Reflexivity in sovereign debt markets

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Master's Thesis
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"Markets can stay irrational longer than you can stay solvent."

- John Maynard Keynes
1 Introduction

1.1 Things just do not add up

On average, bulls are slaughtered after four years of feeding. This unwanted event must come as a total surprise for the animal, but hardly to the butcher. What one considers extremely unlikely or an outlier event, might be the expected outcome from another point of view. Induction is flawed by our subjective observation and interpretations.

This seems intuitive and logical to most people, but for some non-apparent reason it is very unfamiliar to many in the financial industry. Goldman Sachs' CFO David Viniar is well remembered for complaining about 25-sigma moves witnessed in the turmoil of recent financial crisis (Larsen, 2007). He was hardly the only Wall Street banker seen complaining about the same matter - history not properly repeating itself.

Businessmen, bankers, politicians and even financial economists were widely fooled by their own inability to recognize the risks prevailing at the time. The IMF even claimed in April 2007, in their bi-annual World Economic Outlook, that the “Global economy remains on track for continued robust growth in 2007 and 2008” (IMF, 2007). As we now know, this was far from the truth.

One of the reasons behind this process is the fact that academic finance has given in for the sin of induction. Ever since the efficient market hypothesis was proposed, unfitting evidence has been often classified as anomalies. Theory itself has become more important than the very truth it is supposed to explain. And as academic models drift ever further from the actual truth, financial professionals end up using models and expectations that are very much in line with Nobel-winning theory, but not so much with the actual events in reality.
Therefore this article has been written for two reasons: 1) because there are obvious problems with current financial models and 2) because there are serious problems with current academic approaches. As a result, things just do not add up.

Acknowledging the limited scope of this article, the goal is not to fix everything that is flawed. Instead the aim is to underline and simplify the problems to such a degree that they cannot be dismissed as irrelevant or obscure. Problems with current academia are assessed in the theoretical section and a simple illustration of the point is given in the empirical section. The sole requirement is to give an actual academic contribution, nothing less. With the findings of this master’s thesis, it is then the job of professional researchers to provide the sufficient improvements to prevailing models and methods.

1.2 Catalyst for discovery

Current economic theory states that a value of a financial asset such as a bond or a stock is determined by its future cash flows, which in turn are determined by the relevant fundamentals. The prevailing paradigm states that though asset prices fluctuate and sometimes differ from their fundamental value this difference is random and occasional.

As most methodologies in economics are derived from natural sciences, analysis often expects that independent variables are genuinely independent. In asset valuation this would mean that asset prices are dependent variables, which can not affect their underlying fundamentals, the independent variables.

Natural sciences lean heavily on the correspondence theory of truth. The theory nominates that the truth-value of arguments are determined by their correspondence with the facts in the real world. Hence, in natural sciences, the refutation of a theory leads to the de facto rejection of that theory. This leads to new theories and eventually to new information. This is the catalyst of scientific discovery.
Appreciating this nature of affairs, this study seeks to falsify the prevailing doctrine of fundamentals being independent variables. If successful, this study will prove many modern theories insufficient in explaining the very intricacies of the modern world of financial markets. The aim is to write this article so unequivocally, that the reader will have no difficulties understanding the divergence between modern academic alchemy and reality.

The theoretical part is divided into three sections. First, market efficiency is reviewed in terms of existing literature, then the concept of reflexivity is brought forward and the hypothesis is presented. Finally matters such as default risk and credit analysis are reviewed.

As the empirical section is crisis-centered, it begins with a broad analysis of past sovereign debt crisis and their intricacies. These findings are then applied to a case study of the recent Greek debt crisis. The final part discusses the findings and their implications to financial theory and practice.

Some of the world’s most comprehensive datasets were used in extending existing datasets. Among these were the World Bank’s International Debt Statistics (IDS) and World development indicators (WDI). The Joint External Debt Hub (JEDH), jointly run by The Bank Of International Settlements (BIS), The International Monetary Fund (IMF), The World Bank and the OECD. Additionally, the International Monetary Fund’s International Financial Statistics (IFS), Government Finance Statistics (GFS), Balance of Payments Statistics (BOPS and Quarterly External Debt Statistics (QEDS) were also used.

The wide range data is used plot out patterns in sovereign debt crisis episodes. Altogether 111 default episodes from 30 countries are analyzed and the findings are used in creating the model for the Greek case study. The Hypothesis is tested with a Vector autoregressive model, which can reveal reverse causality.
1.3 Hypothesis and results

A hypothesis itself contains just as much confirmation as any amount of supportive evidence ever could. Therefore one must be very precise when forming a hypothesis and the corresponding test regime. Initially the goal should be the falsification of the very hypothesis the paper stands to defend. This approach was however dismissed due to the fact that the hypothesis is *de facto* a falsification test of the independence expectation and therefore it fulfills the scientific criteria, though itself is not formulated self-falsification in mind.

The hypothesis of the study is fourfold:

1) Interest rate change (change in asset price) can affect the underlying fundamentals
2) Because of 1) there is reverse causality between asset prices and the relative fundamentals
3) Because of 2) static asset pricing and credit risk models are insufficient tools
4) Because of 3) we need dynamic asset pricing models, which can take in to account the reflexive nature of the relationship between asset prices and their underlying fundamentals

In the Greek case study, it is found that the interest rate change can affect the underlying fundamental factors. Moreover reverse causality between bond yields and fundamentals is observed. This however is not enough to empirically refute all current valuation tools, but it helps to understand the time-specific nature of price movements. In the end, certain situations are identified, where self-reinforcing price movements are apparent and conceivable. In these cases dynamic asset pricing models could bring added value to financial professionals worldwide.
2 Theoretical background

2.1 Part 1: Market Efficiency

2.1.1 Introduction

Market efficiency, as it is known today, means in its simplest form that no investor is able to outperform the market. The logic behind the theory is derived from the idea that when all market participants have the same information, abnormal returns become random events.

The origins of this theorem can be traced to 1863, when a French economist, Jules Regnault published his thesis *Calcul des Chances et Philosophie de la bourse* (Jovanovic & Le Gall, 2001). 37 years later a French mathematician, Luis Bachelier was the first to test the random walk, but the theory was only put under rigorous scientific testing when computers came available (Fama, 1970). The first efficiency related arguments were based rather on the concept of random walk than informational efficiency. Therefore the starting point of Fama's ground breaking work (1965) on market efficiency was the statement: “future price changes can not be determined by past events”.

Market efficiency, or the efficient market hypothesis, later EMH, is conceptualized with three different forms of efficiency; weak form, semi-strong and strong form efficiency. The weak form efficiency implies that all historical information is reflected in stock prices. Semi-strong efficiency implies that all publicly available information is disclosed in market prices. Finally, the strong form efficiency implies that all publicly and privately held information is reflected in stock market prices. (Fama, 1970)

Some researchers have found positive autocorrelations in asset prices, indicating that the EMH, even in its weak form, is invalid ((Conrad & Raul, 1988) (Lo & Mckinley 1988)). Others have even found statistical support for positive abnormal returns by technical trading on longer time spans (Brock et al, 1992) (Hudson et al, 1996).
These findings are concentrated interpreting the efficiency on a short-term basis and even though they hint that the market might be somewhat inefficient, they fail to invalidate the EMH. When applying actual trading costs and taking into account different firm sizes, these findings do not allow investors to make consecutive excess returns, hence the market can be considered efficient enough on a short-term basis for the hypothesis to hold.

When concentrating on the longer-term weak form efficiency, there has been striking evidence against it. Studies have managed to illustrate that on a longer time span negative autocorrelations exist and more over, they are statistically significant (Shiller, 1984) (Summers, 1986). Intuitively, this would imply that stocks deviate from their fundamental values on long time spans, causing mean reverting and long swings around the fundamental value. The Summers-Shiller theorem applies on NYSE between 1926 and 1985, however if you delete the data until 1940, the negative autocorrelations vanish (Fama & French, 1988).

The findings of Fama and French (1988) invalidate the Summers-Shiller theorem, since it is proof that it does not apply always and everywhere. However, though not often mentioned, the findings of Summers and Shiller also refutes the EMH on weak-form efficiency, since they manage to prove that on certain time spans and on certain markets, it has been possible to outperform the market just on the basis of past information.

To test the semi-strong form of market efficiency, one should be able to analyze the impact of the arrival new information with given assets. If markets were to be efficient, new information should be reflected in stock prices without additional delays or substantial overreactions.

De Bondt and Thaler (1985) find support for their hypothesis that investors have a tendency of overreacting to new information. They find that investors’ reaction is asymmetric, past losers outperform far more than past winners underperform in the following years. But since their scope is over a longer term, their findings do not
challenge semi-strong form efficiency, as they do weak-form efficiency. (De Bondt & Thaler, 1985)

In order for the semi-strong form efficiency to apply, announcements on income or acquisitions should be reflected in market prices without a greater delay. However, several studies show that this is not the case and post-announcement drift is a real phenomenon ((Asquith, 1983), (Roll, 1986), (Franks et al. 1991), (Ball & Brown, 1968), (Bernard & Thomas, 1990)). Fama (1991) admits that some events studies illustrate that stock prices do not always respond quickly to new information, even so he claims that with a few exceptions, the evidence is supportive.

To test for strong form-efficiency one should be able to test for the existence of private information that is not already reflected in stock prices. Though there has been evidence of such information leading to abnormal returns (Jaffe, 1974), it can be impossible for the wide public to profit from this kind of insider information. Hence, the question of strong form efficiency is merely a trivial one.

2.1.2 Connections to CAPM and the debate between low and high PE stock returns

Shiller (2000) argues that if markets were efficient, low p/e value stocks would not outperform high p/e growth stocks, which actually often happens. EMH proponents conclude that this can be because growth stocks have a higher beta (Dreman & Berry, 1995).

The problem with this rationale is that beta is just a result, not a driver. It is the ratio of the covariance of the market's returns and security's returns to the variance of the market's return. The second problem lies in the assumption of CAPM that beta is consistent over time. This view has refuted as betas have been proven to vary over time (Blume 1971) (Moonis & Shah 2003) (Lewellen & Nagel 2006).
Perhaps the most compelling evidence against the beta explanation is the findings of Baker et al. (2013). They demonstrate that low beta stocks over-perform high beta stocks. This reinforces the view that beta is just a result of a simple calculation.

![Graph of P/E Ratios and Returns](source: irrationalexuberance.com/shiller_downloads_data.xls)

**Figure 1 - P/E Ratios and Returns (Shiller, 2000)**

### 2.1.3 Rational expectations and the EMH

The theory of rational expectations is fundamentally embedded in the EMH. Not only does the EMH rely on the concept of equilibrium prices, it assumes investors' behavior on aggregate to be rational and utility maximizing.

According to the theory, expectations about the future are reflected in markets prices, as these expectations are part of the information available. However, the rationality of expectations is not the only assumption underlying the EMH. In order to analyze the
feasibility of the EMH, one should be able to evaluate the usability of assumptions underlying these assumptions.

For example, as theory of rational expectations does not oblige rational behavior from investors, it claims that on average the market is rational. This implies that investors’ views present the optimal view of future. On the original representation of the rational expectations theory Muth (1961) adds that individuals’ expectations can not affect the economic systems which they are related to. In other words expectations can not affect the actual course of events that they expect.

These statements or assumptions have run into two major problems. First, behavioral economists have falsified the assumption that though individual behavior would be irrational, on average the aggregate behavior is rational (Shefrin, 2000). Secondly, the view that individuals expectations do not affect the events and systems, they are related to, has been dismissed by sociologists long ago (Merton, 1949) (Giddens, 1984). A good example of this is the expectations embedded in economic sentiment surveys. If people become weary of the future and as a result, reduce consumption, their expectations or fears become self-fulfilling prophecies.

2.1.4 Rationality

As stated above the theory of rational expectations does not assume that all individuals are rational, though often misinterpreted. Is merely assumes that the average expectations of the future is more accurate than that of individual participants (Muth, 1961). This would be the case if expectations about the future would be normally distributed around the actual course of events.

The problem arises, when situations appear, where individuals systematically behave against the expectations set forward by the theory of rational choice. Daniel Kahneman and Amos Tversky (1979) illustrated in their widely cited article Prospect Theory, that in many occasions people do not behave according to the utility maximization theorem. The importance in their findings lies in the fact that their results were statistically relevant, scientifically robust and they managed to prove that
certain choice related behavioral patterns are systematic and not normally distributed, hence invalidating the assumption of aggregate wisdom.

