's stock price gains were not matched by a significant net decline in interest rates. As a result, the yield on ten-year Treasury notes now exceeds the ratio of twelve-month-ahead earnings to prices by the largest amount since 1991, when earnings were depressed by the economic slowdown. One important factor behind the increase in stock prices this year appears to be a further rise in analysts' reported expectations of earnings growth over the next three to five years. The average of these expectations has risen fairly steadily since early 1995 and currently stands at a level not seen since the steep recession of the early 1980s, when earnings were expected to bounce back from levels that were quite low. (Federal Reserve Board, 1997)

After the report an analyst Ed Yardeni of Deutsche Morgan Grenfell named the relationship the Fed's Stock Valuation Model and started to publish reports that were using the model for stock market valuation. However, there has been debate that I/B/E/S has been publishing such a relationship between forward earnings, stock prices and treasury bonds since 1986. [5]

2.2 Earlier research

The stock valuation research and earnings forecasting has changed quite significantly during the last three decades. Earlier studies and theory concentrated on random walk process in stock price appreciation both short and long-term research. During the 80's and 90's more empirical evidence was found to support the stock and bond market predictability especially in long-term studies. We introduce the earlier research starting from older studies that paved the way for more advanced and sophisticated research methods that we will also use in this research.

As we move on to describe the earlier studies of market forecasting with valuation ratios, one should first understand what the stability of a valuation ratio itself implies about mean reversion. According to Campbell and Shiller (1988), if we accept the premise for the moment that valuation ratios will continue to fluctuate within their historical ranges in the future, and neither move permanently outside nor get stuck at one extreme of their historical ranges, then when a valuation ratio is at an extreme level either the numerator or the denominator of the ratio must move in a direction that restores the ratio to a more normal level. Something must be

[5] The Institutional Brokers Estimate System (I/B/E/S) is a unique service which monitors the earnings estimates on companies of interest to institutional investors. The I/B/E/S database currently covers over 18,000 companies in 60 countries. It provides to a discriminating client base of 2,000 of the world's top institutional money managers. More than 850 firms contribute data to I/B/E/S, from the largest global houses to regional and local brokers, with US data back to 1976 and international data back to 1987. (www.thomson.com)

forecastable based on the ratio, either the numerator or the denominator. For example, high prices relative to earnings - a low earnings / price ratio - must forecast some combination of unusual increases in earnings and declines (or at least unusually slow growth) in prices. The conventional random-walk theory of the stock market is that stock price changes are not predictable, so that neither the dividend–price ratio nor any other valuation ratio has any ability to forecast movements in stock prices. But then, if the random walk theory is not to imply that the earnings / price ratio will move beyond its historical range or get stuck forever at the current extreme, it requires that the earnings / price ratio predicts future growth in earnings.[6]

The documentation of the possible usefulness of earnings and market forecasting and ratios such as the price-to-earnings or it's inverse of earnings yield ratio have a long history as also explained by the Graham and Dodd (1962):

> Theoretical analysis suggests also that both the dividend yield and the earnings yield on common stocks should be strongly affected by changes in the long-term interest rates. It is assumed that many investors are constantly making a choice between stock and bond purchases: as the yield on bonds advances, they would be expected to demand a correspondingly higher return on stocks, and conversely as bond yields decline. (Security Analysis, 1962)

Earlier studies concentrated mainly on the standard present value model testing. The standard present value model has also been extensively tested at an index level. LeRoy and Porter (1981) studied and rejected the model and the more recent studies have not been able to prove otherwise. Campbell and Shiller (1987) used cointegration tehniques and found no significant long-term relationships i.e cointegrating vectors to support the present value model. Cochrane (1992) noted that time-varying discount

[6] The random-walk theory is a special case of the efficient-markets theory of stock prices. In general, the efficient-markets theory allows the equilibrium rate of return required by investors to vary over time. (See for example Campbell and Cochrane, 1999.)

factors could explain failures of testing the present value model. However, there is little evidence to support this argument.

Granger (1986) states that the economic theory suits the long-run equilibrium studies well enough, but in the short run there may be shocks that push the variables away from the equilibrium values. After moving away from the equilibrium, it may take some time for the equilibrium values to be restores. The important idea is that there is a force that ensures the returns to equilibrium. Granger's approach suits the stock markets quite well. Intuitively, the market valuation is driven by economic fundamentals in the medium- and long-run. In econometric terms, this means that the economic variables are cointegrated. In the short run however, the market can, diverge from the "fair" valuation levels for quite long periods of time. The deviation from this state of equilibrium can be substantial, but the market mechanisms ensure that the over- or undevaluation is restored when investors recognize the possible valuation gaps.

Keim and Stambaugh (1986) found evidence that expected returns vary in time. The regression analysis in their paper was restricted to only short period study, focusing on monthly returns. They found proof that changes in anticipated bond returns were predictable but for stock returns only the expected returns in January were predictable. Their study was the first remarkable regression based research that actually started the wide-spread discussion of predictability of earnings.

Campbell and Shiller (1988) noted that real earnings moving average can be used to predict the dividends that were to be paid out by a company. They also found out that E/P-ratio explains quite well the forward earnings, especially in the long run. In their research the E/P-ratio was the best vehicle to explain the stock market earnings in the long run.

Fama and French (1989) concentrated on variables affecting the stock and bond market earnings. Research was conducted to test and study the possibility that the variables affecting the stock and bond market could be the same. They conclude that corporate bonds, short term government bond earnings yield and stock market earnings yield have similar variables affecting the expected earnings.

Ziemba and Schwartz (1991) studied Japanese stock market by using a long bond minus earnings yield model as a stock market danger indicator. The main idea is to construct a tool for strategic asset allocation for stock and bond markets. The stock and bond markets are treated as substitutes competing for investment funds, hence there should be a tool to determine whether to invest in stocks or bonds and with a proper allocation. When the bond yields are high, bonds provide a high coupon payments plus capital gains if interest rates decline. Stock market earnings are at the same time discounted with higher nominal interest rates, and thus the value of stock market should decrease as well. Ziemba and Schwartz (1991) conclude that if this spread is well above the historical median, the stock market should move closer to the historical equilibrium level when compared to bonds.

Ziemba and Schwartz (1991) also show that this measure was able to predict the October 1987 crash in the US and Japan. They studied this measure during 1948 to 1989 and the results conclude that whenever the measure was in the 95% confidence danger zone there was a decline of 10% or more within one year. Also, they can show that the measure was in 99% confidence danger zone in late 1989 prior to the 1990-1991 decline of the Nikkei stock average. As a final conclusion they add that the measure was able to predict all major stock market crashes in Japanese market during this 43 year long period, even though there were some 10% declines that were not predicted by their model.

Berge and Ziemba (2003) continued the study of predictive ability of the Ziemba and Schwartz measure. They developed the measure with various data estimation techniques for the US, Japan, Germany, Canada and the UK. For 1970-2003 Berge and Ziemba found that the measure provided signals to enter and exit the stock market that were also superior to a very common benchmark of buy and hold strategy. They also found signals that predicted large declines.

Mills (1991) uses a cointegration method to model stock price index (Pt), the associated dividend index (Dt) and a 20-year government bond yields (Rt).[7] Durré and Giot (2007) note that although not set in the cointegration framework, the so called GEYR ratio is very similar to what Mills (1991) uses. The GEYR ratio, or gilt-equity yield ratio, is defined as the ratio of the coupon yield on long-term government bonds to the dividend yield on the stock index. Furthermore, Mills' approach proponents argue that the GEYR ratio fluctuates around a central value and that any deviation from this equilibrium state indicates that the stock market is over- or undervalued.[8] Thus, the current GEYR ratio should have predictive power when forecasting future stock index returns.

Shiller and Beltratti (1992) studied the bond and stock market relations by a present value model. They conclude that real stock market valuation and long-term bond yields have negative correlation stronger than assumed. However, they could not find enough evidence that stock market would overreact more than the bond market, which is also what Modigliani-Cohen hypothesis states.

Lander et al. (1997) formalize Graham and Dodd's[9] observation that common stock and bond valuations are linked by an equilibrium relation

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[7] Mills (1991) concludes that for the UK data, the three series expressed in logs, are cointegrated (with one cointegrating vector). This issue is again discussed in the Sections 3 and 4 of this paper.

[8] See Clare et al. (1994) or Levin and Wright (1998).

[9] Graham and Dodd (1962) noted that earnings yield on common stocks should be strongly affected by changes in long-term interest rates.

between forecasted earnings yields and bond yields and that stock prices tend to move to restore deviations from this equilibrium. With the resulting model they obtain one-month-ahead forecasts of S&P500 returns and implement a market timing trading rule that alternates between the S&P and cash. For the 1984-1996 sample period, the trading rule performed well compared to the alternative of buying and holding the S&P500 and yielded significantly higher returns (in a statistical sense) than what would be expected by pure chance. Surprisingly, the rule also tended to produce returns with significantly lower variance.

Harasty and Roulet (2000) study the stock market returns predictability by constructing a dividend discount model equation to determine a fair market value that can be compared to forecasting model values. They develop a two-step econometric model. The first step is to estimate long-run relationship between the market and its fundamentals according to present value theory. The error correction model enables the identification of cointegrating relationships between the stock markets forward earnings and long-term interest rates. They conclude that concepts of long-run fair-value and short-run deviations formalize the intuitive vision investors have of the functioning of financial markets. The long run regression confirms the correlation between the market and the fundamental that many investors have in mind, and quantifies this relationship. It provides investors with an order of magnitude for present and previous valuation gaps and how long they have lasted. The second regression sheds light on additional variables that have and impact in the short run. According to Harasty and Roulet (2000) the model can be a useful tool in the investment process by providing a consistent framework of analysis and indicating the order of magnitude of the key variables.

Harris and Sanzhez-Valle (2000) note that when the time series forecasting is to be used as a tool for trading strategy, to be applicable the equity indice also has to be a tradable one. Buckle, Clare and Thomas (1999) use the stock-gilt relationship to forecast returns on the FTSE 100 futures contract, which is tradable, and find that while their model has substantial in-sample explanatory power, the trading strategy returns that it yields are negligible. They therefore conclude that the *ex post* predictability that they find is not inconsistent with market efficiency, and suggest that the evidence of profitable trading strategies based on return predictability reported elsewhere may be attributable to the fact that they are normally defined over the return on non-tradable indices. The profitability of the trading strategies identified in this paper would therefore have to rely on the ability of investors to trade in a small number of liquid stocks that mimicked the index portfolio.

Historical studies of stock prices over long periods of time of one hundred years and more appear in Constantinides (2002) and Siegel (2002). These studies show that stock prices dominate other asset classes such as bonds, cash and gold over long periods of time. However, there has been long periods of time when stock market underperformed and some of these time periods have been very long. As we are studying a long time period as well, it will be one of the interesting questions to analyze possible periods of under-and overvaluation (according to the Fed model) and the factors that might have caused them.