Since the *Prospect theory*, a vast amount of research has been conducted in the area of behavioral economics. This research has illustrated a fair amount of situations where behavior contradicts utility maximization. For example, people have a tendency to be risk averse when winning and risk-seeking, when loosing (Kahneman & Tversky, 1979) (Abdellaoui et al., 2007).

Shefrin & Statman (1985) Claim that investors’ reluctance to realize losses causes the disposition effect, which states that the propensity to sell and asset declines as the price moves away from the original purchasing price (Shefrin & Statman, 1985). Kaustia argues that the prospect theory is an unlikely explanation for the disposition effect (Kaustia, 2004). He (2010) suggests that the change in risk perception, due to experiencing losses or gains, may cause the disposition effect. It should also be noted that there seems to be a tendency for investors to sell their assets when the price equals the original purchasing price (Einiö et al, 2008) (Kaustia, 2010). These findings hardly support the concept of mean reverting rationality.

The setting of a situation also affects how people react. If for example asked about a preference of treatment for cancer, people choose depending on the way the question is presented to them. Answers differ depending if the question is presented through mortality rates or survival rates. Probably even more striking is the fact that the effect is not altered between respondents’ roles. Doctors, business students and patients alike alter their preference on the basis of the question setting. (McNeil et al., 1982) The behavior is not solely restricted to medical situations. The same effect can be found in various settings involving monetary outcomes. (Tversky & Kahneman, 1986)

There are many more examples and studies illustrating the previous point. There are instances where people systematically behave irrationally and even unintentionally against their best interest. Because these findings are not an improbable tail of an otherwise rational expectations distribution, leads this to the conclusion that the market as a whole can be irrational even on a systemic level. This contradicts heavily
with the theory of rational expectations and the findings invalidate it up to point, where it should not be used as basis, even in the absence of a better model.

### 2.1.5 Reflexivity

The second problem arises with the assumption that the markets are independent from market participants’ expectations. In sociology it has been acknowledged that participants’ thinking often affect the very situation what they are a part. This has been labeled as reflexivity by academics in sociology and later by investor George Soros (Bryant, 2002).

One of the most cited academics in the human sciences, Anthony Giddens theorized reflexivity in his widely cited work *theory of structuration* (1984). He describes human involvement in situations with other participants to be reflexive monitoring. This means that people have a discursive and rational level on consciousness. The former relates to the ability to reason and rationalize the surrounding world and behavior and the latter meaning *unarticulated knowledge* or subconscious functions. (Giddens, 1984)

Though in the theory of structuration, reflexive monitoring is assessed in a social interaction context involving *ontological security* and a *sense of trust* between individuals, it has a lot to offer to economics and the studies of financial markets. Giddens claims that ontological safety is achieved with the successful reflexive monitoring of participants and unconscious routines and rules. In other words in social relations people ‘get along’ when they properly assess their surrounding world and their own particular behavior in relation to that and also obey unconscious modes or rules of conduct. (Giddens, 1984)

Investor and philanthropist George Soros has criticized (1987) the prevailing view of independence with his theory of reflexivity. Instead of the common assumption that the relationship between expectations and their related course of events is a one way street, Soros claims that this is more like a two way street. His reasoning is remarkably similar to Giddens’, but he applies it in an economic context.
A bit like Giddens, Soros constitutes that people have two functions in their social conduct. He calls them the **cognitive function** and the **manipulative function**. Contradicting with the theory of rational expectations, Soros argues that our understanding about the surrounding world is biased, which leads to biased, or imperfect understanding of reality. This in turn may lead misjudged actions that can affect the very reality people so hard try to understand. (Soros, 2009) Figure 2 illustrates relationships in Soros’s Theory.

![Concept of reflexivity](image)

*Figure 2 - Concept of reflexivity*

With the cognitive function, investors try to understand the world around them and with the manipulative function they try to affect the situation to their advantage. Reflexivity is when these functions interfere with each other. This often creates feedback loops, which can result in self-reinforcing cycles. One example of such a cycle is the leverage cycle, where banks increase lending as collateral asset values rise, leading to even higher asset prices and more lending. (Soros, 1987)
Often two functions work together and they complement each other. For example, when driving, a car the cognitive function takes care of interpreting the things the driver sees and hears and also makes the required judgments about the following actions. On the basis of this perception and judgments the driver acts, turning the wheel in a curve and braking into traffic lights.

Driving is fairly simple and serious misinterpretations by the drivers are not very typical. However, the world of financial markets is much more complex and emotive. Rising stock prices inspire new investments, which end up raising the stock prices even more. This can go on until prices are perceived to be too high compared to fundamental values. Eventually the cycle reverses, causing an inverse cycle, which will end up turning again eventually. According to Soros, this is the sequence behind the boom and bust cycle that is often observed in financial markets. (Soros, 1987)

The major implication of this theory is, that instead of equilibriums, markets tend to be volatile by nature. This would explain the long term swings around fundamentally implied asset values as well the “noise” in asset prices. Moreover, it suggests, that we need a dynamic asset pricing model which is able to take into account the imperfections in market participants’ understanding and actions.

2.1.6 Market efficiency summarized

Intuitively many contrarians refute the theory of efficient markets just because some well-known superstar investors have outperformed the market consecutively for decades. This, however is not sufficient evidence against EMH, since when we live in a world with millions of investors, there is statistically room for some superstar investors who seem to continue to beat the market, though actually it would just be a result of a series of a random events.

The EMH does not state that no one can beat the market, it just simply states that investors’ performance is normally distributed around the market performance as its’ mean, which implies that it is statistically improbable to outperform the market on a long term basis, without taking extra risks.
The debate of market efficiency has raged for decades and the academic world is flushed with papers measuring some kind of efficiency somewhere in some time span. The debate has often been more emotional than rational, which is well reflected in the discourse around the matter.

Conventionally the scientific process of obtaining new knowledge relies on the process of testing different hypothesis. A hypothesis must be testable and refutable. In the case of the EMH however, the theory has been made almost irrefutable. Studies and phenomena conflicting with the theory have been classified as anomalies and contesting theories have been called attacks against efficiency, and have even been related to the devil (Fama, 1991, pp. 28).

Bad attitudes aside, most agree that most markets are often fairly efficient. The EMH is a usable context for discussion, but as a scientifically hypothesis it certainly can be consider falsified. Its feasibility as a scientific hypothesis can be preserved if and only if it is addressed in the context of social sciences and disregarding the Popperian criteria of the unity of method.

2.2 Part 2: Theoretical framework and hypothesis

From the viewpoint of this paper, the EMH is actually irrelevant. The purpose of the previous section is to illustrate the problems related with the theory and to gain some ground for the actual hypothesis. The irrelevance of the EMH stems actually from its assumptions and the prevailing way of economical thinking.

As the EMH and its supportive arguments emphasize how the arrival of new information is quickly reflected in market prices, it ignores the possibility that the actual change in the market price could affect the underlying fundamentals. In economics and finance, the prevailing paradigm for the past couple of decades has been the one-way effect from fundamentals to prices.
The hypothesis of this paper is, that instead of a one-way effect, a change in an assets’ price can also affect the underlying fundamentals, resulting in a two-way effect. A price change in an asset, induced by a change in a fundamental factor, may therefore, according to this hypothesis, affect the very same fundamental factor, possibly even reinforcing the original movement.

Instead of building yet another model measuring various variables and their effect on a set of assets, this article seeks to illustrate the recoil impact that asset price changes can have on their underlying fundamentals. At this point, for clarity’s sake, the concept will be termed the ‘feedback hypothesis’.

Inductively the hypothesis seems plausible. If profitability increases for a given company, it tends to lead to a rise in the company’s share price *ceteris paribus*. As the raised share price implicates raised firm market value and a stronger than earlier market valuation of the firms balance sheet, it should lead to improved financing opportunities for the firm. Given that the valuation of the company’s assets has increased, their valuation as collateral should have increased also. Therefore leading possibly to improved loan terms or lower cost of debt.

Another example, more related to the topic of this article, can illustrate the two-way effect in bond markets. As many firms roll over their existing debt by issuing new bonds the cover for the existing ones, the operability of this strategy is dependant of the interest rate and credit risk at the time of the roll over. If for example mistrust is provoked prior to the roll over, it can lead to higher financing costs and even to the failure of refinancing. This is a case where a change in an assets’ price (bond price) will have an affect on the financing possibilities and even the liquidity of the borrower (fundamentals).

If to be proven correct, the feedback hypothesis would explain the volatile price patterns observed in financial markets. Some changes would contribute the market prices swinging further from fundamentally implied values, other would make them return. Swings too far out from the fundamental values would themselves signal investors to act on the mispricing.
The concept owes a lot to George Soros’ thinking (2009) and to the concepts of social sciences. Figure 3 illustrates the relationships, the hypothesis implies, exemplified with a sovereign bond.

Conventional bond valuation, as reviewed later, is a simple model of discounting future cash flows and adjusting for default probability. Often sovereign bonds are valued without the prospect of default, hence the expression of risk free rates. During the Euro crisis of 2010, it became evident that such assumptions are far from realistic.

According to the prevailing paradigm and the spirit of the EMH, market prices reflect available information about an asset and its relative fundamental factors. It implies that a change in the fundamentals will result in a consecutive change in the market valuation, \( X_1 \), in figure 3. This relationship is elucidated here and labeled now as the resulting function. Conceptually the resulting function contains all the available information about the fundamentals, which results in the market price observed.
The feedback hypothesis, in the other hand, states that this kind of change would result in a change in the fundamental factors themselves. This change is illustrated here as the feedback function.

This function is perhaps best understood through an example. If the GDP growth forecast for a given country would be lowered, ceteris paribus. Would this normally lead to the depreciation of that country’s bond’s market price, ceteris paribus. However, as such depreciation means higher yields for these bonds, it also means greater re-financing costs for the country when it needs to roll over it’s debt. Should the yields rise to unsustainable levels, would the country be de facto denied from the international financial markets. This naturally does not help the original problem of deteriorating GDP outlook. In the absence on international lenders of last resort, such as the IMF or the World Bank, would the country in question be forced to trim down public expenses. As public consumption is an integral part of any country’s GDP, we find us in a situation where the change in the bond price has de facto affected the underlying fundamental factors.

The above example is similar to what happened to Greece in 2010. After the Greek government had restated their actual deficit, markets became weary and Greek bond prices fell abruptly. This led to the country’s inability to roll over their debt and it had to seek international financial aid. (Higgins et al., 2011)

2.2.1 Mathematical illustration of the hypothesis

Mathematically the feedback hypothesis actually concerns only the default probability component. As bond valuation can be divided into two components:

\[ P = \left( \sum_{n=1}^{N} \frac{C}{(1+i)^n} + \frac{M}{(1+i)^N} \right) - \left( P_{\text{default}}(1 - \text{Recovery rate}) \right) \]

Where, \( P_{\text{default}} \) is the default probability of the bond and recovery rate is the expected value recovered incase of a default.
In the equation above, the first component is the value of undefaultable bond and the second part is the default loss rate. Since the first component is merely a mathematical expression of pre-determined characteristics of the bond in question and it’s variables are determined in the issuance documents of the bond, all bond price movements should be derived from either changes in the discount factor $i$, or the default loss rate, both observable through $i$.

If conventionally $P_{\text{default}}$ is perceived to be an equation, with various variables of different fundamental factors, it could be illustrated the following way:

$$P_{\text{default}}(n) = f(t_1, t_2, \ldots, t_z)$$

Where, $P_{\text{default}}(n)$ depicts the default probability in time $t_n$

Then the feedback hypothesis would be simply an extension of that

$$P_{\text{default}}(n) = f(t_1, t_2, \ldots, t_z) + f(\Delta x_{n-1})$$

Where, $f(\Delta x_{n-1})$ is the feedback function of price change $\Delta x$ at time $t_{n-1}$

As each previous price change $\Delta x_{n-1}$ affects always the following $P_{\text{default}}(n)$ the hypothesis asserts a constantly fluctuating nature to the default probability component, which results in a constantly fluctuating market price. Though this is contrary to currently prevailing financial theory, it is in line with the actual state of affairs in markets.

2.2.2 Relation to the Theory of reflexivity

As the feedback hypothesis clearly owes a lot to the theory of reflexivity it should not been seen as a rival evolution of the theory. Instead the theories complement each other.
Where theory of reflexivity addresses the unintentional irrationality of individual investors and how their actions result in naturally volatile price behavior, the feedback hypothesis addresses the phenomena from the asset’s point of view.

However, that is not their only difference. Theory of reflexivity argues that in a world of information asymmetry and imperfect understanding, it is the misguided acts of investors and the subsequent misinterpretation of the following course of events lead to the volatile nature of markets. Instead of concentrating on the fallacies of individuals, the feedback hypothesis does not take a stance on individual behavior. It just articulates the obvious; price changes can affect the fundamentals and the continuation of this, results in volatile prices. It can affect, and most probably is the cause of both.

Some might see similarities between the dual functions in the feedback hypothesis and the theory of reflexivity. However, this is not the case. Reflexivity is mostly related to the resulting function and it grasps the market events that are a result of investors’ decisions under imperfect information. In the heart of reflexivity is individuals’ thinking and his subjective picture of the world. The feedback hypothesis instead focuses on the objective reality and measurable things.

Theory of reflexivity suggests that the feedback function affects investors’ thinking, but it ignores the possibility of it affecting the objective fundamentals. It states that it is only the thinking and actions of the individuals that can then affect the world. Reflexivity is concerned about individuals’ misjudgments inter alia of price changes and the information they signal, hence causing price deviating market behavior. The feedback function no doubt affects people’s thinking, but it can at the same time affect the underlying fundamentals. In this context the feedback hypothesis complements the theory of reflexivity.

In a way, reflexivity can bee seen as a micro level agent and the feedback hypothesis as a more macro level contributor to price volatility. Either way they are conceptually tied together in terms of probable reality, but can be scrutinized separately for the needs of academia.
2.3 Part 3: Risk and valuation

The following part of the paper assesses the determinants of credit risk and the relationship between bond valuation and risk. A short review of the evolution of credit analysis is given in order to put the quantitative approach in to perspective.

2.3.1 Credit risk

Credit risk means the risk of losses in the event of a credit event of the borrower. Instances, where the borrower fails to meet the debt agreements partially or as a whole are defined as credit events. Credit risk, however is much more than just the possibility of a credit event.

Credit risk can be seen as the loss suffered in the case of a credit event. Besides the actual probability of a credit event, it incorporates the risks associated to the possible recovery values and further exposures to the same risks from other sources. (Bessis, 1998)

An example of exposure risk for an investor would be holding both shares and bonds of the same company. Then in the case of default, would the investor experience losses not only from his bond position, but also most likely from his shares of the defaulting company.

Recovery risks are difficult to evaluate, especially in the absence of sound collateral of a legal framework for investor protection. In the case of corporate defaults, bond covenants and the quality of the company’s balance sheet help to estimate the recovery risks related. However, in the case of sovereign borrowers, recovery risks can be more difficult to assess, because they can be subject to political will. In addition, in sovereign default, the threshold of taking the borrower to court for debt reorganization may prove to be too high for most investors.
Since the scope of this article is limited and the focus is on sovereign borrowers, exposure risks are not assessed further. Mostly from the same reasons and for the reasons noted above, recovery risks are not either thoroughly assessed. Instead the focus is on default probability and the possibility that instrument prices can affect their underlying fundamental factors.

### 2.3.2 Default probabilities

Since all bond issuers can default on their debt, investors have to rely on different methods of valuation when evaluating default probabilities. On the course of history the various methods of assessing risk have evolved and improved.

Traditionally banks have relied subjective evaluations of the borrower's reputation, collateral, financial ratios and the loan conditions. Even though modern statistical evaluation has come to aid, banks even today rely on subjective or expert opinion, when deciding on granting credit. (Bessis, 1998) (Altman & Saunders, 1998) The problem with this is that, according to research, multivariate statistical models outperform subjective judgment in prediction accuracy (Sommerville & Taffler, 1995).

Academia has produced various different methods of assessing credit risks and namely default probabilities. Probably the most widely studied models are models relying on discriminant analysis and logit model analysis. Later models have been using, among other methods, option pricing theory to valuate the probabilities regarding default.

In his article, *Financial ratios, Discriminant Analysis and the prediction of corporate Bankruptcy*, Edward Altman introduced (1968) the *Altman Z-Score* to world. His model is still widely used by practitioners around the world today.
The Z-score was originally defined the following way:

\[ \text{Altman Z-Score} = 0.012(X_1) + 0.014(X_2) + 0.033(X_3) + 0.005(X_4) + 0.999(X_5) \]

Where,

\[ X_1 = \text{Working capital/total assets} \]
\[ X_2 = \text{Retained earnings/total assets} \]
\[ X_3 = \text{EBIT/total assets} \]
\[ X_4 = \text{Book value of equity/total liabilities} \]
\[ X_5 = \text{Sales/Total Assets} \]

Later Altman (2000) revised the equation by reducing the variables to four and by adding a constant. This was done to minimize the sensitivity to industry specific characteristics.

\[ \text{New Altman Z-Score} = 6.56(X_1) + 3.26(X_2) + 6.72(X_3) + 1.05(X_4) + 3.25 \]

As the name of the article suggests, the Z-Score is designed to evaluate corporate credit risk, not sovereign. Originally scores above 3 were considered good and these companies had a low probability of default during the next two years. With scores below 1.8 defaults were considered likely and the area between 3.0 and 1.8 was termed grey due to the uncertainties of forecasting. (Altman, 1968)

A decade after introducing the Z-score, Altman et al. (1977) introduced the ZETA™ analysis. It could predict bankruptcy with 90% accuracy a year prior to the event and with a 70% accuracy five years prior the default. Unlike the original model, the ZETA™ analysis is fairly indifferent between retailers and manufacturers. However, since the ZETA™ analysis is a proprietary effort, it’s exact variables remain undisclosed. (Altman, 2000)

As both the z-score and ZETA™ analysis methods are forms of linear discriminant analysis, they can not be used to define accurate default probabilities as such.
Instead the methodology seeks to classify borrowers to two different groups, trustworthy and untrustworthy. This is done by maximizing the variance between the groups and minimizing the variance within.

The logit models can be viewed as more evolved models since they measure the probability of default. The logit model resembles the discriminant analysis method, but it estimates the probabilities of the variables belonging to a group or class, such as default or not to default. Since the discriminant analysis assumes that the independent variables are normally distributed, the logit model is more suitable for many instances, as it does not.

Using a multivariate logit model Lawrence et al. (1992) find that payment history is a powerful factor when determining likelihood estimates for default in mobile home loans. On the basis of their logit analysis, Feder & Just (1977) suggest several factors as determinants of default probabilities. Moreover, Platt & Platt used the logit model (1991), as they compared un-adjusted and industry-relative financial ratios as bankruptcy predictors. They found that in the industry specific model prediction accuracy was slightly improved.

In comparison to the accounting based approaches of discriminant analysis and the logit method, there have been attempts to construct a more market-based approach. These attempts can be classified as the option price models (OPM), since their apparent inheritance to the option pricing methods of Black & Scholes (1973) and Merton (1974). (Altman, 1998)

Hillegeist et al. (2004) have compared the discriminant analysis models with the OPM approach. Their predisposition is similar to the EMH and they expect that the OPM approach should reflect all available information, as it is market based. They find that the OPM model is more accurate in predicting bankruptcy, than either the Z-Score or the O-Score, named after Ohlson (1980). According to their findings the OPM model was better than the two discriminant analysis models combined, but still insufficient as a stand alone method. The findings also implicate that the two approaches should be used together, as the discriminant analysis models were able to capture different information than the OPM model did. However, perhaps their
most important finding is that in addition to these models they found several significant variables that neither approach managed to utilize. (Hillegeist et al., 2004)

As most OPM based approaches, Hillegeist et al. are subject to the restrictions of the assumptions made originally by Merton (1974). Merton’s original model assumes that the volatility of the company’s stock price can be used as an accurate estimate of the variability of the value of the company’s assets, which is a bold assumption, to say the least. Moreover, as OPM approaches use the market value of assets and their volatility, the approach is not much use in estimating sovereign default probabilities.

Litterman & Iben (1991) take a different approach to the market based models. They try to derive market’s expectations on future defaults from the term structure of risk-bearing and risk free rates. To be true, this approach requires the expectations theory of interest rates to be true (Altman, 1998).

The approach preferred by credit rating agencies, is the mortality method introduced by Edward Altman (1988). The method is named after the logic behind the concept. Before the mortality method, average default rates and losses at default for given credit ratings, were obtained from large samples of data.

The problem was that the companies migrated between rating classes, bonds matured and callable bonds were called. This meant that using simple averages, would inevitably lead to inaccuracies. The logic underlying the mortality approach is similar to what is used in medicine. Instead of using averages, the aim was to follow the survival rates of certain populations or collection of bonds. (Altman, 1998)

To estimate the probability if a bond is in default or not after four years, the cumulative survival rate is calculated by using the following formula:

\[ \text{The cumulative survival rate} = (1-mm_{r1}) \times (1-mm_{r2}) \times (1-mm_{r3}) \times (1-mm_{r4}) \]

Where,
\[ \text{mmr}_t = \text{the marginal mortality rate on time } t, \text{ it is obtained from empirical observations about default rates for different years for the given rating class. (Altman, 1988)} \]

The problem with the mortality approach is that it utilizes past data on defaults. This leads to distorted default estimations over time, especially if market interest rates are changed and lead to higher financing costs for corporations.

### 2.3.3 Deriving default probabilities from credit default swaps

Since the creation of credit default swaps, there has been a direct market estimates about the default probability of an issuer. As CDS spreads indicate the cost of insuring against an issuers’ default, they should evolve parallel to credit spreads. It has been shown though, that CDS markets are the primary source of price discovery, as changes in corporate fundamentals is first reflected there and then credit spreads adjust to this (Blanco et al., 2005).

Longstaff et al. (2004) found that the majority of corporate credit spread is due to the default risk, even with the highest rated credit bonds. The discrepancy between CDS’s and credit spreads could be the result of asymmetrical liquidity, as some less traded bonds contain a liquidity premium. At the same time there have indications that liquidity risks can play a role in pricing CDS spreads (Tang, 2007).

CDS data also allows researchers to estimate the relative price of credit risk in the markets. It has been shown that actual default probabilities are much lower than risk neutral default probabilities. This means that price of protecting against default is significantly higher than the actual present value of the loss at default. (Berndt et al., 2004) (Driessen, 2005) These kinds of findings can be viewed as signs inefficiency in credit risk markets.
2.3.4 Fundamental factors affecting bond prices

As opposed to corporate debt, sovereign borrowers’ ability to pay is not dependant on the success of their business. Instead, traditionally sovereign borrowers have been regarded as risk free. This holds true, so far, for at least investment grade rated issuers, mainly the creditworthy developed countries.

The reason behind the risk free assumption is at least partly due to their legal right to collect taxes. Tax revenue can be viewed as certain cash flows that can be adjusted by raising or lowering the tax levy. As history has proven us, sovereigns do default and it can be due to their ability to pay, or their willingness to pay.

As decision makers change over time in sovereign borrowers, it is fair to assume that the willingness to repay debt varies over time too. Therefore, a country’s ability to pay can be easier to estimate. The goal is to establish a framework of fundamental factors that affect sovereign yields.

Sovereign debt crises are often painful and memoirs can be imprinted in the collective mind for a long time. Therefore one might be surprised how often sovereigns actually default. One explanation offered to the inconsistent pattern of sovereign behavior is the dilution problem. The rationale is that, borrowers have a difficult time in understanding the impact that issuing new debt has to old outstanding commitments.

Hatchondo et al. (2010) argue that the dilution problem counts for most of the sovereign default risk. Others have suggested that a debt seniority system would solve the matter with sovereign borrowers as it has done so in corporate debt markets (Chatterjee & Eyigungor, 2012). If the dilution problem could be solved, it has been estimated that the actual sovereign default probability could be reduced by a staggering 84% (Martinez, et al., 2012).

Since the level of indebtedness naturally affects a country’s ability to cope with the interest expenses, it is a natural factor to start the review from. It has been shown that high deficits and public debt tend to raise credit spreads, but the actual impact depends on the prevailing fiscal, institutional and structural conditions (Baldacci &
Kumar, 2010). There is also evidence that the level of public debt is linked to GDP growth (Caner et al., 2010). It seems that when the debt burden becomes unsustainably high, it starts to hinder economic growth. This naturally aggravates the problem, as diminishing economic growth worsens the relative indebtedness.

Among other proposed variables, are per capita income, exchange rates, government income inflation and default history come up in studies. Especially the default history seems to play a significant role in sovereign credit ratings (Mellios, 2006). Moreover, there is also strong evidence that countries that default, will do so in a serial manner (Qian et al., 2011). This seem to hold especially for countries that are in their developing stage.