Asness (2003) studies the possible long-, and short-run forecasting power of the Fed model. For forecasting real stock returns over long horizons it is found to be best to use P/E ratio or some other reasonable measure of valuation without regard to nominal interest rates. For forecasting relative stock versus bond returns the comparison of P/E or the like to a real bond yields is the suggestion made by Asness, Fed model is found to have some power when explaining why P/E's are where they are, based on investors behaving in a similar to the past. Asness recommends the use of modified Fed model with volatility taken into account. Even though there is some explanatory power over the P/E levels, it should not be confused to a tool for making long-term recommendations for investors. The final conclusion is that the Fed model can be used for making short-term forecasts as it is found to be a success at explaining how investors actually set current market P/E's. There is found to be strong evidence that investors set stock market E/Ps lower (P/Es higher) when nominal interest rates are lower and *vice versa.*

Yardeni (2003) has also studied the Fed model method to find signals predicting large stock market moves. The stock market prices are found to be rising and continue to rise even when the measure signals the danger zone and thus suggests a market decline. Yardeni finds that stock markets eventually decline for 10% or more from the initial signal level within one year. Similarily stock prices continue to fall when the measure suggests an increase but eventually the prices are found to rise. Yardeni's model is more effective in the US and Japan and less effective in Germany, Canada and the UK.

Salomons (2004) builds a tactical asset allocation (TAA) tool based on Fed model. His TAA-model is found to be quite succesful in theory, but lacks some very important qualifications to be used in practice, mainly in the long run asset allocation. In the long run only absolute valuations (earnings yield) have predictive power over subsequent returns, but in the short run this is like rolling a dice. For short term forecasting the well-known FED model, a relative valuation model that compares earnings yield and bond yield, is popular but theoretically flawed. Salomons makes a strong statement and says that because the Fed model compares a real with a nominal variable, it could be rejected on first principles, which is also what we discuss in this paper. Despite this fact, his model explains the variation of earnings yield to some extent. This is due to the fact that investors suffer from money illusion and consistently confuse real and nominal variables. When risk perceptions are added, it shows how investors set the earnings yield as a function of bond yields and the relative volatility of equity versus bond. Basically, it describes what valuation investors are willing to pay for equities. When the actual earnings yield is substantially above the perceived yield, expected returns for the short-run are high and vice versa. A tactical asset allocation model aimed at benefiting from these observations has persistent positive excess returns. Strategic asset allocators, who invest for the long run, should disregard relative valuation models and only focus on absolute earnings yield. If earning yields are below their historic average, expected long-run returns are low. Still tactical asset allocators can pick up some additional short-term returns when risk adjusted relative valuations are diverging.

Johnson (2005) developed a model describing the relationship between the stocks and bonds of a particular firm. The study is unique in that it is the first and one of the most conclusive paper to develop a model relating the stock and bond processes for a single firm rather than for aggregated stocks and bonds in the overall economy. Johnson finds that at corporate levels the stock-bond relationship is somewhat useful as there is found to be cointegrating relationship and the stock price yields can be predicted by the changes in corporate bonds. However, this study is very interesting example of stock-bond relationship but even with the largest companies the corporate bond market is somewhat illiquid and thus there seems to be no chance for generating abnormal profits.

Maio (2005) uses the yield gap - the difference between the stock market earnings yield and the long term bond to build a simple measure of the yield spread of stocks versus bonds. He derives a dynamic accounting decomposition for the yield gap, where it is positively correlated with future stock market returns and negatively correlated with future dividends to earnings payout ratios, growth rate on future equity earnings and future bond returns. This decomposition provides the rationale for the predictive role of the yield gap over asset returns. Maio finds that his model has greatest forecasting power at near horizons declining gradually with the horizon, contrary to other variables which have forecasting power increasing with horizon. The yield gap method has a very significant effect on bonds, forecasting negative excess returns for long-term bonds, both at short and longer horizons ahead. The out-of-sample forecasting power of the yield gap, is found to be economically significant, as indicated by the significant gains in the Sharpe ratios associated with dynamic trading strategies conditional on the predictive ability of yield gap and other variables. Thus, it is found that the yield gap can be an important variable to be used in dynamic portfolio optimization.

Koivu et al. (2005) used vector equilibrium correction (VEqC) model along with VAR model and found out that VEqC model is more useful when incorporating long-run equilibrium relationships derived from economic theory with short-run dynamic characteristics deduced from historical data. Their results are in line with Ziemba and Schwartz (1991) and Berge and Ziemba (2003) results stating that the Fed model and related bond-stock yield difference have some predictive power related to future crashes and price rises. Like the bond-stock yield model, the Fed model is also better in predicting crashes than for subsequent stock price rises.

Giot and Petitjean (2006a) form a valuation model with an intent to predict stock market returns. Their model includes both valuation ratios and bond market components, with both short-and long-term bonds. The short-term interest yield and, to a lesser extent, the long government bond yield are found to be the best out-of-sample predictors of stock returns. However, the out-of-sample predictive power of these variables does not appear to be economically meaningful across countries and investment horizons. Stock returns of the U.S. appear to be predictable in-sample. While such evidence does not completely vanish out-of-sample, forecasting gains appear to be very limited. The economic analysis of predictive regression strategies generally confirms these findings.

Giot and Petitjean (2006b) create a bond-equity yield ratio (BEYR) pricing tool to dynamically allocate capital between equities and long-term bonds on a monthly basis. More precisely, they assess the short-term predictive ability of the BEYR from an economic perspective by implementing trading strategies that rely on either the extreme values or regime switches of the

BEYR. They also state that active strategies outperform passive benchmark portfolios in the US market with a relatively high Sharpe ratio, somewhat validating the Fed model approach. They conclude that the regime-switching strategy (which is based on the forecasted probability of being in the high regime of the BEYR) appears to be the best strategy to time the market. However, the performance of the regime-switching strategy is closely correlated to the extreme value strategy (which is based on the 90th percentile of the historical distribution of the BEYR). When one of the two strategies fails to beat the buy-and-hold benchmark portfolios, the other usually fails too (and vice versa).

Giot and Petitjean (2006b) also note that in practice, the Fed model suggests asset allocation decisions based on the perceived degree of over- and underpricing of the S&P500 with respect to its fair value. Similar models have been suggested in the literature on empirical asset pricing. For example, Pesaran and Timmermann (1995) include both the interest rates and equity yields as possible explanatory variables of stock market movements. Shen (2003) uses the spread between the earnings yield and prevailing interest rates to time the market.

Clemens (2007) finds that when used appropriately, the Fed model can be a useful tool. When predicting absolute stock returns, price-earning ratios and the Fed model are not competing but complementary models as the former (P/E) has its advantage over the long term (5-10 years), while the latter (Fed model) has its advantage over the short and medium term with the optimal prediction horizon being in the interval of 12-36 months. However, being a relative valuation model, the Fed model works best when predicting relative returns of stocks versus bonds. The difference in the optimal horizon is of course useful for investors and may be due to P/E ratios being more persistent than the E/P-Y spread in the Fed model. Like the prediction models often do, the Fed model is found to work best at extreme observations.

Durré and Giot (2007) estimate cointegrated models for thirteen countries and ascertain if there exists a long-run relationship between the earnings index, the stock index and the long-term government bond yield. Their empirical results show that such a long-run relationship indeed exists for many countries (including the United States and the United Kingdom) but that the long-term government bond yield is not statistically significant in this relationship. Put simply, the long-term government bond yield does not affect the 'equilibrium' stock market valuation. They also test the short-term effects, and show that rising/decreasing bond yields do impact contemporaneous stock market returns and thus have an important short-term impact on the stock market.

2.3 Theoretical background and modeling

When evaluating stock market in the long run we most often use fundamental analysis. Fundamental analysis is a method of evaluating stocks intrinsic value by studying the related economical, financial, quantitative and qualitative factors. Fundamental analysts try to study and understand every factor that can affect security prices. The goal of fundamental analysis is to produce a fair price for a security considering the surrounding environment. After producing a fair price for a security, one can use the data to evaluate the possible under- or overpricing of the security. For assessing stocks, this method is most often used by analyzing dividends, earnings, future growth and return on equity to determine a company's underlying value and potential future growth. In terms of stocks, fundamental analysis focuses on the financial statements of the company being evaluated.

We move on to describe the Fed model and its inputs in the following section and also provide analysis that leads to the Fed model that we will assess in the methodological part of the thesis. We describe the connection of the Fed model to the classical stock market valuation models in order to rationalize the use of this model.

For an investor to long one share in a given stock, the expected holding period return from t to $t+1$, HPR^e_{t+1} can be expressed as the sum of the expected dividend, D^e_{t+1}, and the expected change in the stock price, $P^e_{t+1} - P_t$:

$$HPR^e_{t+1} \equiv \frac{P^e_{t+1} - P_t}{P_t} + \frac{D^e_{t+1}}{P_t} = \frac{P^e_{t+1} + D^e_{t+1}}{P_t} - 1 \qquad (1)$$

For the sake of the analysis, we assume that the expected return is constant h i.e. $HPR^e_{t+1} = h$. Rearranging the previous equation, we then have:

$$P_t = \left[\frac{P^e_{t+1} + D^e_{t+1}}{1+h} \right] \qquad (2)$$

Solving equation (2) N periods forward, we get the usual specification for the price of the stock:

$$P_t = \left[\sum_{i=1}^{N} \left(\frac{1}{1+h} \right)^i D^e_{t+1} \right] + \left[\left(\frac{1}{1+h} \right)^N P^e_{t+N} \right] \qquad (3)$$

When $N \to \infty$, the second term on the right hand side of the Equation (3) tends to zero and we are left with:

$$P_t = \sum_{i=1}^{N} \left(\frac{1}{1+h} \right)^i D^e_{t+1} \qquad (4)$$

If dividends are expected to grow at a constant rate d, equation (4) can be simplified as:

$$P_t = \frac{D_{t+1}^e}{h-d} = \frac{(1+d)D_t}{h-d} \qquad (5)$$

which holds true only if $h > d$. This is the classical stock valuation model of Gordon (1962).[10] Equation (5) can also be written as:

$$P_t \frac{\delta(1+d)E_t}{h-d} \qquad (6)$$

where δ is the payout ratio and E_t are the earnings of the firm at time t. Finally, the required rate of return is usually expressed as $r_f + RP$, where r_f is for example the 10-year government bond yield and RP is the risk premium demanded by investors (in excess of r_f) to hold the stock. This finally yields:

$$P_t = \frac{\delta(1+d)E_t}{r_f + RP - d} \qquad (7)$$

The general representation of the Fed model is quite closely related to the equation (7). The general representation of the Fed model is as follows:

$$\frac{E_t^e}{P_t} = \alpha + R_t \qquad (8)$$

where, α is an intercept term that is often interpreted as a constant risk premium, E_t^e are forecast (expected) earnings, P_t the stock price index, and R_t the 10-year nominal government bond yield. However, the α term

10 Gordon (1962) developed a dividend growth model and also contributed to establish the relationship between dividend yields and earnings yield compared to interest rates. Also, Weigand and Irons (2006) found that the E/P and Y time series in the Fed model became cointegrated around 1960, suggesting increased investor awareness of the relationship.

is quite often omitted in the discussions of the Fed model. For instance, Koivu et al., 2005) leave the α term off from the equation, thus using the so called "ratio" version of the Fed model:

$$\frac{E_t^e}{P_t} = R_t \tag{9}$$

This equation above gives us a ratio that can be used as a "fair" value for equities, with given variables. This version is problematic to use as the denominator (interest rate) approaches zero.[11] The ratio is less intuitive than an arithmetic difference for most people.