Reinhart and Rogoff (2011) highlight the link between banking crises and sovereign debt crisis. According to their findings, banking crises are often triggers to sovereign debt crises, but not because of the possible recapitalization of the finance sector, but instead because of the diminishing tax revenues banking crises tend to cause.

We know that elections typically raise the cost of lending for developing countries. (Block & Vaaler, 2004) find that developing countries experience credit rating cuts more often on election years. They also link the phenomena to the elections, as they are able to show that credit spreads tend to be higher before elections and lower after them.

McGuire & Schrijvers (2003) find that sovereign spreads in emerging markets move in tandem and that approximately one third of this movement is due to mutual factors. Their findings suggest that emerging market spreads are mainly driven by investors’ appetite for risk. This is consistent with the findings of Remolona et al. (2007), who found that the actual sovereign risk and the risk premium can evolve asymmetrically. The default risk seems to be dependant on country specific fundamentals, as risk premiums seem to be dependant on investors’ risk tolerance.

Controlling for macroeconomic variables and the structure of external debt Detragiache & Spilimbergo (2001), show that the probability of debt crises are related
to the liquidity of a country. This is consistent with the hypothesis and supportive arguments of this paper. A country defaults, if it is unable to roll over its debt.
3 Quantitative analysis

The quantitative research consists of two sections: 1) A broader analysis of sovereign default episodes and 2) a case study of the Greek debt crisis. The first section seeks to highlight similarities and differences in various credit crises. The goal is to evaluate different reasons and motivations for governments to default during the last few decades. Additionally, the multitude of events and their event-related fundamental factors are assessed before, during, and after default episodes in order to explain the often-sorrowful course of events that take place in sovereign defaults.

The second section will tackle the very hypothesis of this study, by examining possible reverse causality and bi-directional feedback between the Greek government 10-year bond yield and its fundamental factors during the last 14 years. In this part a vector autoregressive model is constructed, with variables chosen with extensive correlation and regression analysis.

3.1 Data description

The first dataset used in this study was constructed using the updated and extended external wealth of nations, later EWN, dataset by Lane & Milesi-Ferretti (2007). The dataset contains information of countries’ different external liabilities and assets from a time period between 1970-2011.

From the dataset, 78 countries were chosen by the size of their economies. Countries were ranked from largest to smallest on the basis of their 2012 GDP converted to international dollars using purchasing parity rates (World Bank, 2013). Though Argentina does not have GDP data for 2012, it was included in the data set as it is the 20th largest economy in the world with a GDP of roughly 771 Billion $ (CIA, 204).

Azerbaijan was excluded from the data. This does not pay a remarkable significance for the study since Azerbaijan has not experienced sovereign default during the time-
period. More over data for Azerbaijan’s external liabilities are limited and extend back to 1995 at best. Also Hong Kong was excluded from the data, since from the statistical components of modern day China, only Mainland China was taken under review. This neither has a dramatic impact since Hong Kong has not either suffered a default on the survey period. Macao’s economy is not large enough to be considered for this selection.

Additional variables regarding economic conditions for the countries were obtained and added from the World development indicators, a database maintained by the World Bank. These variables add information about inflation, GDP, savings rates, FDI, government expenditures and various other factors.

Sovereign bond yields were obtained from the Datastream® database. When possible official government 10-year benchmark yields are used for the sake of comparability. Countries that do not have a 10-year benchmark yields, or it was not available, equivalent 10-year zero coupon yields were used.

All rates are constructed similarly using the bootstrapping technique. Interest rate data obtained was daily, though most macro economical data is annual, or quarterly at best. From the daily data, annual averages and interest rate volatilities were calculated in order to be used with the annual data. Besides annual volatility as a variable, the interest rate range for a given year was constructed by subtracting the lowest interest rate on a given day of the year from the highest. This helps to comprehend the actual scale on interest rate changes on a given year. One single drop or a rise, no matter how enormous, is not quite captured in the annualized volatility, if for the rest of the year volatility was scarce.

Finally a dummy variable was added implicating a state of default. The dummy was given a value of one, if the country was in default at that given year; otherwise the dummy got a value of zero. The default events were obtained from prior academics’ work, mainly Carmen Reinhart and Kenneth Rogoff (2011) (2009). This data is used because the default data is gathered from various sources, since most sources are somewhat incomplete (Reinhart & Rogoff, 2009).
The Polish default of 1981 is added to the data since Reinhart and Rogoff miss to include it in their data. In the very early 1980’s Poland experienced a severe political and economical crisis, which eventually lead to a substantial rescheduling of Poland’s financial liabilities to western banks. (Toledo Blade, 1982) (Sigerson, 1981) (Borensztein & Panizza, 2009).

The definition of default is far from unambiguous. Often defaults do not involve the actual loss of nominal principal, but because a severe violation of original loan terms the event can be regarded as a default. The same applies with currency crisis and inflation shocks, which can lead to significant losses in real terms though the nominal would be paid fully. Table 1 illustrates the default episodes captured in the data.
Since the majority of the default events are originally derived from standard & poor’s default statistics, their default definition is used to define a state of default in this study. S&P defines default as a failure to meet interest or principal payment on the predefined payment date, or within a reasonable period within the original date.
Similarly a violation of original debt terms is considered as a default. This applies especially if the debt is rescheduled at less favorable terms than the original loan. Most events in the sample classified as defaults involve some reimbursement to creditors, as outright defaults are extremely rare.

With 78 countries, the sample captures more than 94,5% of world GDP by 2012 figures and therefore information on the most influential sovereign debt crises from the time period. There are 61 individual episodes of sovereign default and 114 years a country is in default altogether. Figure 6 illustrated the frequency of sovereign defaults in the sample.

3.2 Fundamentals arising from data

The variables in the modified EWN data do not correlate very well with the interest rate yields. All original and added variables in the EWN data were tested for correlation with the dummy variable of default and more importantly with the actual 10 year bond yields.
The most prominent correlations seem surprising at first, but a detailed inspection of the dataset helps to give more answers. Against intuition, it seems that when the amount of a country’s total liabilities increase, it rather decreases than increases borrowing costs and credit risks. A closer examination reveals that countries with great liabilities tend to have also substantial assets in general. Another notion is that, during the sample period, the countries that have experienced sovereign default are mainly small or middle-sized economies. This is why GDP growth seems to decrease borrowing costs and credit risks.

The same set of correlation was run for shorter time periods and with an emphasis around times of credit events. In general the correlations were not remarkable, though they varied with different samples. For example FX reserves and FX ratio have a negative correlation with both borrowing costs and credit risks, but this correlation is about doubled around sovereign defaults. The correlations prior the year 2000 and for the years after that were similar, but their strength differed somewhat. Correlations were on average two times higher between 1989 and 2000 than after the year 2000.

Table 2 illustrates the most significant correlations from the whole sample.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total assets</th>
<th>Total liabilities</th>
<th>GDP</th>
<th>NFA/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation with default</td>
<td>-0.0455</td>
<td>-0.0423</td>
<td>-0.0510</td>
<td>-0.0824</td>
</tr>
<tr>
<td>Correlation with yield</td>
<td>-0.2105</td>
<td>-0.1886</td>
<td>-0.1566</td>
<td>-0.1158</td>
</tr>
</tbody>
</table>

The low correlations and their variation brings up the first important finding of this paper: since there are no generally valid constant sovereign yield affecting fundamental variables, there can be no general widely applicable quantitative model of assessing sovereign credit risks trough fundamental factors. I.e. bond valuation is and should always be time specific. This is in line with Remolona et al’s (2007) asymmetry of risk. Moreover, if this is the case with fixed income instruments, should
the same apply to equities as well, since they are somewhat substitutive instruments in the inventing space. This certainly is a topic in need of more research.

More than others, this time and county specificity is apparent for sovereign credit instruments. As noted before a country just does not go out of business, but the decision to neglect financial obligations is often more or less a well thought and reasoned strategic decision.

When doing a detailed examination of the data, certain matters arise, which help to understand the time-varying risk asymmetry. First, most defaulting countries are not pure democracies, which can cause erratic legislations and behavior towards foreign lenders. Secondly, oil producing countries stand out from the rest, since their defaults are not usually related with continuous current account deficits or illiquidity issues. Finally, variables that anticipate sovereign debt crisis accurately for small countries, do not work the same with large countries.

For example the deficits witnessed with the US and Australia probably could not have been possible for smaller countries. The levels of fiscal deficit seen in Japan are out of the scale for most countries. When most developing countries default with PPG debt levels well under 80%, can Japan sustain a government debt to GDP ratio of around 200%. Though, Reinhart and Rogoff (2008) claim that the reason, why Japan can withstand the huge debt levels it has, is that the debt is mostly domestic i.e. held by domestic residents.

### 3.2.1 Country specific differences

The Lane & Milesi-Ferretti data with added variables about average sovereign yields, yield volatility and annual spread is a comprehensive tool in assessing the links between sovereign fiscals factors and bondholder confidence. Nonetheless, sovereign interest rate data in datastream’s database is somewhat incomplete.

Datastream has daily sovereign interest rate data for 34 countries and monthly for 11 countries. On average the observations date back to the very late 90’s. Most of the
countries that have data reaching further into history happen to be developed countries that have not suffered defaults during the past decades. The only two countries that have sovereign bond yield data from and around years of default are Greece and Venezuela.

Considering the common-good nature and the vital role of knowledge in modern societies, it is somewhat appalling that so little data is freely available for academic or other research. Due to the limitations of the interest rate data, a comprehensive multiyear analysis covering dozens of countries has to be dismissed at this point. Instead the data is assessed on a broader spectrum and a more detailed case study is performed with data concerning the Greek default during the recent Euro crisis.

To illustrate the time and country specific nature of the relationships between fundamentals and bond yields, correlation coefficients with the respective bond yield were calculated for several countries. Table 3 highlights some of these correlations.

Table 3 - Correlations between fundamentals and bond yields

<table>
<thead>
<tr>
<th>Country</th>
<th>FX reserves minus gold/Total liabilities</th>
<th>OFFICIAL IIP</th>
<th>GDP (US$)</th>
<th>NFA/GDP</th>
<th>current account (IFS or WEO)</th>
<th>capital account balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>0.812</td>
<td>0.586</td>
<td>-0.594</td>
<td>0.669</td>
<td>0.564</td>
<td>-0.704</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.853</td>
<td>-0.481</td>
<td>-0.680</td>
<td>-0.305</td>
<td>0.493</td>
<td>0.036</td>
</tr>
<tr>
<td>Finland</td>
<td>0.839</td>
<td>-0.122</td>
<td>-0.685</td>
<td>-0.187</td>
<td>-0.717</td>
<td>-0.823</td>
</tr>
<tr>
<td>Greece</td>
<td>-0.078</td>
<td>-0.182</td>
<td>0.206</td>
<td>-0.146</td>
<td>-0.099</td>
<td>0.051</td>
</tr>
<tr>
<td>India</td>
<td>-0.892</td>
<td>-0.106</td>
<td>-0.232</td>
<td>-0.131</td>
<td>-0.015</td>
<td>-0.636</td>
</tr>
</tbody>
</table>

Intuitively the ratio of a country’s foreign reserves and total liabilities would seem to correlate negatively with a country’s bond yield. Instead the opposite happens with many countries. Especially with developed countries the correlation was mainly strong and positive.

This is however most likely a clear case of quasi-correlation where the common denominator behind the correlation is elsewhere. In the data many developed countries have seen their interest rates decrease during the last decades. With low borrowing costs, sound credit history and a decent reputation the need for substantial foreign reserves are lower, especially if the average maturity of outstanding debt is long.
Decreasing borrowing costs have been the norm throughout the developed countries during the last decades. There can be many reasons behind this development and some of them can be illustrated through examples.

Following an example given by Nobel Laureate Robert Shiller, on his lecture *Theory of Debt*, we can imagine the simplest possible economy as a ‘Robinson Crusoe’ economy. In a Robinson Crusoe economy there is only one participant and therefore no trading. There is also only one good: Grain. The island-stranded Crusoe can decide between eating his grain and planting it. If diminishing returns are dismissed, the production possibilities function is linear.

In this example the economy’s interest rate is set by the technology and be derived from the production possibilities frontier. If decreasing returns would be included the PPF would be curved and the interest rate could be derived from the tangent.
Similarly if Crusoe’s preferences change, it would affect the interest rate with the shifting slope.

The reason all this is important, is that throughout the western world interest rates have decreased during the past decades. As interest rates can be also seen as a result of supply and demand of saving, low interest rates imply a consumption oriented society. This is also supported by the Robinson Crusoe example, as low rates equals a gently sloping tangent to the PPF. This directly translates as a high substitution cost between consumption and saving; one has to give up a lot of today’s consumption to improve future consumption by saving.

This is not strange as private consumption constitutes a lion’s share of total GDP in most developed economies. However, this rises the question that do modern service oriented societies waste growth potential by focusing so much on current consumption. Another question relates to inflation. Stand alone bond yields are not very useful when analysing the actual interest rate environments. One should take inflation in to account.

Figure 7 illustrates the US 10yo bond yield and the real yield bond holders would have gained if holding these treasuries. The real interest yield is the 10 year bond rate adjusted for dollar inflation. The inflation data is derived from the US Bureau of Labour Statistics’ monthly data, where from annual averages are used as comparative proxy (Bureau of Labour Statistics, 2014). This figure also supports the idea that modern consumption focused societies have low interest rates. For the US this is no surprise as private consumption there is one of the highest in the world and constitutes close to 70 percent of GDP. (U.S. Department of Commerce, 2014)
The clear change in the western interest rate environment during the past decades makes interpreting short-term interest rate changes tricky. As bond yields are eventually determined by the market prices of these securities, lower yields also imply that investors are satisfied with lower returns. The reasons for this can be multifaceted and are by no means in the scope of this study.

This acknowledgement however underlines the nonlinear nature of links between bond yields and fundamental factors. No security can be valued just on the basis of it’s fundamentals, the valuation must always be set to a context, as the world is full of substitutes. Therefore definite conclusions about the variables and their trends should not be made. Instead a remark is in place that links between fundamental factors and bond yields vary over time and place. Some environments result in expected relations with some countries and currencies, elsewhere the opposite might happen.

If among the conclusions of this study is a need for more dynamic asset pricing models due to two-way causality, a notion of effort to include elements of relative valuation should be made. Moreover as discussed earlier the often irrational behavior of investors can be one of the explaining reasons behind the discrepancies between fundamental developments and yield.
India for example has had a significantly high ratio of foreign reserves to total liabilities and the negative correlation with the country’s sovereign bond yield has been clear. India however belongs to low-income developing countries. Rogoff & Reinhart (2008) divide countries in three categories on the basis of their Institutional Investor Rating and debt intolerance, where low-income countries fall to categories more prone to default.

India has defaulted twice during it’s independence, in 1947 and in 1972. The country can hardly be considered as a serial defaulter, but it is more debt intolerant than the most developed countries. This may partly be due to the country’s sensitiveness to bond holder confidence, which would explain well the clear negative relation between borrowing costs and FX reserve ratios.

Another observation arising from the data resembles running out of money. In fact, some crisis countries’ sovereign bond yields have risen dramatically when the ratio between FX reserves and Total liabilities has decreased to record lows. Although, there are other factors also at play. For example, Spain and Ireland both suffered from a real estate crisis, which in Ireland turned into a devastating banking crisis.
3.2.2 Average interest rates and interest rate volatilities

As noted already, the Datastream database contains daily interest rate data for 34 countries. Though there are differences between the countries, on average the sovereign interest rates have decreased during the last three decades. On an aggregate level, interest rate volatility has spiked four times during this period; in the early and late 90’s, early 2000’s and during the euro crisis.

In the early 90’s Russia, Brazil, Algeria, Dominican Republic and Iraq and Kuwait were among the countries that did not respect their liabilities. However, in 1992 there was only one new sovereign default recorded and even 1993 had only two new events. Despite of this, the average sovereign interest rate volatilities continued to climb. The number of defaults peaked in 1994, with six countries being in default, African countries mostly. The causal links between these courses of events certainly deserves more in depth research.

In 1997 the Asian financial crisis helped the price decline of various commodities such as oil and basic metals. Though the Asian crisis did not lead to Asian sovereigns to default, it indirectly caused the Ruble crisis of 1998, which eventually lead to the default of the Russian federation and Ukraine as well.
The most prominent sovereign crisis of the early 2000’s was the Argentinean default of 2001, though the burst of the dot-com bubble the previous year might have also contributed to the instability in sovereign bond yields. The moderate level of rise in volatility can be explained by the fact that not very many other countries actually defaulted in the early 2000’s. Only in the year 2000 was there a surge of defaults, with the African countries being on the center stage, but the size of these defaults and the combined GDP affected was moderate at best.

The latest torrent of sovereign interest rate volatility has been during the euro crisis. And most likely can be mostly explained with the dramatic dispersion of European sovereign rates after the fiscal problems in Greece became evident and central European leaders had rushed to assure voters that investor would bear the burden.

Figure 8 was plotted from 1987, since most interest rate data existed from there onwards.

![Average interest rate and interest rate volatility](image)

Figure 10 - Average interest rate and average volatility

Regardless of how interesting the different surges in sovereign interest rate volatilities are, the actual levels do not necessarily reveal the true identities of the sources. To shed more light on the different surges trough time, all the countries with
current account and gdp data in the EWN dataset, were divided in to three groups or Tiers on the basis of their average current account deficits during the examination period.

The reasoning behind this was the claim Reinhart, Rogoff and Savastano made (2003) that countries could be divided to different clubs on the basis of their debt intolerance. Their original division criteria were the Institutional investor’s IIR rating and external debt ratios. This approach was dismissed and instead the current account deficit approach was chosen. The reasoning for this was that according to previous studies, ratio between current account balance and GDP is a usable indicator in predicting currency crashes (Kamisnky et al., 1998) (Goldstein et al., 2000). Currency crashes or strong exchange rate fluctuations are often strongly related with events of sovereign default, as shown later.

The simple arithmetic unweighted averages were used instead of medians due to the two facts that 1) the mean and the average values for the samples were close together in each case and 2) the arithmetic average better captures the magnitude of extreme current account deficits that would be overlooked by the median. However, it still is in place to note that most countries clearly had periods of continuous deficits and periods of continuous surpluses. This aspect was disregarded with the approach using simple averages.

Countries with relevant data in the EWN dataset were divided in to three groups on the basis of their average current account to GDP. Countries which had a average ratio on the sample period of below -3% were designated Tier 3, between -3% and 0% Tier 2, and a positive ratio on average Tier 1.

Intuitively countries in the first tier should be most immune to currency crisis and therefore likely to be also more immune to sovereign debt crisis as well, but there are some exceptions also. Oil producers usually enjoy healthy current account surpluses though on average they are not among the most trusted borrowers. On the other hand for example if there would not be such a faith in the dollar, the deficits the US has been maintaining could have easily caused a currency crash.
Most countries in the first tier are developed high-income countries with a sound credit history. Between 1970 and 2011 tier one countries have witnessed 14 years of default altogether. Venezuela is responsible for seven default years and Nigeria for four years. The reason why they have ended up in the first tier, is that they both are notable oil producers and therefore enjoy mostly of current account surpluses.

Tier 2 countries are of mixed breed. Combined they had 36 years of default between 1970 and 2011, of which Angola is responsible for 13 years and Argentina for six. The Angolan debt problems however are not captured in the volatility or yield series, since there is no data for Angolan sovereign yields. Otherwise, the group consists of developed countries as well as developing countries. Some countries have had moderate deficits during the whole period when others, such as Denmark ran decades of deficits in the 1970’s and 1980’s, but have since returned to surpluses.

Tier 3 has to most default years, with a combined figure of 42 defaults between 1970 and 2011. However Dominican Republic solely counts for 28 default years, as the country was practically in constant state of default from 1975 to 2001. The Dominican Republic neither has yield data on its debt, so it is not captured in the average Tier 3 interest rates and rate volatilities. Australia seem somewhat out of place in Tier 3, but a closer examination reveals that the country has been running large current account deficits for decades. Only time will tell how accurately Tier 3 describes Australia among other countries.

Table 4 - Country division by tiers

<table>
<thead>
<tr>
<th>Tier 1 countries</th>
<th>Tier 2 countries</th>
<th>Tier 3 countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>Belgium</td>
<td>China</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Norway</td>
<td>Finland</td>
</tr>
<tr>
<td>Singapore</td>
<td>Sweden</td>
<td>France</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Germany</td>
<td>Japan</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Kuwait</td>
<td>Malaysia</td>
</tr>
<tr>
<td>Venezuela</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
When the average sovereign yields and the interest rate volatilities are graphed for each tier, the remarkable finding is that each of the volatility spikes seems to be caused by a different tier. The graphed rates however are simple unweighted compound rates and can give a somewhat misleading perception of the actual economic state of affairs.

The highest spike in volatility in the first tier is during the late 1990’s and a closer examination reveals that though most European countries had significantly elevated sovereign yield volatilities during the Ruble crisis, the main cause for the spike are the extremely high volatilities in Malaysia and Venezuela during the years 1997-1998. The 1993 volatility hike is mainly due to increases volatilities in Japanese and the Finnish bond yields and the 2002-2003 hike can be solely explained by Venezuela, which defaulted soon after.
Tier 2 countries are mainly responsible for the mid 1990’s peak in yield volatility. Though most of the group countries had significantly elevated sovereign yield volatilities during 1993-1994, the main cause for the peak was Brazil, which witnessed a banking crisis and strong currency devaluation in 1994. To put the Brazilian yield volatility to perspective the intra-year range, eg. the difference between the minimum and maximum yields during 1994, was a staggering 50 percentage points. This volatility is more than enough to spike the simple unweighted average of tier 2 countries. The early 2000’s seem as a stable period, which is partly explained by the fact, that no sovereign yield data was available for Argentina.
The third tier of countries seem have had also some part in the mid 1990’s volatility spike, and most likely even had, since Kenya and Morocco both defaulted in 1994. However datastream has not sufficient interest rate data for these countries for the given years. The data representativeness greatly improves only from the 2000’s and is best for the most developed sample countries.

Therefore the dramatic spike in interest rates and volatility for the tier 3 graph is a result of the recent Euro crisis. The fascinating thing is that the use of a single variable (current account/GDP) could capture the worst hit countries in the recent crisis. More in depth analysis shows that both Greece and Portugal sustained double-digit deficits four years during the run up for the Euro crisis. Therefore there was clear indication of things to come and without the single currency there would have most likely been a significant currency crisis due to the drastic devaluation of to local currency. A thing most notably discussed by the media and academics with the term ‘grexit’.

As a summary of the interest rate data one can safely say that, on average sovereign yields have decreased trough out the sample during the last decades. Interest rate volatilities have spiked in different countries during high-level periods. More over, just by using the ratio between current account and GDP, one can establish a fairly reliable classification of crisis risk on an average level.
3.2.3 Event windows

To describe the most relevant data, an +/-4 year event window around each default was chosen following the footsteps of Reinhart & Rogoff (2008). All 114 default years and the preceding four years and the four subsequent years of each episode was picked from the dataset. These, mostly nine-year windows help in assessing the vast data. Some episodes however last more than one year and there are many cases of serial defaults where a country defaults in a serial manner but with a higher frequency than an eight-year interval.

Another issue is that the aftermath one default may simultaneously be the run up of the next episode. Therefore one must decide how to categorize these years for later review. In this study a bipolar approach was chosen. First all default preceding years were given the run up status; regardless of did they belong to an aftermath of a previous episode. Then another category was constructed, where each year was primarily categorized as a crisis-following year though it would have preceded the next default. All Descriptive statistics are described with both emphasizing methods.

3.2.4 When a country defaults

An outright default affects countries in various ways and not all defaults play out the same way. However, on an aggregate level certain aspects arise from the data.

![FX Reserves/Total liabilities](image)

**Figure 14 - FX reserves before and after default**
For example, there is a clear decline in the ratio of FX reserves and a country’s total liabilities preceding a default. In a default scheme the FX reserve ratio declines on average by more than 26% from the level three years prior a default. The important thing to notice is that the FX ratio generally starts to decline well before a crisis and can therefore give some indication of the possible things to come. Another clear trend regarding the FX ratio, is that it generally increases substantially after defaults as the countries recapitalize.

The ratio is on average more than 60% higher four years after an event than it is during the default. The four-year post event ratio is even 11,2% higher than the whole sample mean, which can be an indication that countries have a tendency to accumulate excess FX reserves after a default. This can be because in order to return to bond markets and regain lender confidence a sovereign borrower may need to post an appearance of having less credit risk than prior to crisis. Other explanations handle with the way the default is dealt with. Haircuts and debt renegotiations decrease a country’s total liabilities, where bail out packages can increase FX reserves. To assess the true reasons in proper depth, further research is needed. As a caveat, it is in place to note that the FX reserves figure in the EWN data does not contain gold.