The Fed model can also be presented as the following "spread" version which brings similarities to the CAPM and is thus intuitively easy to understand for most investors.

$$\frac{E_t^e}{P_t} - R_t \tag{10}$$

Durré and Giot (2007) discuss that the present value relationships such as described above provide the framework for stock yield - bond yield relationships as used in the Fed model which we will characterize later on. In this simplified framework, declining interest rates or bond yields lead to higher stock prices, provided that the growth rate of earnings is not affected. In the same vein, an upward revision in expected earnings (or their long-term growth rate) leads to a stock price appreciation for the firm, provided that the discount rate does not increase when the growth rate of earnings increases.

The mechanical relationship implied in the Equation (7) also states that market participants constantly arbitrage the stock and bond market. When

[11] For instance, the interest rate has been very close to zero in Japan during the early 21st century.

money has to be invested and interest rates are low it is expected that this money inflow will mostly find its way in the stock market, which is especially true if dividend yields are high. The opposite should be true when interest rates are high. As such, there exists a substitution effect between stocks and bonds which is strongly shaped by the relationship of the dividend yield to the bond yield. According to Durré and Giot (2007), another example of could be the so called “carry-trade”, which means that the market participants would take advantage of the low interest rates and purchasing stocks on a margin. In practice, low interest rate environment supports stock prices as portfolio managers use low borrowing costs when buying equities and when the interest rates rise these equities would be sold when the borrowing costs rise.

It can be seen and is also underlined by Vila-Wetherilt and Weeken (2002) that the Equations (6) and (8) are strongly related if assumed that $\delta = 1$ and $d = 0$. This shows that the Fed model is very similar to BEYR or GEYR framework,[12] with anticipated earnings instead of dividends and 10-year government bond instead of gilts or bonds. Although these studies do not directly relate to the Fed Model, BEYR or GEYR they are quite similar, and there has been numerous academic studies that focus on the ability of dividend yields and earning yields to predict equity returns and stock market valuation. (See e.g. Fama and French (1988, 1989); Campbell and Shiller (1988); Shiller (1989); or Campbell and Shiller (1998, 2001)).

[12] Bond-Equity Yield Ratio (BEYR) and Gilt-Equity Yield Ratio (GEYR) are very similar to the Fed model method. The GEYR method is used and studied in United Kingdom and BEYR method outside the UK. Clare et al. (1993) provide an ECM based study on the GEYR ratio.

2.4 Theoretical questions

2.4.1 Inflation illusion

Since the so-called Fed model has become popularized by many practitioners and academics, it has also faced lot of criticism over the theoretical background and the simplicity of the model.

A version of the money illusion hypothesis is the inflation illusion hypothesis proposed by Modigliani and Cohn (1979) to explain aggregate stock market valuations. According to Modigliani and Cohn, economic agents fail to incorporate the effect of expected inflation in forecasting nominal earnings, but at the same time incorporate the effect of expected inflation on nominal discount rates. Modigliani and Cohn (1979) observed that in late 1970s investors were using a model quite similar to what we in this paper call the Fed model. Their study finds that investors were wrongly pricing equities to a very low P/E because interest rates and inflation were high. Investors were found to confuse the real and nominal. They were also able to use this logic to predict the bull market of the 1980s and 1990s.

Durré and Giot (2007) state that in contrast to the developments of the Gordon model which authorizes a discussion of the impact of inflation, the earning yield (expressed in real terms by definition) is here simply equalled to a nominal bond yield. At equilibrium, both should be equal, although one compares a real variable with a nominal variable. Cambell and Vuolteenaho (2003) explain that the simplest form of the model Equation (9) implies a strong correlation between the earning yield and inflation, as most variations in nominal bond yields are explained by inflation. The role of inflation has been discussed by many others among Marshall (1992), Boudoukh and Richardson (1993), Anari and Kolari (2001) and Spyrou (2004). Even though there is empirical evidence that shows that equities could be a good hedge against inflation, the role of inflation and its supposed effect on stock prices is not clear in the Fed model. Decreasing inflation can lead to a smaller nominal earnings growth rates, which thus affects the numerator (earnings and their growth rate) and denominator (discount factor) of the valuation model.

Durré and Giot (2007) also underline that when focusing solely on the earnings growth without any adjustment for the firms wealth given specific cases (e.g. due to changing inflation environment), a debt capital gain error is made. One has to also understand that when there is increasing inflation that reduces the nominal earnings of the firm, the inflation also erodes the debt, which increases the real value of the firm. The simplest form of Fed model as shown in Equation (9) faces both of the shortcomings explained above.

Feinman (2005) argues that although inflation clearly affects bond yields it should not affect earnings yields. This is due to the fact that although changes in inflation are inversely related to stock prices through R_f , they also are positively related to stock prices through the expected growth of earnings *(G)*. In other words, these two effects of inflation on prices should cancel out and leave earnings yields unchanged.

Basu et al. (2005) examine whether financial analysts' earnings expectations fully incorporate information about expected inflation. Basu et al. notify that even though the investors earnings expectations might vary from analysts earnings expectations it is likely that both suffer from inflation illusion.

One reason for interest in the relationship between long and short rates is that most central banks at some time or another attempt to influence short-term interest rates as a lever on the real economy, in an attempt to ultimately influence the rate of inflation. Changes in short rates (with unchanged inflationary expectations) may influence real inventory holdings and consumers' expenditure. Short term interest rates may have an effect on interest rates on long maturity government bonds; this is the yield curve or term structure relationship. The behaviour of bond prices and interest rates is very interesting as a test-bed for various behavioural hypotheses about market participants and market efficiency. Bond prices may shed light on the validity of the EMH, the results of which may be compared with tests based on stock returns and stock prices. (Cuthbertson and Nitzsche, 2005)

Siegel (2002) neatly concludes the discussion of inflation and says that if it is assumed that bonds are the major asset class that competes with stocks in an investor's portfolio, one might expect that low interest rates would be favourable for stocks. But since in the long run low interest rates are caused by low inflation, the rate of growth of earnings, which depends in large part on the rate of inflation, will be lower also. Over long periods of time, changes in the inflation rate cause changes in earnings growth of the same magnitude and do not change the valuation of stocks.

2.4.2 Interest rate

Ritter and Warr (2002) examine two possible problems regarding the estimation of the Fed model as specified by it's simplest form that is shown in Equation (9). When using 10-year nominal interest rate on government bonds, the discount rate is not adjusted for risk. Ritter and Warr (2002) define this as a capitalization error.

When we move further from the valuation gaps, economic theory assumes that the stock market valuation is based on present value models, i.e. discounting the forward dividends (earnings) into the present. Stock market valuation is thus determined by dividends (earnings) and the interest rate of which is used as a discount rate. When thinking of the volatility of these two variables, the stock market volatility can be seen as very high compared to the interest rate or dividend volatility. Thus, it can be argued that the market is rarely "fairly" valued in the short run. Instead, the market valuation seems to fluctuate around it's equilibrium valuation in the short run at least.

The implicit assumption that is build inside the Fed model states that nominal bond yield is mainly explained by the real rate. However, many authors such as Mishkin (1990) have shown that the expected long-term inflation is the main driving factor in long-term interest rates, also stating that the real rate should be relatively stable and disconnected from the nominal levels. As a result, it is expected that changes in the long-term expected inflation will not affect the earning yield (i.e. inflation is supposedly neutral for the earning yield while there is an inflation premium in R_t). Durré and Giot (2007).

In contrast to well renowned and studied relationship of determining stock prices and anticipated returns by valuation ratios such as P/E, E/P or B/P the Fed model extends into the role of interest rate as a valuation method. Philips (1999), Cambell and Shiller (1998, 2001) or Jones et al. (2002) show that valuation ratios are the main determinants of future stock price performance and that the bond yields do not have much explanatory power. The interest rate problem arises and is quite easily shown by a following example also used by Durré and Giot (2007); The Fed model takes as input the nominal bond yield to set the 'right' stock index price (if the nominal bond rate would decrease to 1% for instance, the 'right' P/E ratio would be at 100).

2.4.3 Risk premium

Harasty and Roulet (2000) note that deviations from equilibrium (fair) value occur mostly when investors adjust their required risk premium to the prevailing environment. They surmise that the changes have three sources: changes in economic and financial variables other than earnings and interest rates; changes in the difficulty of estimating the fair value; and changes in investor sentiment.

Harasty and Roulet (2000) among Arnott and Henriksson (1989), Solnik (1993), and Ferson and Harvey (1994) discuss that the first source of volatility of the risk premium is the business cycle. When liquidity rises, the interest rates are driven down and the risk premium shrinks as risky assets become more attractive to investors, thus making the prices climb up. Second, the estimation of fair value can depend on market conditions. The volatility of interest rates can increase or decrease, or the fundamentals in microeconomic risk levels can change proceeding from changes in macroeconomy. Again, macroeconomic variables can be used to determine and track this risk. Third, investors behaviour is known to depend heavily on the sentiment which also impacts the required risk premium. Investors over- and underreaction to information as well as herd effect are shown to effect the market. The variations in market risk premium affects the short-run analysis but the long-run market valuation is more dependant on fundamentals that bring the market back to its fair value.

Harasty and Roulet (2000) point out that the evaluation of the intrinsic value of the market needs a proper risk premium. They offer a “equilibrium” risk premium as the evaluation for intrinsic value is needed. The use of previous periods periods implicit risk premium is thus not possible, as that variable retraces the short-run factors such as investor sentiment, change in appreciation of risk and seasonality. Harasty and Roulet (2000) also note that one could also use the average historical implied risk premium calculated over one or several complete “cycles”, i.e., the periods of time during which the market has deviated from and returned to its intrinsic value. This would be equivalent to assuming a priori that 1) stock prices revert to their intrinsic value, an assertation that is by no means trivial, and 2) on average the market has been in equilibrium during the period. Empirically, this risk premium varies considerably when one changes the calculation period, making it difficult to estimate with confidence.

To conclude this section of describing theoretical challenges behind and inside the Fed model that we use in this paper, we can say that when using Fed model as a valuation tool, investor has to understand that there are mainly two inflation related issues to understand. (1) capitalizing real cash flows at nominal rates and (2) failing to incorporate shareholder capital gains arising when inflation reduces the real value of fixed nominal liabilities. One also has to understand the interest rate and risk premium related questions that are the most substantial part (that is missing) of the most basic version of this model. However, We follow the Durré and Giot (2007) and Ritter and Warr (2002) view that to overcome these errors have no theoretical impact upon the estimates since the accounting earnings include inflation holding gains, and thus creating a connection between expected earnings and inflation. Also, the inflation illusion problem of analysts expected earnings does not come into the picture in this study, as we use the 1-year ahead earnings as a proxy for expected earnings. Also, we want to test the Fed model at the simplest form that is most often described to be used by practitioners and quoted by the media.