Similarly to the FX reserve ratio, sovereign defaults tend correlate with a significant drop in Gross Domestic Product of the defaulting country. On average the GDP is over 27% lower during default than the year preceding it.

![GDP](image)

*Figure 15 - GDP before and after default*
Another notion is that the GDP growth seems to come to a halt the year preceding a sovereign default. The slowing growth rate can be seen as a late stage indicator of financial distress as real GDP growth often slows down in the years preceding financial crisis (Rogoff & Reinhart, 2008).

Another explanation can be that, sovereign debt crisis seldom obey the constraints of a calendar year. Often the problems and indirect consequences of a default can begin before the actual default occurs. If foreign investors lose confidence, capital flight and the resulting devaluation of currency among other factors can affect the GDP growth rate.

Reinhart and Rogoff also argue (2008) that sovereign crisis are often preceded with banking crises, which in turn are often preceded with massive debt accumulation. If this were the case, it would certainly explain the GDP growth slow down prior to sovereign default, especially in the cases that are related to banking crisis.

According to the researchers, the reason, banking crisis so often lead to sovereign debt crisis is not due to the recapitalizing the banks, but the sudden loss of tax revenues. In a banking crisis typically banks and financial institutions cut down their lending, which in turn translates to lower levels of corporate financing. When firms can not finance their everyday business, the only option left is to scale back operations, which inevitably leads to recession.

As GDP growth comes to a halt on average one year prior a sovereign default, the ratio between a country’s net financial assets (assets- liabilities) and GDP weakens also dramatically. This suggests that defaulting countries’ indebtedness increases during good years, which eventually becomes a problem when economic growth stops. This is contradictory to the view of counter-cyclical fiscal policy and raises once again an interesting research topic: does pro-cyclical fiscal policy increase the probability of sovereign default?
In addition to GDP effects, sovereign defaults are often associated with currency crisis. It can be that governments seek to inflate their debt burdens to more manageable levels, which can cause the currency to plummet. In other cases the currency might seem solid at first, but the abrupt loss of confidence and the resulting fire sale stressed bonds and other assets lead to the devaluation of the currency. The devaluation process itself can be self-reinforcing when each decline in the currency intensifies the need to reduce holdings in the plummeting currency.

The EWN data does not contain detailed data about exchange rate changes during default years. Instead the series contains data about the average exchange rate during each year. On top of this, there is a variable depicting the exchange rate in the end of each year. Together these two variables are used to get a very crude estimate about exchange rate change during each year. The Exchange rate difference
variable for each year is obtained by subtracting the end of the year exchange rate from the average rate for the whole year.

Even though this is approach is very crude, the trend regarding currency fluctuations and sovereign default seems very clear. On average during the default year the difference between the average exchange rate and the end of the year rate is over 30 percent. Another remarkable notion is that, when excluding states of continuous default and longer periods of currency free falls, currencies tend to plummet prior or after a default, but not very often both.

When calculating the frequency of exchange rate differences of more than 20%, they most typically occur during the year of default (37%). The likelihood of the currency drop happening the year prior or just after a default event is equally high (26%), but the probability of the currency difference being more than 20% prior and after the default, is only 11%. On average the exchange rate differences are somewhat larger prior to defaults than just after them.

A third striking notion is that on average the exchange rate difference was negative during the whole event window. In addition to that, cases where the difference was positive and more than 20% were very seldom and seemed to be paired the years of extreme negative differences. The dispersion of between exchange rate observations was by far largest during the years prior and after an event.

More over it seems to be slightly more typical that, if the exchange rate difference is positive prior or post an event, it is so during the build up of the crisis. Positive currency movements after defaults seem to bee related mainly to African countries.

Though the method used, is not very exact, the results it indicates are in line with Reinhart & Rogoff (2008), who claim significant correlation between periods of wide spread high inflation and periods when a high share of countries are in default.
3.2.5 Venezuela defaults in 2004

The Venezuelan default of 2004 is dismissed at this point due to the nature of the incident. The country missed its payment on the 15th of October 2004 on its oil-indexed obligations, because the finance ministry had not received the corresponding oil price from the state owned Petroleos de Venezuela SA for the calculation of the payment. The company had fired half of its staff a year earlier because the employees had striked to protest against the dictator Hugo Chaves. The layoffs compromised the oil company's finance department and at the time of the default the company had not released its financial statements for almost two years. (Bloomberg, 2005)

It is somewhat fair to conclude that Venezuela's 2004 default was not so much about bond holder confidence as the country’s borrowing costs were absurdly high from the late 90's due to the default episode of 1998. Moreover, the country was not objectively considered to be a predictable democracy. Besides the improvement in the country's fiscal state was mainly due to the increase in oil prices during the 2000’s. Oil was and still is Venezuela’s most important export and source of government revenue.

Figure 18 - Venezuela's NFA and Yield
As a sovereign equivalent of a junk status borrower, Venezuela is left out from this study.

### 3.2.6 Summary

Some countries counter difficulties with reasonably low levels of public debt, others can seem to manage preposterous levels of public debt and have even low running yields. Many countries default, though they could have easily managed to clear their financial obligations, if the matters would have been dealt with appropriately. Others decide to respect their obligations even though it would not be the best for the people.

The fact is that each and every sovereign default has so many case-specific variables and causalities, that defaults should be studied as unique events rather than through statistical test from large data samples. Though it is good to know what thing increases sovereign credit risks in general, it is even more important to understand the very details that eventually decide the fate of countries under distress.

Therefore this paper takes the most recent sovereign default of Greece under closer examination. During the writing of this article, Argentina is in the middle of a sovereign debt crisis and the countries’ debt papers have been downgraded to default status. But as the eventual course of events is still to unravel, the case is dismissed here and left to later scholars for to study.

### 3.2.7 Absurdness of confirmation

As this study articulates a hypothesis and brings forward rationale and arguments supporting it, the empirical part should seek to falsify the very statement the whole paper stands to defend. Most academic, or so-called academic studies, especially in modern economics, formulate an idea or hypothesis and then try to find evidence supporting it. Academics too often seek confirmation from empirical evidence that is fitting to their paradigm.
This inductive method of doing scientific research is absurd and de facto is not aimed at unraveling new knowledge. As an example one can take the notion of bulls being slaughtered on average after four years of feeding. The unpleasant event of being slaughtered might and most likely is a total surprise for the animal, but hardly to the butcher. What one considers extremely unlikely or an outlier event might be the expected outcome from another point of view. Induction is flawed by our subjective observation and interpretations.

More over, induction can give us estimates and probabilities based in historical events, but it can never reveal facts. This flaw is enhanced by people’s remarkable ability to add causal explanations for historical events, no matter how random and non-causal they would have originally been. The pursuit for new understanding would be missed if the empirical part of this study would submit itself for finding reassurance in fitting evidence.

Seeking confirmation in academic studies is a waste of time since the hypothesis itself contains as much truth-value as any amount of supporting evidence ever could. Therefore the aim of the empirical scrutiny in this study is not to find supportive evidence, far from it. The only way this, or any other study, can contribute genuinely is to try to falsify the hypothesis, it’s own or a rival one. No matter how many perfectly matching events are found from empiria, the first event to mismatch is enough to render the hypothesis back to the drawing board.

If this study fails to invalidate the prevailing paradigm on independence, it does not mean that the prevailing wisdom is true. However, if the hypothesis is rejected with certainty, results this to a confirmation that the hypothesis is not a description of truth, but merely a entertaining narrative. The problem with the position of this article’s hypothesis is that it is neglected and the shear possibility is even dismissed in prevailing financial economics. Therefore, what we have is a special case, where rejecting the stated hypothesis would not change anything.
3.3 Case study: The Greek debt crisis

3.3.1 Greek history of default

Though investors might have expected a degree of joint responsibility among the euro countries prior to the euro crisis, a closer look at the individual countries’ default history would have given reason to price in larger spreads way before the turmoil. Spain, Portugal and Greece have a impressive record of defaulting.

Greece has defaulted in 1826, 1843, 1860, 1893, 1932 and in 2012. The country’s first default occurred three years before it’s independence, as the debt was mainly used to finance its independence struggle against the Ottomans. The last default prior to the current crisis occurred during the great depression and lasted until 1964. Greece has practically been in a state of default half of the time since 1800. (Reinhart & Rogoff, 2009)

The last default of 2012 was a close call, as the country almost managed to restructure its debt without the disgrace of labeled as a defaulter once again. After continuous bailouts it became evident, that Greece’s debt burden would have to be renegotiated one way or the other. As the participation rate for the restructuration known as the “hair-cut” reached only 83,5% of the debt outstanding, Greece was forced to activate its collective action clause to enforce participation. This lead to the International Swaps and Derivatives Association, ISDA to declare a credit event, signaling for a default and triggering credit default swaps. (Economist, 2012) (CNBC, 2012)

3.3.2 Limitations and chosen approach

Due to the uniqueness of sovereign default episodes, the limitations of the data available and the limited scope of this article, the hypothesis is tested on a case study of Greece during the euro crisis. Daily sovereign interest rate data is used. The Greek 10 year bond yield data dates from July 10th 1999 to August 24th 2014. Unlike with historical data dating decades back, data availability is not an issue.
Since most macro economical data is annual or quarterly at best, the daily yield data is converted to quarterly data by using the average interest rate during the given quarter. Daily interest rates have naturally a high correlation with the respective yield volatilities and this relation is not disturbed with the averaging method.

### 3.3.3 Data

The preliminary quarterly dataset was comprised of 27 different variables suggested for data screening by prior studies and intuitive reasoning. Due to the individual nature of sovereign default events, correlations between fundamental factors and bond yields differ from case to case. Therefore it was vital to choose proper case-specific variables and not build solely on the models suggested in prior studies.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10yo interest rate</td>
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</tr>
<tr>
<td>Interest rate volatility</td>
<td>0,942984448</td>
</tr>
<tr>
<td>GDP</td>
<td>0,084092815</td>
</tr>
<tr>
<td>GDP growth</td>
<td>-0,721835406</td>
</tr>
<tr>
<td>Current Account</td>
<td>0,250316886</td>
</tr>
<tr>
<td>Current account deficit</td>
<td>0,241452181</td>
</tr>
<tr>
<td>Capital Account</td>
<td>-0,252310903</td>
</tr>
<tr>
<td>FX reserves</td>
<td>0,12015394</td>
</tr>
</tbody>
</table>
Correlations between the quarterly variables and the correlations between the variables themselves were studied in depth and the various reasons underlying the relationships were assessed. As most directions of correlation seem logical, there are also surprises that evoke the question of direction of causality.

For example the relationships between the GDP related variables and yield seem somewhat surprising. In general GDP per capital has been seen to have a negative correlation with sovereign credit risk as so far sovereign credit events have most related with emerging economies.
In the case with Greece, we see that the GDP begun to shrink already during the financial crisis, but unlike most other economies Greece did not recover even to perform a double-dip.

However, the relationship between GDP growth and the bond yield is more intriguing. After the financial crisis ignited by the fall of Lehman Brothers and the bursting of the US house bubble, Greece's bond yield started to climb before the GDP growth plummeted, indicating the possibility of Granger causality. When to decrease in GDP growth started to ease out, it seems that the explosion of bond yields from around and below 15% to close to 20% ruined the recovery and the country was hit again, with accelerated GDP contraction. Intuitively this is in line with the drastic austerity measures undergone by the Greek government. Only after the haircut, started the yields decrease to more sustainable levels and the GDP contraction pace started to slow down.

On top of GDP figures, the correlation between bond yields and FX reserves and Taxes collected are somewhat bizarre. It seems that the increases in FX reserves and taxes collected are related to increases in sovereign bond yields. This finding arises the question of causality; are the countries increasing FX reserves to prevent
default with rising interest rates or are the countries forced to accumulate excess reserves in order to continue borrowing.

Another interesting aspect is the relationship between bond yields and debt servicing capabilities. The government Gross debt divided by annualized quarterly revenues can be used as a proxy to evaluate the government’s ability to sustain it’s debt levels.

![Debt to revenue and Yield](image)

**Figure 22 - Debt to revenue and yield**

The debt to revenue ratio also seems to increase in advance to the bond yield. This suggests that it affects bond yields with a lag, indicating a possibility of Granger causality.

### 3.3.4 Methodology

As the goal of this study is to refute the assumption of independence in asset prices in relation to their fundamentals the final variables chosen for the statistical model have to be relevant regarding the hypothesis. As noted before, the hypothesis brought forward in this study can be divided to following way:

1. Interest rate change (change in asset price) can affect the underlying fundamentals
2. because of 1) there is reverse causality between asset prices and the relative...
7) because of 2) static asset pricing and credit risk models are insufficient tools
8) because of 3) we need dynamic asset pricing models, which can take in to account the reflexive nature of the relationship between asset prices and their underlying fundamentals

To refute these statements, a model is needed, which will reveal a possible two-way causality function between bond yields and the given fundamental factors. The model needs to reveal enough information in order to assess all the statements illustrated above, but still maintain it’s statistical integrity.

As at the very heart of the hypothesis is the question of independence, or more precisely exogeneity, a two-stage least squares approach was chosen. To tackle the question of exogeneity versus endogeneity, a Hausman test is performed. Then the possible two-way causality is tested for with a vector autoregressive model.

Vector autoregression, or VAR is useful when analyzing multiple time series, because it treats the variables as equations. In essence VAR models treat the variables as equations and regress the lags of the given variables against the equations. As VAR models can be considered as ‘let the data decide’ oriented models since they do not call for deep understanding of the relations between the variables compared to structural methods built upon simultaneous equations. The variables in the model still need to be chosen on the basis of theoretical reasoning in order to avoid an inductive approach.

The variable selection process was two staged. First, the most important factors affecting sovereign bond yields were chosen on the basis of prior studies. Then, the individual variables from the data available were chosen in terms of their suitability and information richness. Even though a variable would seem to have a clear correlation and intuitive reasoning would support it’s presence in the model, it could be dismissed if similar variables that contained more information and predictive power over bond yields were found.
The three most important factors chosen for the model were 1) Future ability to honor commitments, 2) fiscal reality and 3) investment landscape.

Cantor & Packer (1996) highlight GDP growth, trade balances and a country’s fiscal balance as determinants of sovereign credit risk. However, the importance of trade balance seems to be case dependant. Prior to it’s default, Greece had run years of current account deficits, but the current account deficit, as severe as it was, begun to improve almost two years before investors lost confident in Greek debt.

Moreover, Venezuela or other oil exporting countries seldom have significant current account deficits, but still many of them default from time to time.

![Current account deficit and Yield](image)

*Figure 23 - Current account balance and Yield*

The term structure of outstanding debt has been suggested as a good proxy of a country’s future ability to repay debt (Blackrock, 2011). This approach is logical as the measure of debt maturing in the near term gives solid picture of a country’s near term liquidity and fiscal operating space. The problem with this approach however is, that the maturity profile of most sovereign borrowers’ commitments is not freely available and has to be purchased or constructed from multiple sources.
As another fiscal indicator, the tax rate has been suggested (Jeanneret, 2009). The higher the tax income, the bigger debt burdens countries are able to maintain and higher debt burdens are often associated with greater likelihood of default. Although there have been arguments claiming that high debt levels are not a necessity for a default, especially with developing economies (Reinhart & Rogoff, 2008)

Equity returns and equity related approaches have been also suggested (Aunon-Nerin et al. 2002) (Longstaff et al. 2007) (Jeanneret, 2009) as indicators related to sovereign credit risk. Researchers remain divided about the fact, do US equity return have an impact compared to local returns, as there is evidence of both. Perhaps this is a consequence of the fact that sovereign default episodes are often very unique events, which occur in very different economic environments and can be caused by a multitude of factors. Nevertheless, equity returns at least offers an anchoring point to the event specific investment landscape.

### 3.3.5 Variables

As a variable depicting the factor related to the country’s future ability to repay it’s commitments GDP growth was chosen. The debt term structure was considered a compelling candidate, but in the absence of relevant data it was dismissed. GDP per capita has also been shown to have explanatory power over credit risk (Reinhart & Rogoff, 2008) (Blackrock, 2011), but GDP growth was chosen instead as the eventual variable in the model. The primary reason for this is that instead of just describing the level of GDP, the growth figure reveals the change and direction of the given economy. The secondary reason is, that according to the hypothesis, GDP growth should be also affected by changes in the yield. When estimating the future ability to pay, GDP growth contains more information about where the economy is heading, than the stationary GDP per capita ever can.

As a variable depicting fiscal space, the annual revenue by gross debt was chosen. This had more explanatory power over the yield variation than the trade balance based variables and the approach mimics corporate credit risk analyzing revealing the country ability to collect revenues in respect to it’s debt burden. FX reserve
related ratios were also considered as variables depicting fiscal space, but they were dismissed in the absence of explanatory power. This probably is at least in part related to the fact that Greece is a part of the Euro zone and therefore the majority of it’s foreign trade is in domestic currency and as a part of a bigger currency union it is less vulnerable to traditional currency crisis.

Finally to anchor Greek debt and it’s return to the risk atmosphere that prevailed before, during and after the Euro crisis, an equity based component was chosen. After analyzing the S&P500 index, Stoxx 600 Europe and the Athens stock exchange ASEX index and their relation to Greek sovereign bond yield, a composite variable was constructed.

This was mainly done because none of the index had a remarkable correlation with the Greek 10 year bond yield. As ASEX and Stoxx 600 Europe have more co-correlation than correlation with the S&P500, the decision was made to construct a composite variable of the difference between ASEX and the S&P500. This composite variable should be able to grasp market premium of Greece compared with the benchmark equity market of the US.
Moreover, the composite variable of the index difference has more explanatory power over the Greek bond yield than all the stock indices themselves. The indices were indexed together using Q1 2000 as the starting point. Since then, the S&P500 has returned over 100% more than the ASEX, less dividends.

Variables for the GDP growth equation were chosen mainly by GDP components. Investments were depicted by capital formation, which was adjusted for seasonality by using an annualized rolling change as a quarterly proxy. Consumption was depicted with unemployment, as these often evolve in tandem. Yield was used as an endogenous variable according to the hypothesis. Net exports were depicted with changes in current account similarly adjusted for seasonality as capital formation previously. However, with the lack of explanatory power, current account changes were eventually left out of the equation.

### 3.3.6 Model

The model consists of two equations, the first concerning yield and the second concerning GDP growth. The structural equations are as follows:

\[
\text{Yield} = \beta_0 + \beta_1(\text{GDP growth}) + \beta_2(\text{Gov revenue to debt}) + \beta_3(\text{S&P500 vs. ASEX}) + u_1
\]

\[
\text{GDP Growth} = \alpha_0 + \alpha_1(\text{Capital formation}) + \alpha_2(\text{Unemployment}) + \alpha_3(\text{Yield}) + u_2
\]
As yield is present in both equations, there is a clear linkage between the equations. To address this endogeneity problem reduced form equations were obtained, as follows:

\[ \text{Yield} = \pi_{10} + \pi_{11}(\text{Capital formation}) + \pi_{12}(\text{Unemployment}) + \pi_{13}(\text{Gov revenue to debt}) + \pi_{14}(\text{S&P500 vs. ASEX}) + v_1 \]

\[ \text{GDP Growth} = \pi_{20} + \pi_{21}(\text{Capital formation}) + \pi_{22}(\text{Unemployment}) + \pi_{23}(\text{S&P500 vs. ASEX}) + v_2 \]

The explanatory power is not remarkably altered with the reduced forms, as the GDP growth equation is clearly more robust. With the endogenous variables removed from the left hand side, the reduced form equations are unbiased and can be therefore estimated using OLS.

### 3.3.7 Endogeneity

Endogeneity was tested with a Hausman test and the relationship between yield and GDP growth were also tested with a two-stage least squares model. The Hausman test statistics are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.018917</td>
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<td>0.8304</td>
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<td>GDP_GROWTH</td>
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<td>SPASEXRATE</td>
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<td>1.432400</td>
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<tr>
<td>R-squared</td>
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<td>Mean dependent var</td>
<td>0.079046</td>
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</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.549542</td>
<td>S.D. dependent var</td>
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<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
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<td>Akaike info criterion</td>
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<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.093142</td>
<td>Schwarz criterion</td>
<td>-3.131493</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>92.91030</td>
<td>Hannan-Quinn criter.</td>
<td>-3.245891</td>
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<tr>
<td>F-statistic</td>
<td>16.85951</td>
<td>Durbin-Watson stat</td>
<td>0.328667</td>
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<tr>
<td>Prob(F-statistic)</td>
<td>0.000000</td>
<td></td>
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</tr>
</tbody>
</table>
As the fitted GDP growth variable is not significant in the Yield equation, it indicates that GDP Growth is exogenous for Yield.

As the fitted Yield variable is significant in the GDP Growth equation, it indicates that Yield is endogenous for GDP growth hinting a possibility of a causal loop.

The results for the two-stage least squares approach are as follows:
All in all, the results are not very revealing. In the yield equation, the GDP growth variable is the only one that is significant on a 95% confidence level. The coefficients are also as expected; negative for GDP Growth and positive for the rest of the variables. With the GDP Growth equations the R-Squared is negative, which should be interpreted with caution. Moreover the coefficients are somewhat surprising; only the yield is as expected, negative for GDP growth.

### 3.3.8 Two-way causality

As the Hausman test performed earlier suggested that there might be a feedback loop from yield to GDP, the possible two-way causality is tested more in depth with a vector autoregressive model. The VAR model has the following four variables: 1) yield, 2) GDP growth, 3) annual revenue/debt and 4) S&P500 vs. ASEX the model will encompass a fairly large number of parameters. A VAR model has basically $(g+k^2)$ parameters, where $g$ is the number of variables and $k$ is the number of lags.

The variables age given the following labels:

Yield = yield, GDP growth = GPD_GROWTH, annual revenue/gross debt = GOV_REVE_TO_DEBT and S&P500 vs. ASEX = SPASEXRATE
In any VAR model the most important question is the proper length of the VAR or how many lags to incorporate in the model. The most suitable lag length was chosen by employing a multivariate information criterion. Table 6 Plots the results.

Table 6 - Information criterion test results

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
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<tr>
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<tr>
<td>9</td>
<td>739.3160</td>
<td>55.62067*</td>
<td>5.36e-16*</td>
<td>-26.87800*</td>
<td>-20.87664*</td>
<td>-24.65241*</td>
</tr>
</tbody>
</table>

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

All of the information criterion deployed, indicated nine lags as the proper VAR length. Non-stationarity was tested with the first differences of all the variables. So the final model regressed equations of the four variables against nine lags of each of the variables.
### 3.4 Results

Table 7 shows the VAR model coefficients and the respective t-statistics.

**Table 7 - VAR model coefficients**

<table>
<thead>
<tr>
<th></th>
<th>YIELD</th>
<th>GDP_GROWTH</th>
<th>GOV_Reve_T</th>
<th>SPASEXRate</th>
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<td><strong>YIELD(-1)</strong></td>
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<td>(0.40550)</td>
<td>(7.35663)</td>
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<td>-0.758666</td>
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<td>0.865419</td>
<td>0.419654</td>
<td>3.288077</td>
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| R-squared | 0.999333 | 0.998306 | 0.997566 | 0.983189 |
| Adj. R-squared | 0.995905 | 0.989597 | 0.985050 | 0.986730 |
| Sum sq. resids | 0.000144 | 0.000302 | 0.000271 | 0.089137 |
| S.E. equation | 0.004528 | 0.006572 | 0.006220 | 0.112844 |
| F-statistic | 291.4977 | 114.6178 | 79.70135 | 11.37174 |
| Log likelihood | 215.4975 | 199.1089 | 201.5281 | 74.00573 |
| Akaike AIC | -8.113524 | -7.368586 | -7.478551 | -1.682079 |
| Schwarz SC | -6.613183 | -5.862425 | -5.978210 | -0.181738 |
| Mean dependent | 0.084796 | 0.012793 | 0.329491 | 0.280693 |
| S.D. dependent | 0.070760 | 0.064429 | 0.050871 | 0.351149 |

Determinant resid covariance (dof adj.) | 4.67E-17 |
Determinant resid covariance | 2.99E-20 |
Log likelihood | 739.3160 |
Akaike information criterion | -26.87800 |
Schwarz criterion | -20.87664 |
With so many parameters in the model, the interpretation is far from simple, especially as the signs on the coefficients vary between lags. In the yield equation, coefficients to the 2nd, 3rd, 4th, and 6th lags of the yield variable were statistically significant according to the t-statistic. The 3rd and 6th coefficients were negative and both of them greater than the positive coefficients, implying that as the bond yields seem to have positive autocorrelation with six month and 12 month intervals, the nine and eighteen month autocorrelations were negative and the impact was stronger. Perhaps more interesting however was the fact that almost all of the other variables’ coefficients were significant with almost each lag. Only GDP_GROWTH and GOV_REVE_TO_DEBT(-3 and -9) and SPASEXRATE(-1,-2,-6 and -8) were insignificant in explaining the yield equation. This hints that the variation in the variables chosen broadly affect changes in the government 10-year bond yields.