3. METHODOLOGY

3.1 Cointegration framework

Modeling tools such as the cointegration and error correction models provide us with tools that can be used for the analysis of stock market returns and valuation. Granger (1986) states that at least sophisticated level of economic theory lies the belief that certain pairs of economic variables should not diverge from each other by too great an extent, at least in the long run. Thus, such variables may drift apart in the short run or according to seasonal factors, but if they continue to be too far apart in the long, then economic forces, such as market mechanisms or government interventions, will begin to bring them together again.

All time series are characterized with respect to stationarity, drift and trend using the standard unit-root methodology, Augmented Dickey-Fuller. After that, we use Johansen's test to determine if cointegration exists among the system of 10-year government bond yield, stock prices and 1-year ahead equity earnings, all expressed in logs. Engle and Granger (1987) have shown that, if a system of variables is cointegrated, then these variables are tied together in a long-run equilibrium relationship. These relationships can be seen as steady-state, long-run equilibriums to which the time series eventually adjusts after the time series is destabilized.

3.2 Stationarity and unit root testing

There are several reasons why the concept of non-stationarity is important and why it is essential that variables that are non-stationary be treated differently from those that are stationary. For the purpose of the analysis, a stationary series can be defined as one with a constant mean, constant variance and constant autocovariances for each given lag (Brooks 2002). This means that with stationary series the time difference affects the autocovariances, not the time of observation. Therefore before tests for cointegration can be undertaken, it is necessary to test whether the time series is integrated to the same order-that is, each requires the same degree of differencing to achieve stationarity.

The testing of autocorrelation function (acf) of the series of interest would be obvious but inappropriate method to test for unit root. Although shocks to a unit root process will remain in the system indefinitly, the acf for a unit root process (a random walk) will often be seen to decay away very slowly to zero. Thus, such a process may be mistaken for a highly persistent but stationary process. Hence it is not possible to use the acf or pacf to determine whether a series is characterised by a unit root or not. (Brooks 2002)

In order to test for the unit root, we apply the conventional augmented Dickey-Fuller (ADF) test. To test for cointegration, Johansen's methodology is followed. This methodology enables testing for the presence of more than one cointegrating vector.

3.3 Augmented Dickey-Fuller test

The early and pioneering work on testing for a unit root in time series was done by Dickey and Fuller (Fuller 1976; Dickey and Fuller, 1979) The basic objective of the test is to examine the null hypothesis that $\Phi = 1$

$$y_t = \phi y_{t-1} + u_t \qquad (11)$$

Against the one-sided alternative $\phi < 1$. Thus the hypotheses of interest are

H_0: series contains a unit root

versus H_1: series is stationary

In practice, the following regression is employed, rather than (1), for ease of computation and interpretation

$$\Delta y_t = \psi y_{t-1} + u_t \qquad (12)$$

So that a test of $\phi = 1$ is equivalent to a test of $\psi = 0$ (since $\phi - 1 = \psi$). Equation (12) is quite often preferred because it makes more complex autoregressive models such as AR(p)-processes easier to calculate.

Dickey-Fuller (DF) tests are also known as τ-tests: $\tau, \tau_\mu, \tau_\tau$. The second and third of these tests, τ_μ, τ_τ, are equivalent to the first, except that the second and third allow for a constant, and a constant and deterministic trend, respectively. Equation (13) is a regression equation which includes a constant α to be deterministic factor and thus we have constructed a mathematical definition for τ_μ-test. Equation (14) is mathematical definition for τ_τ-test, because we have added a constant α and a deterministic time trend δt.

$$\Delta y_t = \alpha + \psi y_{t-1} + u_t \qquad (13)$$

$$\Delta y_t = \alpha + \delta t + \psi y_{t-1} + u_t \qquad (14)$$

The parameter ψ is the subject of interest when used pure random walk model or augmented models. When $\psi = 0$, there is a unit root for researched time series. Thus time series is non-stationary and suitable for co-integration test.

Augmented Dickey-Fuller (ADF) test is used to study the order of integration of the variables. A constant term is included in the ADF test if the series clearly seems to be trending or if the ADF test without the constant term suggests that the series is exploding. In some cases it is seen worthwhile to study the existence of a unit root further by employing the Phillips-Perron[13] (PP) unit root test or the KPSS[14] test in which stationarity is the null hypothesis. (Oikarinen 2006)

Traditional Dickey-Fuller tests are valid only if u_t is white noise. In particular, u_t is assumed not to be autocorrelated, but would be so if there was autocorrelation in the dependent variable of the regression Δy_t which has not been modelled. If this is the case, the test would be "oversized", meaning that the true size of the test (the proportion of times a correct null hypothesis is incorrectly rejected) would be higher than the nominal size used (e.g. 5%). The solution is to 'augment' the test by using p lags of the dependent variable. The alternative model in case is now written

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + u_t \qquad (15)$$

The lags of Δy_t now 'soak up' any dynamic structure present in the dependent variable, to ensure that u_t is not autocorrelated. The test is known as an augmented Dickey-Fuller (ADF) test and is still conducted on ψ, and the same critical values from the DF tables are used as before. (Brooks 2002)

A problem now arises in determining the optimal number of the lags of the dependent variable. There are two ways to do this. First, the frequency of

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[13] Phillips and Perron have developed a more comprehensive theory of unit root non-stationarity. The tests are similar to the ADF tests, but they incorporate an automatic correction to the DF procedure to allow for autocorrelated residuals. The tests often give the same conclusions as, and suffer from most of the same important limitations as, the ADF tests. (Brooks 2002, 381)

[14] For more information on KPSS see: Kwiatkowski et al. (1992)

the data can be used to decide. So, for example, if the data is monthly, use 12 lags, if the data is quarterly, use 4 lags and so on. Second, an information criterion can be used to decide. Information criterions are used by choosing the number of lags that minimises the value of an information criterion. (Brooks 2002) Since we use quarterly data in this research, we have used 4 lags as the optimal lag length. This decision is later discussed with more depth on the methodological problems part of this paper.

3.4 Cointegration analysis

3.4.1 The Fed model in cointegration framework

In most cases, if two variables that are I(1) (unit root) are linearly combined, then the combination will also be I(1) (unit root). This means that variables would not have long term equilibrium. If non-stationary variables I(1) that are integrated in the same order can be found to have a stationary linear combination I(0), the variables are cointegrated. More generally, if variables with differing orders of integration are combined, the combination will have an order of integration equal to the largest. (Brooks 2002)

In practice, cointegrated variables include a long term relation even though they can deviate from their relationship in the short run. (Brooks 2002) Explains this relationship with following explanation: The easiest way to understand this notion is to consider what would be the effect if the series were not cointegrated. If there were no cointegration, there would be no long-run relationship binding the series together, so that the series could wander apart without bound. Such an effect would arise since all linear combinations of the series would be non-stationary, and hence would not have a constant mean that would be returned to frequently.

There are two main methods for the testing of cointegration between variables. First and the most straightforward is the Engle-Granger (1987) method. This method includes the estimation of cointegration using ordinary least squares (OLS)[15] method. The structure of this method is to test the stationarity of residuals of the least squares. This potentially presents a problem for the OLS regression, which is capable of finding at most one cointegrating relationship no matter how many variables there are in the system. Also, one can not be sure if the possibly found cointegration relationship is the "best" or strongest among the other possible cointegrating relationships. (Brooks 2002, 393)

The Engle-Granger method also has a problem of being a two-step[16] method and thus the mistakes during the first step of the testing process will be inherited to the second step of the process. Johansen (1988) developed a method which does not have the weaknesses of Engle-Granger method. We will continue the empirical analysis and testing of the Fed model by testing the variable's cointegrating relationship with Johansen's method, but first explain the logic behind the use of Johansen methodology when compared to earlier Engle-Granger (1987) OLS methodology.

In the earlier literature, the Fed model is most often tested by using the OLS method. For example, Asness (2003) estimates the following model:

$$\Delta P_t = \alpha + \beta_1 (EP_t - R_t) + \varepsilon_t \qquad (16)$$

where ΔP_t is the ten-year real returns for the S&P500 index α is an

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[15] More information on the OLS and regression analysis can be found from Watsham and Parramore(1997)

[16] Engle and Yoo (1987) developed a 3-step procedure and (EY) added another step into the original Engle-Granger method. The third step includes updated estimates of the cointegrating vector and its standard errors. EY does suffer from all of the remaining problems of the EG approach and is rarely employed in empirical applications. (Brooks 2002)

intercept and $EP_t - R_t$ is the contemporaneous difference between the earnings yield (EP_t) and the ten-year US Treasury bond yield (R_t). Over the very long analysis of 1881-2001 time frame, Asness (2003) finds that the weak statistical significance of the β_1 coefficient which had a t-statistic equal to 1.41, due to the inclusion of the earnings yield in the expression. Asness (2003) also states that when the earnings yield and the ten-year bond yield are included separately, EP_t is strongly significant with a t-statistic of 4.13, while R_t is not significant with a t-statistic of 0.06.

Durré and Giot (2007) note that other authors in a related OLS framework have predefined the weights for the variables and then assessed the forecasting properties of the combination of variables (e.g the forecasting performance of the P/E ratio, as in Cambell and Shiller, 1998 and 2001, or the GEYR ratio as in Harris and Sanchez-Valle, 2000).

The clarifying description of OLS methodology and how it has been used in the Fed model studies is important to understand to see the potential and benefits of using the far more developed Johansen methodology instead. When looking from an econometric point of view, an OLS analysis of the Fed model can be seen as “restrictive” in the sense that it is found to be very complicated method when trying to combine both long- and short term dynamics into analysis. Indeed, OLS regressions that do not include dynamic time series effects cannot disentangle and properly assess the short-run and long-run dynamics. Durré and Giot (2007) also point out that from the finance point of view it would be crucial to be able to separate long- and short term effects. Indeed, even if bond yields do not impact stock prices in the long run (i.e. what is also mostly argued by the academics and practitioners who criticize the Fed model), we cannot rule out the fact that maybe variations in long term bond yields affect stock prices in the short-run. This could also be the reason why the model this simple has gained substantial popularity in the financial press.

In this paper, we follow the Durré and and Giot (2007) to analyze these short-term and long-term effects within the cointegration framework. More precisely this analysis uses dynamic time series models i.e. VECM models. Durré and Giot (2007) summarize that the cointegration methodology allows an assesment of possible long-term relationships between economic or financial variables while explicitly modeling the short-term dynamics. In other words, a cointegrated model lets the future time path of a variable be governed by a long-term equilibrium and a short-term dynamics.

We have presented many closely related studies that are in the same field of testing the stock-bond relationship, gilt-equity relationship, or the Fed model. However, the most recent study by Durré and Giot (2007) is the only paper assessing the cointegration methodology for both long- and short-term dynamics. Mills (1991) studied the GEYR ratio and recently Koivu et al. (2005) the Fed model by using the cointegration framework. It has to be noted that even Koivu et al. (2005) constrain the coefficients from the long-term relationship.