In the GDP Growth equation, lags of yield seem to be more significant on a longer-term than on the short-term. This appears logical, as GDP Growth decreased before the yields started to climb. GDP Growth itself was significant with 1st, 4th, 6th and 9th lags, possibly hinting seasonality in the GDP growth patterns of Greece. This is neither hardly a surprise, as Greece is very dependant on tourism, which is a seasonal and especially cyclical business. The GOV_REVE_TO_DEBT is significant with all but the 2nd and 9th lags. This is also understandable as government revenues are often very dependant on economic progress. SPASEXRATE behaves well like the YIELD in the GDP Growth equation, which is expected as economic growth is often related to equity returns.

GOV_REVE_TO_DEBT equation has clearly less significant lag coefficients compared to the previous equations. YIELD is significant with only 2nd, 6th and 9th lags, with the two first having negative coefficients. This may be a sign that the variables have common factors, as falling revenues and rising debt levels are associated with sovereign debt crisis as rising yields are. GDP_GROWTH has significance in the 4th, 6th and 8th lags, with the coefficient being negative in the 6th lag. The interpretation of this can be challenging, as faster growth should translate to increasing revenues, but greater borrowing capacity as well. SPASEXRATE has significance only in the 7th lag, which itself can be a coincidence.
Moreover, in the SPASEXRATE equation, none of the lags of the other variables are significant, with only the 7th lag of itself showing significance. This raises the questions that, should SPASEXRATE be dropped out of the model. This however is not urgent as the other results are far from unambiguous. In order to reveal more about the relations in the equations a Granger causality/Block exogeneity Wald test is performed.

Table 8 - Granger causality test results

<table>
<thead>
<tr>
<th>VAR Granger Causality/Block Exogeneity Wald Tests</th>
<th>Date: 09/27/14   Time: 21:24</th>
<th>Sample: 2000Q1 2014Q2</th>
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<tr>
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<td>df</td>
<td>Prob.</td>
</tr>
<tr>
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<tr>
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<tr>
<td>All</td>
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<tr>
<td>Dependent variable: GDP_GROWTH</td>
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<td></td>
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<td>Prob.</td>
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<tr>
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Dependent variable: SPASEXRATE

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<th>df</th>
<th>Prob.</th>
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</thead>
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<td>0.6473</td>
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<td>0.6008</td>
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<tr>
<td>All</td>
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<td>27</td>
<td>0.9900</td>
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</table>

The test indicates that all of the chosen variable can be said to *Granger cause* fluctuations in the bond yield. This is hardly surprising, but the fact yield *Granger causes* fluctuations both in GDP Growth and Revenue to debt with 99,9% certainty, is in the light of this study’s hypothesis, almost astonishing. The Granger causality test also reveals, that the equity index variable does seem to affect the other variables, but the significance is one-directional.

The Granger causality test should not be confused with direct causation. Instead the proper conclusion is that changes in the yield seem to lead to changes in GDP Growth and the ratio of government revenue to it’s debt. But as the lags of yield are significant in the other variables equations and vice versa the presence of reverse causality or at least bi-directional feedback seems very probable.

As the block tests reveals which variables have significant impacts on each other, it does not reveal the magnitude, sign or lag of the effects to take place. Therefore *impulse response testing* and *variance decomposition plotting* was conducted. Both tables are included in the appendixes but some of the relations are highlighted next.
A shock in the yield itself is found to be self-reinforcing in the short-term before reversing to negative in the medium-term and reversing eventually back. This is consistent with the reasoning of George Soros in his description of the volatile nature of asset prices and markets. Shocks in the GDP growth rate increases bond yields in the short and medium terms, even when the initial effect is forced at zero. Also somewhat surprising is the fact that the effect stays for six lags before finally wearing out.

Shocks in the bond yield however do not seem to have contemporary effects of GDP growth, but after a while the effect starts to take place. And what is surprising is that the effect seems to last for many quarters. The delay however is logical, especially if the GDP growth change is due to changes in fiscal policy measures forced by increased bond yields. This is a clear confirmation of the hypothesis that changes in asset prices can have an effect on the underlying fundamentals themselves.

However some of this variation is at least part of the time caused by the variables’ own shocks. The magnitude of the forecast errors due to the variables’ own shocks can be estimated with the variance decomposition. For example the 100% of the
forecast errors of the variable YIELD are attributable to itself. The effect diminishes very quickly, but is present with all times.

This suggest that short-time fluctuations in the interest rate is mainly driven by itself, a clear violation of EMH and the paradigm considering asset prices as independent variables determined solely by their fundamentals.

The variance decompositions of YIELD and Growth are also interesting. Consistent with the impulse responses, the amount of effect is minor on short term, but increases after the third lag. If the first response is imposed as zero by ordering, the later variance of YIELD attributed to shocks in GDP growth are substantial at over 60 percent, but the level decreases.
4 Conclusions

This study sought to build a novel and comprehensive sovereign default risk model and to prove that there is reflexivity between asset prices and their fundamental factors. The first real finding in this study was that sovereign defaults are mostly individual events by nature and a ubiquitous model cannot and should not be constructed to assess sovereign default risk. Instead they are often strategic choices made by the governments in time specific environments, with participating investors as decisions makers on the other side, their actions limited by the boundaries of the time specific alternative asset and investment space.

The goal of this study is to provide information about the suitability of static asset pricing models. The hypothesis of the paper have been set as follows:

1) Interest rate change (change in asset price) can affect the underlying fundamentals
2) because of 1) there is reverse causality between asset prices and the relative fundamentals
3) because of 2) static asset pricing and credit risk models are insufficient tools
4) because of 3) we need dynamic asset pricing models, which can take in to account the reflexive nature of the relationship between asset prices and their underlying fundamentals

Though scientifically more rigorous, this study did not aim to refute it’s own claims. This was partly because these claims are addressed in modern economics as if they had been refuted earlier. Instead the refutation of assumptions currently prevailing in financial economics became to the goal, as confirming hypothesis 1) *de facto* eliminates the possibility of considering asset prices as mere results of their fundamental factors.

As the relation with YIELD and GDP_GROWTH clearly indicate, asset prices can affect their underlying fundamentals, with statistical significance. Therefore Hypothesis 1) can not be rejected. Bi-directionality was also found between bond yield and GDP growth, but this is no more reassuring or confirmative, than the
hypothesis itself. As hypothesis 2) can neither be rejected, the argument is laid out in such a manner that too wide generalizations should be avoided. One can summarize by stating that, though changes in government borrowing rates most probably affected Greek fundamental factor as the country was forced to austerity measures, it does not confirm, that this is the case always and everywhere.

Logically, not rejecting 2) leads to confirming 3) at least partly. As asset prices can affect their fundamentals, in some instances static asset pricing models can be somewhat insufficient and at least some dynamic aspects should be incorporated in the models, confirming 4). Or there is the possibility of not developing better tools for valuation, which would not be very surprising considering that the finance industry still relies heavily on models that have been proved either inconsistent with reality eg. Beta based approaches or insufficient in depicting the uncertainty they are designed to model eg. Black & Scholes approaches.

As the findings of this paper are rather straight forward, the final part of this paper seeks to illustrate the very events where these findings and their implications may be relevant.

Naturally sovereign debt crisis and other credit events involving changes in investor confidence, dynamic models could help to assess and evaluate the risks of loosing confidence. This is especially important for two reasons 1) bond holder losses suffered by evaporating confidence are partly self-imposed 2) the monetary risk of loosing confidence hardly is a linear function of increasing credit risk, which makes the assessment of these risks very difficult with modern valuation tools.

Another instance where dynamic asset pricing models would be useful are, IPO’s. As some offerings become hyped and lead to repeated increases in the eventual offer price preceding the IPO event, the offer price increases can become self-fueling. This is somewhat understandable at least in cases where the IPO proceeds are used for buying other companies. The more money raised, the more capacity to make even more money by buying companies from the market.
Third, somewhat more incremental illustration can be an example of a company, which’ share price has increased steadily, perhaps more than the fundamental valuation would preliminary suggest. This rise can, though affect the very fundamentals, as the share price increases, so does the market value of the company’s equity. This in turn, may lead to a reduction in debt financing costs, which are an integral part of fundamental valuation trough WACC for example.

The common factor in the above example is movement in an asset’s price. Therefore the natural benefit of non-static asset pricing models would be the ability to explain momentum, often witnessed in asset values.

This study has revised a vast dataset extending back decades and performed a case study with recent data. Unsurprisingly there have been results that are as expected and there have been those that are not. Some findings of this paper are more important than others, but the most important are the findings in future studies, inspired by this paper.
List of references:


Appendix 1 - Impulse Responses in VAR model
Appendix 2 - Variance decomposition in VAR model
Appendix 3 - Yield Equation OLS

Dependent Variable: YIELD
Method: Least Squares
Date: 11/08/14   Time: 16:04
Sample (adjusted): 2001Q1 2014Q1
Included observations: 53 after adjustments

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<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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</thead>
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<td>0.0048</td>
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<tr>
<td>GOV_REVE_TO_DEBT</td>
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<td>0.0340</td>
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R-squared 0.581328  Mean dependent var 0.079046
Adjusted R-squared 0.555695  S.D. dependent var 0.065633
S.E. of regression 0.043749  Akaike info criterion -3.348240
Sum squared resid 0.093783  Schwarz criterion -3.199539
Log likelihood 92.72835  Hannan-Quinn criter. -3.291056
Prob(F-statistic) 0.000000

Appendix 4 - GDP Growth Equation OLS

Dependent Variable: GDP_GROWTH
Method: Least Squares
Date: 11/08/14   Time: 16:01
Sample (adjusted): 2001Q1 2014Q2
Included observations: 54 after adjustments

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R-squared 0.836962  Mean dependent var 0.022372
Adjusted R-squared 0.827179  S.D. dependent var 0.063038
S.E. of regression 0.026206  Akaike info criterion -4.374484
Sum squared resid 0.034337  Schwarz criterion -4.227152
Log likelihood 122.1111  Hannan-Quinn criter. -4.317664
Prob(F-statistic) 0.000000
### Appendix 5 GDP Growth with omitted variable

Dependent Variable: GDP_GROWTH  
Method: Least Squares  
Date: 11/08/14  Time: 16:12  
Sample (adjusted): 2003Q2 2014Q2  
Included observations: 45 after adjustments

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<tr>
<td>YIELD</td>
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<td>-1.389125</td>
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<td>CURRENT_ACCOUNT_CHANGE</td>
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<td>0.011108</td>
<td>1.307975</td>
<td>0.1983</td>
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</tbody>
</table>

R-squared: 0.832184  
Mean dependent var: 0.011940  
S.D. dependent var: 0.063949  
Akaike info criterion: -4.246610  
Schwarz criterion: -4.045870  
Log likelihood: 100.5487  
Hannan-Quinn criter.: -4.171776  
F-statistic: 49.58906  
Durbin-Watson stat: 0.873521

### Appendix 6 - Yield Equation reduced form OLS

Dependent Variable: YIELD  
Method: Least Squares  
Date: 11/08/14  Time: 16:21  
Sample (adjusted): 2001Q1 2014Q1  
Included observations: 53 after adjustments

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S.D. dependent var: 0.065633  
Akaike info criterion: -3.237590  
Schwarz criterion: -3.051714  
Log likelihood: 90.79614  
Hannan-Quinn criter.: -3.166111  
F-statistic: 14.64656  
Durbin-Watson stat: 0.256619

### Appendix 7 - GDP Growth reduced form OLS

Dependent Variable: GDP_GROWTH  
Method: Least Squares  
Date: 11/08/14  Time: 16:32  
Sample (adjusted): 2001Q1 2014Q2  
Included observations: 54 after adjustments

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<td>YIELD</td>
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<td>0.085429</td>
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R-squared: 0.832184  
Mean dependent var: 0.011940  
S.D. dependent var: 0.063949  
Akaike info criterion: -4.246610  
Schwarz criterion: -4.045870  
Log likelihood: 100.5487  
Hannan-Quinn criter.: -4.171776  
F-statistic: 49.58906  
Durbin-Watson stat: 0.873521
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