To test for the presence or absence of cointegration for the system of time series, we employ the methodology developed by Johansen. This methodology links the vector auto regression (VAR) modeling with cointegration. We describe the VAR-based cointegration tests using the methodology developed by Johansen. Equation (6) shows the vector autoregression equation:

$$y_t = \beta_{1yt-1} + \beta_{2yt-2} + ... + \beta_{kyt-k} + u_t \quad (17)$$

In order to use the Johansen test, the VAR equation (6) above needs to be turned into a vector error correction model (VECM) of the form

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta_{y-2} + ... + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \qquad (18)$$

where

$$\Pi = (\sum_{j=1}^{k} \beta_i) - I_g \qquad (19)$$

and

$$\Gamma_i = (\sum_{j=1}^{i} \beta_j) - I_g \qquad (20)$$

When defyning the VAR-model in VECM-form, we gain information of changes in long- and short-term relationships of estimates Π and Γ_i in relation to changes of variable y_t. The Johansen test centres around an examination of the Π matrix and Π can be also interpreted as a long-run coefficient matrix. In practice, cointegrating relationships can be observed by looking at the Π matrix and if variables are cointegrated the rank of Π will be significantly different from zero. Correspondingly, if the variables are not cointegrated, the rank of Π will not be significantly different from zero. Johansen and Juselius (1990) suggest two different methods for the testing of numbers of cointegrating vectors:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \qquad (21)$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad (22)$$

where λ_{trace} is a joint test where the null is that the number of cointegrating vectors is less than or equal to *r* against an unspecified or general alternative that there are more than *r*. $\lambda_{\max}$ conducts separate tests on each eigenvalue, and has as its null hypothesis that the number of cointegrating vectors is r against an alternative of $r + 1$.

Both methods above, testing the number of cointegrating vectors are based on maximal eigen value. Osterwald-Lenum (1992) provides a more complete set of critical values for the Johansen test. For both methods we can compare the test results with simulated critical values, and if the test statistic is greater than the critical value we reject the null hypothesis.

We illustrate the methodology of cointegration applied to the testing of Fed model by focusing directly on the variables involved in the model. The variables are $e_t = \ln(E_t)$, the log earnings index, $p_t = \ln(P_t)$, the log stock index and $r_t = \ln(R_t)$, the log government bond yield.[17] The cointegration model for the Fed model testing can thus be written as:[18]

$$\Delta e_t = \gamma_e + \alpha_e (e_{t-1} + \beta_p p_{t-1} + \beta_r r_{t-1}) + \quad e + \varepsilon_{e,t,} \tag{23}$$

$$\Delta p_t = \gamma_p + \alpha_p (e_{t-1} + \beta_p p_{t-1} + \beta_r r_{t-1}) + \quad p + \varepsilon_{e,t,} \tag{24}$$

$$\Delta r_t = \gamma_r + \alpha_r (e_{t-1} + \beta_p p_{t-1} + \beta_r r_{t-1}) + \quad r + \varepsilon_{e,t,} \tag{25}$$

The equations shown above illustrate the rationale behind the Fed model testing in cointegration framework. For example, the change in stock prices (Δp_t) is driven by both past disequilibrium in the long-run

[17] An alternative specification also notified by Durré and Giot (2007) would include $p_t = \ln(P_t)$, $e_t = \ln(E_t)$ and Rt, instead of $r_t = \ln(R_t)$, as inputs, We as well follow the Durré and Giot (2007) approach and prefer to work with the log government bond yield as taking the log of supposed Fed model relationship *Et / Pt = Rt* gives $e_t - p_t - r_t$. As detailed in the equations given above, this is thus the supposed long-run relationship if the Fed model is valid. The log specification is also suggested in many papers, see e.g. Cambell and Shiller (1989), Timmermann (1995), Campbell, et al. (1997), Koivu et al. (2005) or Durré and Giot (2007)

[18] As we have three different variables, In theory there could be up to two cointegrating relationships. Anticipating on the empirical results, we always have 0 or 1 cointegrating relationship, hence we do not detail the specification which features 2 cointegration relationships.

relationship $e_{t-1} + \beta_p p_{t-1} + \beta_r r_{t-1}$ and the short-run dynamics. If the economic rationale underpinning the Fed model framework is correct, the coefficients of the long-run relationship (i.e. β_p and β_r) are expected to be negative. As to the adjustment speed coefficients (i.e. α_e, α_p and α_r), they determine how each variable is affected by the disequilibrium in the lagged long-run relationship.[19]

We do not add any dummies into the cointegration equations since it is often discussed that unadjusted data are preferable. For example, any adjustments into seasonality of the data can lead to less cointegration (Lee and Siklos, 1997) or can induce spurious regression (Ermini and Chang, 1996). Including any other dummy-type variable also affects the underlying distribution of test statistics, such that the critical values for these tests are different depending on the number of dummies included.

Durré and Giot (2007) furher discuss the sign of α_p in Equation (24).[20] Economic good sense suggests a positive α_p if β_p is negative: if stock prices increase (decrease) more than warranted by the increase (fall) in earnings, there is a negative (positive) disequilibrium in the cointegration vector. That is, $e_{t-1} + \beta_p p_{t-1} + \beta_r r_{t-1}$ becomes negative (positive). The system should 'correct' by having stock prices decrease (increase), requiring α_p to be positive. Nevertheless, a positive α_p will only be obtained if the mean-reversion dynamics operating through the stock index variable over the next month is sufficiently strong to respond to long-run disequilibrium effects. For instance, if α_p was equal to zero, the

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19 Because the variables are expressed in logs, the adjustment speeds could also be interpreted as the proportion of the long-run disequilibrium error that is corrected at each time step.

20 The importance of the a*p* coefficient is stressed by Lamont (1998) and Campbell and Shiller (2001) in their analysis of TVR. They argue that prices rather than fundamentals (dividends or earnings) do most of the adjustment in bringing the ratios back towards their long-run equilibrium levels.

reversion dynamics of p_t would be solely governed by short-run effects at the monthly interval.

3.4.2 Variance decomposition

The basic idea of variance decomposition is to use a transformation to decompose a time series into different temporal frequency components and then to compute the seasonal variance of each frequency component. The variance decompositions are calculated for the estimated VAR. Variance decompositions explain the proportion of movement in the dependent variables that are due to the “shocks” in their own system and compare the shocks to the other variables. What we are looking for is i.e. that movement in the stock prices can be explained by the movements in the bond yield or the earnings yield. If there is a dynamic between the researched variables, it is of interest to see that how much in proportions does the movement for etc. in bond yields affect the relationship. Also, to see that how fast does the effect of the shock die away in the cointegrated system, which can also be explained as the movement back to the equilibrium level of studied variables.

3.4.3 Granger causality

Granger (2003) notifies in his Nobel prize speech,[21] that when the idea of cointegration was developed, it became clear that if a pair of series was cointegrated then at least one of them must cause the other. There seems to be no special reason why these two quite different concepts should be related; it is just the way that the mathematics turned out. It appears that causality will play a basic role in the generalization of the error-correction model, but that it is still a work in progress. However, the statement about

[21] Granger received a shared Nobel prize for his work "for methods of analyzing economic time series with common trends (cointegration)" with Engle "for methods of analyzing economic time series with time-varying volatility (ARCH)" in 2003.

causality is said to have two components. First, the cause occurs before the effect, and second, the cause contains information about the effect that is unique and is in no other variable.

The reason why we state the speech of Granger in this occasion is that we wish to continue our methodological part of this paper by describing the concept of Granger causality and how this is connected to the concept of cointegration and can help us understand the role of the long term government bonds when trying to explain stock market valuation.

The following step is to construct a standard Granger causality test. The conducting of this test helps to explore the short and long-run dynamic relationships among the stock prices, bond yields and stock yields. The estimated long-run causal relationship among variables is based on the error correction model (ECM). Based on the theoretical background, if two variables, i.e. y_t and x_t are cointegrated with each other, then the error correction term is required in testing Granger causality as follows by Granger et al.(2000);

$$\Delta y_t = \alpha_0 + \gamma_1 (y_{t-1} - \phi x_{t-1}) + \sum_{i=1}^{k} \alpha_{1i} \Delta y_{t-1} + \sum_{i=1}^{k} \alpha_{2i} \Delta x_{t-1} + \varepsilon_{1t} \qquad (26)$$

$$\Delta y_t = \beta_0 + \gamma_2 (y_{t-1} - \phi x_{t-1}) + \sum_{i=1}^{k} \beta_{1i} \Delta y_{t-1} + \sum_{i=1}^{k} \beta_{2i} \Delta x_{t-1} + \varepsilon_{2t} \qquad (27)$$

Where γ_1 and γ_2 represent the speed of adjustment, and the $(y_{t-1} - \phi x_{t-1})$ represents the error correction term. The null hypothesis for equation (26) is that H_0 : $\alpha_{21} = \alpha_{22} ... \alpha_{2i} = 0$ and $\gamma_1 = 0$ in case of rejecting the null hypothesis, this implies that x_t does Granger cause y_t . The null hypothesis for equation (27) is that H_0 : $\beta_{21} = \beta_{22} ... \beta_{2i} = 0$ and $\gamma_2 = 0$ in case of rejecting the null hypothesis, this implies that y_t does Granger cause x_t .

Concept of causality tests seek to find answers for simple questions usually described as ‘Do changes in bond yields cause changes in stock prices?’ The argument follows that if bond yield changes in fact cause changes in stock prices, the lags of bond prices should be significant in equation for stock prices. If this is the case and not vice versa, it would be said that the bond yield Granger-causes stock prices, or that there exists unidirectional causality from bond yields to stock prices.

On the other hand, if stock prices cause changes in bond yields, lags of stock prices should be significant in the equation for bond yields. If both sets of lags were significant, it would be said that there is a ‘bi-directional causality’. If bond yield is found to Granger-cause stock prices, but not vice versa, it would be said that bond yield is strongly exogenous (in the equation for stock prices). If neither set of lags are statistically significant in the equation for the other variable, it would be said that bond yields and stock prices are independent. Finally, the word ‘causality’ is somewhat misleading as Granger-causality really means only a correlation between the current value of one variable, for instance stock prices, and the past values of others such as the bond yields. It does not mean that movements of one variable cause movements of another. However, Granger causality is very useful in a case where we want to determine whether one time series such as bond yield, is useful in forecasting another, in this case stock prices.

Brooks (2002) states that if the variables in the VAR are stationary, the joint hypotheses can easily be tested within the F-test framework (which is included in Granger causality tests), since each individual set of restrictions involves parameters drawn from only one equation. The equations would be estimated separately using the OLS to obtain the unrestricted RSS, then the restrictions imposed and the models re-estimated to obtain the restricted RSS. The F-statistic would then take the usual form where two regressions are required, known as the unrestricted and restricted regressions. The unrestricted regression is the one in which the coefficients are freely determined by the data, as has been constructed in the previous section of this paper. The restricted regression is the one in which the coefficients are restricted. Thus the F-test approach to hypothesis testing is also termed restricted least squares, for the reasons stated above. This being said, the evaluation of the significance of variables in the context of a VAR almost invariably occurs on the basis of joint tests on all of the lags of a particular variable in an equation, rather than by examination of individual coefficient estimates.

In summary, now that we have described the methodology used in this paper we study the validity of the Fed model approach by testing three research questions: (Q1); Is there a cointegration relationship between earnings, stock prices and government bond yields (Q2); How does the deviation from the long-run equilibrium impact stock prices such that the long-run equilibrium is restored (Q3). Do the long-term government bond yields play a significant role in the relationship.

3.5 Methodological problems

First, when working with the methodologies that we use in this paper, it is crucial to be able to choose an optimal lag length. Reliable results of cointegrated process studies are only obtained by a careful truncation lag lengt selection which is also pressed by Brooks (2002) and Vo (2006) who suggest the frequency of the data to be used as a guideline for lag length selection. Another way to select a lag length is by looking at the information criterions. One of the most comprehensive studies of information criterions is provided by Ng and Perron (2000) who conclude that the most often used information criterions such as AIC and SIC are not flexible enough for unit root tests and lag length selection in general. The most commonly used information criterions tend to choose a lag length that is very small.

Second, there are studies such as Coombs and Algina (1996) and Cheung and Lai (1993) who find that the Johansen procedure is heavily depended on the sample size of the variables, and also on the number of variables included. These studies find that with smaller sample sizes the Johansen methodology is biased to finding cointegration more often than what asymptotic theory would suggest.

We definetly have to keep in mind the methodological issues when analyzing the cointegration results. However, when using one of the most popular cointegration tests such as Johansen, we can get very informative results that are also based on academically sound framework. For us, the main rationale behind using the Johansen methodology is that the latest previous studies have found the methodology to be very useful when studying the relationships among the relative stock market valuation models such as the Fed model is. Also, this procedure allows us to look at both long-and short run relationships with an academically proven methodology.

4. DATA

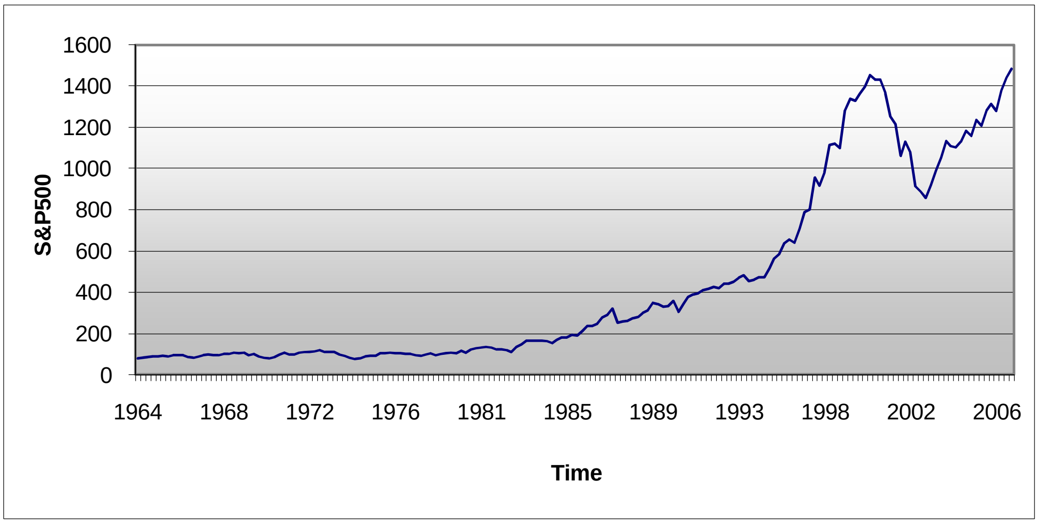
The empirical part of this paper focuses on single country, United States. We aim to approach stock-bond relationship from an empirically and statistically valid viewpoint and the reliable data for long enough maturity is a necessity for such study. We have obtained the United States Government 10-Year treasury bond data and the S&P500 price index from the Thomson Financial Datastream. We use the S&P500 index for the stock price indice as it is probably the most well known and renowned standard index for the stock market in the United States. The earnings for the S&P500 are downloaded from the Standard and Poors. Ohlson (2006) noted that more accurate earnings measures exist as earnings themselves might not reflect the equity valuation as also discussed in Ohlson (1995) and Ohlson and Zhang (1998). In this study we use the current earnings instead of the expected earnings as the latter are not available for long enough maturity. Expected earnings such as provided by the I/B/E/S database have only been available for some of the largest markets such as the United States for the last 20 years. We use the same approach as the Koivu et. al. (2005) and Durré and Giot (2007) who also use the same kind of data, i.e. they also focus on current earnings and not expected earnings. In fact, Durré and Giot (2007) use a 1-year ahead earnings[22] as the anticipated earnings, and we also follow the same approach.

All time series are quarterly values for the period of March 1964 to March 2007 giving in total 172 observations. Time period was chosen to cover long enough time range to include many full market cycles. When using the co-integration framework, it is important to have a long enough time frame to cover full market cycles and this indeed is the case with the chosen data.

[22] The use of 1-year delay in the approximation as the anticipated earnings is also discussed and suggested in the empirical evidence by Capstaff et al. (2001) and Ou and Sepe (2002).

The S&P500 is one of the most commonly referenced United States equity benchmark. The index is very diverse and comprises of more than 70% of total market capitalization of all stocks traded in the United States. S&P500 consist primarily leading companies from a variety of different economic sectors, which makes it also quite usually preferred benchmark index when studying the whole market. The index is market capitalization weighted and thus the largest companies have greatest impact on the value of the index. On the other hand, the smaller and quite often the faster growing companies are left out of the index because of the high market capitalization requirements.

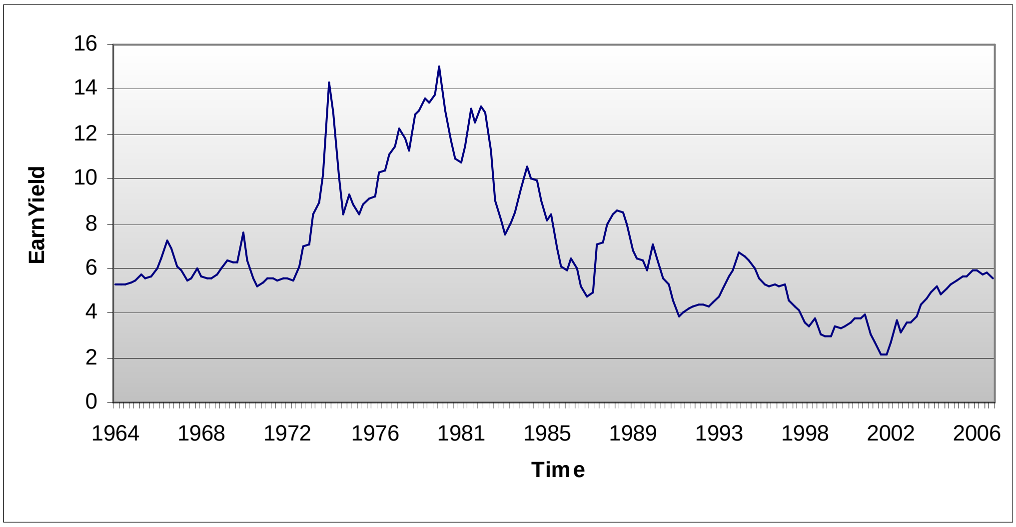
Figure 2. S&P500 Price Index.



The Composite Price Index of S&P500 is part of the forward E/P ratio where the estimated forward earnings are divided by the price of the index, this is also called a forward earnings yield that is used in the Fed model. Clearly visible in Figure 2 are the bull market of the late 20th century as well as the market correction of 2000-2003. The market rise of the 2003-2007 can also be notified.

The S&P500 earnings yield is the earnings of the securities in the S&P 500 Index divided by price. This is the inverse of the well-known price to earnings ratio. The earnings yield is a gauge to evaluate the return to the investor in the form of earnings, relative to current stock prices. The earnings yield of the S&P500 index shown is Figure 3, is essential part that is needed for the Fed model estimation.

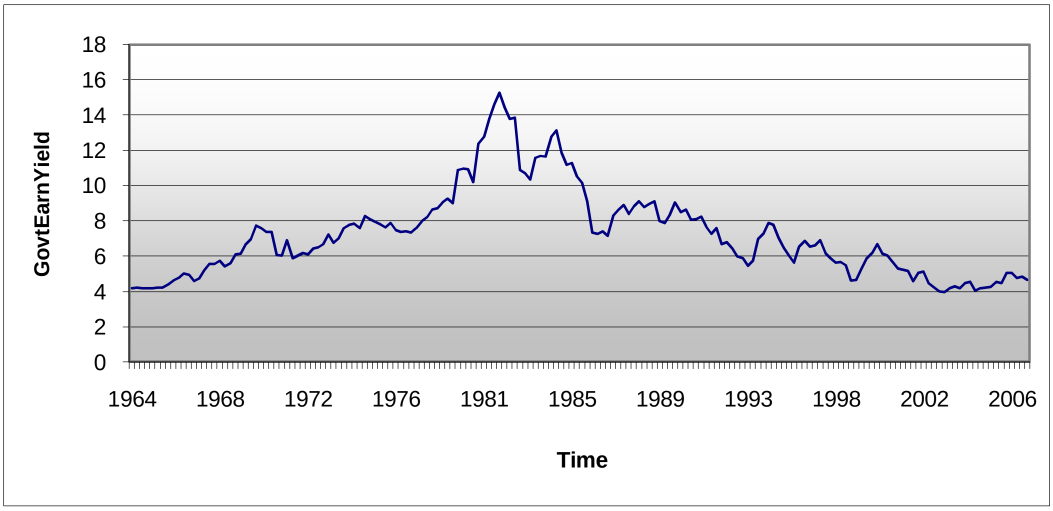
Figure 3. Earnings Yield of S&P500 index.



We have calculated the earnings yield from the S&P500 price-to-earnings ratios provided by the Standard and Poors by dividing the S&P500 value by the P/E ratio on order to get the actual earnings. After that the actual earnings were divided by the S&P500 value and multiplied by 100 to gain percentage value easily comparable to 10-year Treasury bond yield which is also shown in percentages. In contrast to Lander et al. (1997) we use current earnings and not the expected earnings as there is no valid data available for long time periods. More precisely, we follow the Durré and Giot (2007) approach and use 1-year ahead earnings as the anticipated earnings in the models. As we are conducting a historical, long-term research, the use of actual 1-year ahead earnings is also justified by the accuracy that really is not always the case with analysts aggregate earnings estimates such as provided by the I/B/E/S.

The second component of the Fed model is the United States Government 10-Year Treasury bond yield which is presented in Figure 4. These bonds are issued by The Bureau of Public Debt which is in charge of borrowing money in order to operate the Federal government of United States. [23] The bonds are often called the T-bonds and they usually pay coupon payment every six months. The secondary market on these bonds is highly liquid and they are quite often used as a proxy for long-term interest rates.

Figure 4. The 10-year bond yield as a nominal rate.



Government bonds in general are considered the most low-risk assets, and are considered the risk free and also made by a risk free interest rate. The government has a possibility to increase it's income and ability to pay for its debt by raising taxes. United States Treasury bonds denominated in U.S. dollars are considered risk free assets in the U.S. However, this does not apply for foreign purchasers who bear the risk of currency exhange rate movements. In addition, this implicitly accepts the stability of the US government and its ability to continue repayments in a difficult financial crisis.

[23] For more information see: www.publicdebt.treas.gov

5. RESULTS

5.1 Descriptive statistics

Descriptive statistics of time series used in the methodological part of this paper are shown in the Table 1. The descriptive statistics were run with the logarithmic numbers of quarterly data from 1964-2007. With respect to mean log values the standard deviations are quite high but can be explained by the fact that the time period of observation includes over four decades of data and also periods of substantially high volatility.

Table 1. Descriptive statistics of time series.

	S&P500	**EarnYield**	**GovtEarnYield**
Mean	5.555	1.831	1.924
Min.	4.303	0.766	1.379
Max.	7.301	2.707	2.725
Std. Dev.	1.022	0.410	0.325
Skewness	0.417	0.068	0.314
Kurtosis	1.630	2.684	2.489
Jarque-Bera	18.66	0.856	4.751
N	172	172	172

Skewness indicates the degree of symmetry in the frequency distribution. Negative skewness results in a longer left tail of distribution with the mean being below median which also means that negative returns are on average larger than the positive returns. All time series in this observation have positive skewness indicating that

A normal random variable has a kurtosis of 3 and as we can see all series have a kurtosis values of less than 3. If random variable has a kurtosis value of more than 3 it is said to be leptokurtic, which means that it's distribution is simultaneously "peaked" and has "fat tails". It can be noted that the earnings yield of the S&P500 index and the earnings yield of the government treasury bond are quite close to normal distribution. However, the log price index has significantly lower kurtosis of 1.63. The Jarque-

Bera test uses skewness and the (excess) of kurtosis to test the assumption of normality. S&P500 log values are from the price index itself and it is quite obvious that normal distribution will not coincide in such time series. Instead the earnings yield of S&P500 and the earnings yield of treasury bonds can be seen to have quite close to normal distribution Jarque-Bera values.

5.2 Results on unit root tests

We research the unit roots by using Augmented Dickey-Fuller test. The test gives statistical values which we compare to the critical values tabulated by MacKinnon (1991). If the statistical value given by the test is larger than the critical value by MacKinnon, the null hypothesis holds, and thus the series contains a unit root and is said to be non-stationary.

Table 2. ADF results.

P-values for the ADF unit root tests for the log earnings index, log stock index and log government bond yield. The *P*-values reported in the table refer to the null hypothesis of a unit root in the given series. The time period is 1964:01-2007:01 (quarterly data) for all series. * implies statistical significance at 1% level.

Index	**Level**		**First Differences**	
	Intercept	**Intercept & Trend**	**Intercept**	**Intercept & Trend**
S&P	0.35	-2.26	-5.84*	-5.95*
EarnYield	-1.78	-2.33	-6.36*	-6.35*
GovtEarnYield	-1.66	-2.13	-6.55*	-6.86*

We can see that for all series, the test statistic is more negative than the critical value when first differenced and hence the null hypothesis of a unit in the series is convincingly rejected. We find that all indices are non-stationary in their levels and become stationary when first differenced. For all of the series the null hypothesis H_1 of stationarity can be rejected at a 1% confidence level and therefore there is a unit root for researched time series. Thus time series are non-stationary and suitable for co-integration test.

Table 3. Critical values for DF-tests. (Davidson & MacKinnon, 1993)

Model	***1 %***	***5 %***	***10 %***
$\Delta y_t = \psi y_{t-1} + u_t$	-2.56	-1.94	-1.62
$y_t = \phi y_{t-1} + \mu + u_t$	-3.43	-2.86	-2.57
$y_t = \phi y_{t-1} + \mu + \lambda t + u_t$	-3.96	-3.41	-3.13

The unit root results are similar to those previously documented in the literature by Durré and Giot (2007), Koivu et al (2005), Harasty and Roulet (2000). As reported in the earlier studies, we confirm that all series exhibit a unit root, and therefore can be said to be of non-stationary process. Thus we can go on with the empirical part of this paper by studying the interralations of these time series in cointegration framework.

5.3 Long run equilibrium results

We have tested for the presence or absence of cointegration for the system of time series, we employ the methodology developed by Johansen. Before running cointegration tests we look at the Akaike information criterion (AIC) Schwarz's information criterion (SIC) and Hannan-Quin's information criterion (HQ) for the selection of lag length. However, it is often noted that when working with smaller data samples such as our's (174), the use of information criterions suggest too small optimal lag length. Also, when looking at the information criterion selection, the optimal lag length's of k*=2 and k*=4 are very similar even though all of the criterions suggest the use of k*=2 with a slight margin to k*=4. Johansen (1992) also suggests the use of lag length that is similar to the frequency of the data, which implies that the lag length of 4 to be more appropriate one to be used, as our data is quarterly. We therefore choose to run the cointegration test's with the lag length of k*=4.[24]

Table 4. Cointegration results for the Model 2.

The cointegration results for the system of log price, log earnings yield and log government earnings yield. The results below are for the Model 2 which uses no trend in CE and no intercept in VAR.

Null Hypothesis	Trace Statistics	5% Critical Value	1% Critical Value	Max Eigen Value	5% Critical Value	1% Critical Value
r=0	32.12	34.91	41.07	14.32	22.00	26.81
r1	17.79	19.96	24.60	12.17	15.67	20.20
R≤ 2	5.62	9.24	12.97	5.62	9.24	12.97

Table 5. Cointegration results for the Model 3.

The cointegration results for the system of log price, log earnings yield and log government earnings yield. The results below are for the Model 3 with unresricted constant and no trend in CE.

Null Hypothesis	Trace Statistics	5% Critical Value	1% Critical Value	Max Eigen Value	5% Critical Value	1% Critical Value
r=0	24.77	29.68	35.65	14.19	20.97	25.52
r1	10.57	15.41	20.04	10.32	14.07	18.63
R≤ 2	0.25	3.76	6.65	0.25	3.77	6.65

The cointegration results of log S&P500 price index, log earnings yield and log government bond earnings yield are shown in a Table 2, and Table 3 respectively. Trace statistics and the maximal eigen value statistics show that there is no cointegrating among these systems of

[24] We also run the cointegration tests with lag length of k*=2. The lag length selection between k*=2 and k*=4 does not change the long-run cointegration results significantly and therefore we present the results for the lag length of k*=4

variables with the test setup described. The test clearly does not reject the hypothesis of no cointegration (r=0) for the log stock price index, log earnings yiels and log government bond earnings yield at any level. Both trace statistics and the maximum eigen value statistics indicates no cointegration at both 5% and 1% levels and the hypothesis of no cointegration can not be rejected.

Table 6. Cointegration results for the Model 4.

The cointegration results for the system of log price, log earnings yield and log government earnings yield. The results below are for the Model 4 with unrestricted constant and restricted trend. The * signifies the rejection of null hypothesis

Null Hypothesis	Trace Statistics	5% Critical Value	1% Critical Value	Max Eigen Value	5% Critical Value	1% Critical Value
r=0	57.40*	42.92	48.45	37.13*	25.54	30.34
r1	20.27	25.87	30.45	13.81	18.96	23.65
R≤ 2	6.46	12.52	16.26	6.45	12.25	16.26

The Johansen test statistics clearly rejects the null hypothesis (at 1% level) of no cointegration (r=0) for the log stock price index, log earnings yiels and log government treasury bond earnings yield. The trace test value of 57.40* is greater than the 1% value of 48.45 and the max eigenvalue of 37.13* is greater then the 1% critical value of 30.34 as presented in the Table 5. The (r=1) hypothesis is not rejected signifying the presence of only one cointegrating vector in the system these variables. The results indicate that there is an underlying factor that links the stock price with the earnings yield and bond earnings yield in the long run.

It is also important to understand that the cointegration was found when using the Model 4 which uses unrestricted constant and a restricted trend.

This could be due to the fact that as the Model 4 allows for linear deterministic trend in data to be included.

The long-run equilibrium results presented here seek to find answer for the research Question 1. Is there a long-run relationship between earnings, stock prices and government bond yields? The implication of these results is that as there is a cointegrating relationship i.e. cointegrating vector among the stock prices, 1-year ahead earnings yield and the 10-year treasury bond yield, thus we can ascertain that the variables do indeed have an equilibrium level in the long run. Series that are cointegrated tend not to wander too far apart in the long run which in turn also means that there is an interrelation between stock market, forward earnings yield and the bond yield which can be seen as a potential evidence that the variables move together in the long run. In order for better visual observation we plot graphs of the ratio of 1-year ahead earnings yield, long-term government bond yield, and the S&P500 price index in log values as they are used as the input variables in the cointegration tests. We also utilize a graph of CR which is the cointegratoin relationship drawn from the input variables used in the cointegration test, for even better visual observation of the relationship between the variables. The earnings yield graph in Figure 5 shows visually the logarithmic 1-year ahead earnings yield of the S&P500.

Figure 5. Log 1-year forward earnings yield of S&P500.

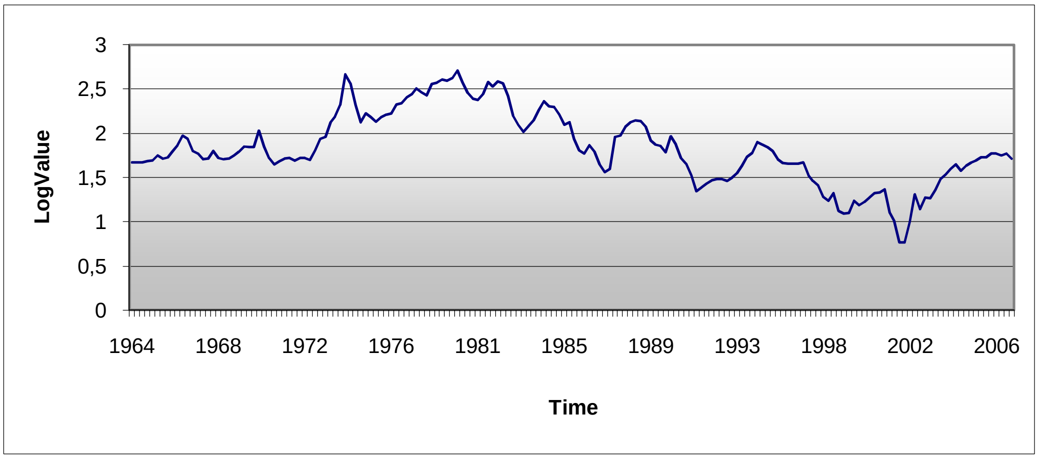
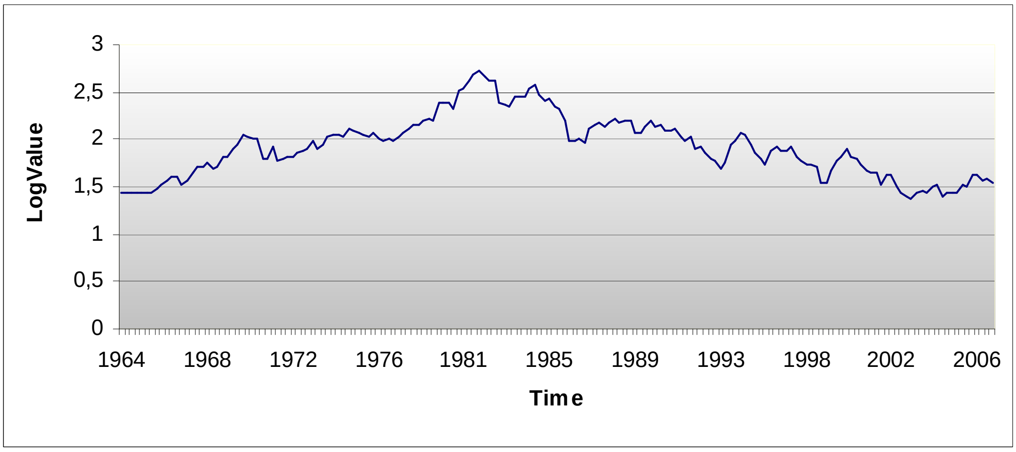


Figure 6 illustrates the logarithmic graph of 10-year government bond yield. These are the time main components used in our methodology of testing the short- and long-term interrelationships between stock prices, earnings yield and the long term bond yields.

Figure 6. Log 10-year Government Treasury bond yield.

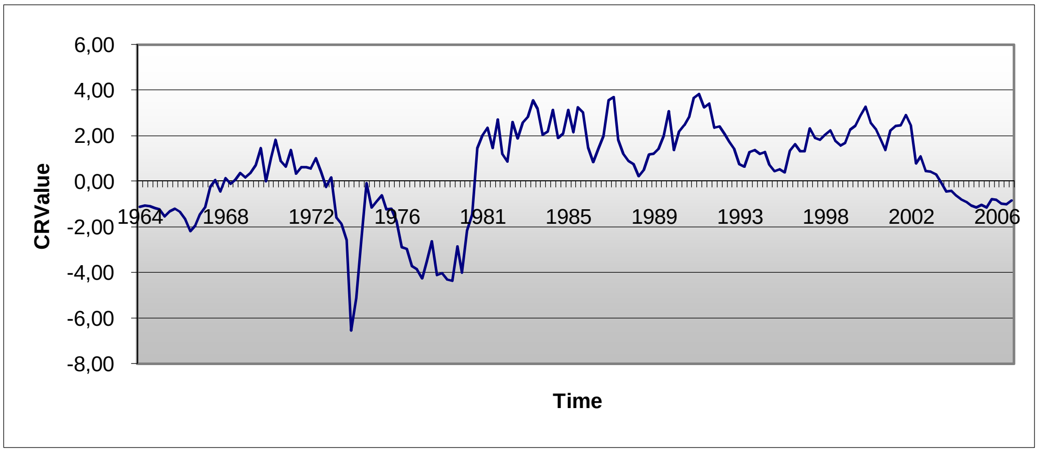


In order for even better visual illustration we also plot the lung-run equilibrium relationhip (called cr) vs time which can be seen in the Figure 7. When looking at the long-run relationship visually, we can confirm that the cointegrating vector is stationary.

The cycles seem to be quite long, which also supports the view that a meaningful cointegration analysis is only sustainable when using a large time sample. These graphs help us to visually observe and understand the nature of cointegrating relationship among the variables. It can be noted that the long-run relationship is not dissimilar to either the ratio of the earnings yield to the long-term government bond yield (Figure 6) or the earnings yield (Figure 5), but at the same time it can be seen as distinctively different.

Figure 7. Cointegrating relationship.

Cr is the cointegrating relationship of variables plotted by the cointegration test.



5.4 Variance decomposition results

The discussion we have provided has so far mainly focused on the long-term relationship of the system between earnings yields of stocks and bonds and the stock prices. However, the short-term effects are important and also very interesting for investors point of view and thus we want to find out if the bond yields matter in the short term basis. Variance decomposition is estimated by the single equation ECM which is also shown in the Equation 24 of methodology part of this paper.

The discussion of long-run relationship results ascertain that there is a cointegrating relationship among the variables The research Question 2 is about the short-run dynamics, mainly the impact on stock prices when the equilibrium gets out of balance. For the most market participants, the short term impact on stock prices is very important. Also, we can not rule out the possible impact of bond yields variations in the short-run. We focus on variance decompositions to ascertain if the bond yields could partially explain the dynamics of ln(P), i.e. Stock prices in the short-run. The results of variance decompositions are presented in Table 7. The variance of the stock price with n quarters ahead is mainly explained by it own innovations. Earnings, even though do have impact on stock prices, do not matter much more. When looking at the bond yields, their influence is significantly weak in the short-run, and seems to get weaker when more looking more quarters ahead.

Table 7. Variance decomposition results.

Quarters ahead	Standard Error	Stock Price	Earnings Yield	Bond Yield
1	0.06	100.00	0.00	0.00
2	0.09	88.89	10.91	0.20
3	0.11	84.01	14.39	1.60
4	0.13	82.96	14.56	2.48
5	0.14	83.55	13.60	2.85
6	0.15	84.64	12.38	2.96
7	0.16	85.83	11.19	2.98
8	0.17	86.97	10.07	2.96
9	0.18	88.01	9.08	2.92
10	0.19	88.91	8.23	2.86

Our results here are somewhat different than the results from earlier studies such as the Durré and Giot (2007) who display results that the bond yields do have almost equal impact on stock prices as the 1-year ahead earnings yield in short-term basis. However, the results that we display here confirm the traditional method of stock market valuation studies such as Philips (1999), Cambell and Shiller (1998, 2001) or Jones et al. (2002), where the valuation ratios such as the P/E or its inverse of earnings yield are found to have the most explanatory power over stock market valuation.

5.5 Granger causality results

When data series have a unit root, the properties of some statistical tests are not ‘standard’. If two or more series have a unit root, then a linear combination may be stationary, which means that the series are cointegrated. Cointegrated series are stationary and hence ‘standard’ statistical results apply. If two or more series are cointegrated, then at least one of the variables is Granger caused by the error correction term.

Table 8. Granger causality results.

Null Hypothesis	F-Statistic	P-value
EY does not Granger Cause Stock Prices	15.13	<0.01
Stock price does not Granger Cause EY	2.23	0.07
GovtEY does not Granger Cause Stock Prices	2.09	0.08
Stock prices does not Granger Cause GovtEY	4.61	0.01
GovtEY does not Granger Cause EY	3.31	0.01
EY does not Granger Cause GovtEy	2.86	0.03

Before further analysis of Granger causality results it is important to clarify what these results actually mean. Granger causality means a correlation between the current value of one variable, for instance stock price, and the past values of others such as the bond yields. This in turn helps us to understand the variable interrelationships in the short run, and what is the effect of other variables in these relationships.

The statistical significance of the p-value is the probability of obtaining a value of the test statistic at least as extreme as the one that was actually observed, given that the null hypothesis is true. The fact that p-values are based on this assumption is crucial to their correct interpretation. If the p-value is larger than the chosen significance level, for instance 95%, the null hypothesis holds if the p-value is larger than 0.05 respectively. This is also the most common criterion when judging the statistical significance with P-value. If this is the case, it can be said that for instance the changes in earnings yield does not affect the stock price in the short run. If the P-value however is smaller than the significance level, the null hypothesis is rejected. This would mean that in the short run, for instance changes in the earnings yield affect the stock prices.

The Granger causality results show that at 95% significance level the null hypothesis holds in two cases. Short run movements in stock prices do not cause changes in earnings yields. Also, one of the most interesting results is that at 95% significance level the past short run changes in long term government bond yields does not Granger cause stock prices. However, if we look at the 90% significance level, the government bond yields do have short-run effect in stock prices, even though the effect is relatively small. This effect however, is in line with the variance decomposition results that show that there is some effect, but the effect on stock prices is not as clear as the effect of changes in earnings yield to the stock prices.

As for the null hypothesis that do get rejected, we can state that the changes in earnings yield do Granger cause stock prices with a p-value of less than 0.01. The past changes in stock prices also seem to have impact on long term government bond yields, which is quite surprising. There is also a clear connection between the past changes in government bond yields and the earnings yields with a P-value of 0.01 which was quite expected after visual observation of graphs of these two variables. The null hypothesis of earnings yield does not Granger cause government bond earnings yield also gets rejected. This is not as clear as the inverse of it, but still gets an p-value of 0.03, also verifying the interrelationship between the variables. The Granger causality results support the variance decomposition results as we find that the changes in past long-term government bond yields effect on stock prices is significant only with 90% significance level, and that past changes in forward earnings yields Granger cause stock prices with a p-value off <0.01, indicating that the cause is significant. As for the research Question 3, we were looking for the role of the long-term government bond yields in the Fed model relationship and found that the role of the bond yields is statistically weak. These results also support the traditional valuation methods that we have described earlier.

6. CONCLUSIONS

Determining the possible under-or overvaluation of the stock market is without doubt always of interest to all market participants. We start this thesis from an augmented valuation model called the Fed model. Simply put, the Fed model argues that the "fair" equity yield should be relative to the long-term bond yield. In the first part of this paper we cover the brief history of the Fed model and previous empirical studies considering the model and other closely related studies of augmented valuation models. We also provide critique of the Fed model in the sense that the model is very simple and thus it is important to understand the theoretical underpinnings considering the model. The model does compare the earnings yield of a stock market, which is a real quantity, to a nominal value of the long-term bond yield. Also, the problem of inflation illusion is not taken into account because the model would automatically drive down the stock prices if inflation was to increase.

In this paper we have discussed the traditional methods of stock market valuation and also described the relative stock market valuation methods with concentration on the Fed model. In a time series analysis we first test for the presence of a long-term contemporaneous relationship between the three components of the Fed model. These variables are the 1-year ahead earnings yield, long-term government bond yield and the stock price index. To test for the validity of the Fed model in a statistical sense, we have used the cointegration framework to study the following research questions.

We confirm that there is indeed a long-run relatioship among the variables. The short run dynamics affecting the stock prices are for the most part related to the innovations in the stock prices itself. The forward earnings of the stock market does have statistically significant impact on the stock prices, which we consider to be part of economic good sense. However, the long-term government bond yields do not seem to play statistically significant role in relation to the stock prices, and also, government bond yields do not seem to have significant role in the relationship. Our results support the evidence found in previous studies of Asness (2003) and Durré and Giot (2007).

Even though the long-term bond yields do seem to have relatively insignificant effect on the studied relationship, it is very interesting to notice that the market participants do set the required equity market yield to the same level as the nominal long-term government bond yield. Also, when observing the government bond yield to an anticipated earnings yield of S&P500 we can see that equity earnings yield has “out-yielded” the bond yields for until early 1980’s. After that there has been a time period when the anticipated equity yield has been lower than the long-term bond yield until the early 21st century, when anticipated equity yields have been higher than the bond yields. This observation leads us to possible uses of the Fed model. We believe that the Fed model is a useful tool when comparing stock and bond market yields in an intent to obtain insights of variation in risk premium and how investor's set their required earnings yield.

Finally, if trying to forecast stock market returns and valuation, our results suggest that it is far better to use E/P ratio or the like without a regard to (nominal) bond yields. The Fed model can be a tool for explaining the P/E’s and why they are at some level. It seems that the Fed model is at it’s best when trying to tackle the issue of investors past behaviour with respect to the fact that there might have been errors such as money illusion for the last four decades.

Further studies of the Fed model could be considered to be done with a multi-country approach. As we have proven that the Fed model at it’s simplest form does not work, the inclusion of time-varying risk premium and the effect of inflation into the model is suggested. Also, out-of-sample testing of models market forecasting power could be considered.

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