Dipartimento di Economia e Finanza
Cattedra: Fixed Income, Credit and Commodities

Market's Expectations and Bond Risk Premia on Italian and German Government Bonds

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ANNO ACCADEMICO 2015-2016

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Introduction

Term structure of interest rates at any moment contains information regarding interest rates that market expects to prevail in the future. These informations are of great importance for central bankers and investors as well. With respect to the former, effective monetary policy relies on communication and therefore central bankers continuously attempt to extract investors' expectations about macroeconomic variables, such inflation and real GDP growth, which, in turns, requires to disentangle expected short rates and term premiums from observable yields. Moreover, unconventional monetary policy measures in response to the global financial crisis and Central Banks efforts work through the so-called channel of "portfolio rebalancing". This assumes market segmentation or preferred habitats and requires to be effective a reducing term premium on Government bonds, higher prices for risky assets, wealth effect and increasing spending. Thus, in a certain sense, it can be stated that term premium is an arguably policy target or, at least, perceived as an instrument for Central Banks.

Regarding an investor perspective, beyond the objective of gauging expectations, estimates of term premium can determine where the trade off between duration risk and reward is most favorable, either in terms of position along the term structure either across bond markets of different Countries. In fact, bond investors seek to select points on the term structure or to intercept Countries that pay the most for any given duration exposure and presents greatest expected returns all else equal.

This research paper provides empirical evidence on the role played by market's expectations and required risk premia in defining today's yield curve and their relation with Government bond performances. The following analysis will consider an international panel dataset, mainly focusing on the Italian and German Government bonds, adding the results from the U.S. Treasuries as a reference, during sample period that includes data from the year 2000 to the last available information of 2016.

Attempts of disentangling market's expectations and required risk premium have become even more crucial in a period of record low interest rate, where Central Banks struggle to boost inflation expectations in the medium term and investors are famish for returns on their investments. In this situation more refined statistical models show their flaws and limitations, due to assumptions on mean-reverting nature of interest rates and lack of robustness in the estimates. Inputs that are incoherent with those assumptions produce outputs that are highly biased and fail to represent reliable forecasts for ex-ante term premium and future interest rates. Because of that most practitioners are turning to the basics and using naive models. In this paper we can do so as well. I will try to overcome such errors in classic term structure models finding different way to analyse the forces underlying the yield curve. Starting from the basics, the following paper has three sections in which we will answer three different questions: what information can we gain from forward rates and how can that be used for our forecasting the future shape of the yield curve? ow can we disentangle the market's expectations and required bond risk premia and how can we estimate separately the two components? which are the main drivers for bond risk premium and how we can interpret the current situation?

In the first chapter, after a brief introduction on the basic concepts of bond instruments, I will present the two most relevant alternative theories on bond yields which concur to determine the shape of the yield curve, the Expectation Hypothesis and the Term Premium Hypothesis. Using the forward rates I will test their theoretical assumptions and find empirical evidence on the expected change in future spot rates and expected time-varying risk premia updating the Fama-Bliss approach (1987).

Then, in the second chapter, I will try to disentangle from long-term nominal yields the market's expectations on future spot rates and required risk premia, which are not directly observable in the markets. There will be presented different techniques for the purpose, each of them assessing a different prospective of the market. The simplest way used by practitioners to proxy the compensation for lengthening the maturity of their investment on Government bonds is to measure the slope of the yield curve. It will be showed that, although an easy way, it is a mixed measure that has controversial correlation with realized excess returns and future yield changes. Another way is to look at term structure models proposed by classic literature. I will follow the analysis proposed by Cochrane and Piazzesi (2005), where it is computed a single return forecasting factor from a linear combination of different forward rates used to predict future excess returns. In addition, I will present a model based on surveys following the methodology proposed by Wright (2008). By doing so, we can avoid the problems inherent with statistical model, indeed, using surveys from market participants, we can pin down proxies of expectations in economic variables that, theoretically, are exactly what we are looking for. This way presents the best results compared with the previous models in estimating the term premia implied by the market.

In the last chapter, I will state as one of the main drivers for term premium the inflation process and a level-dependent inflation uncertainty. It will be argued that there is a positive relation between the yield level, the level of expected inflation and the inflation risk premium. In order to assess this relation I will construct different measures to proxy inflation uncertainty exploiting the forecasts from financial surveys and relate them to the measure of term premium. Finally, using the evidence gained by the analysis, albeit the positive relation between inflation level and inflation uncertainty, we will observe that when inflation is close to zero, the uncertainty increases. Thus, presuming that in the market there is a part of investors that predict a boost in inflation level opposed to another part that predict a prolonged phase of zero inflation, I will test the so called "deflation risk", namely the cost of deflation and debt sustainability priced by the market, finding a negative relation with the German term premium and a positive relation with the Italian one.

Chapter 1

Understanding the Yield Curve

This section begins by reviewing the fundamental concepts of the yield curve, including the necessary "bond math", that will be used in the remainder of the paper.
After this summary, through the Fama-Bliss approach (1987), I assess the predictive power of forward rates on future spot rates testing the two most relevant alternative theories on bond yields, the Expectation Hypothesis (EH) and the Term Premium Hypothesis. The empirical evidence is much more controversial than what might seems from the theory and shows quite clearly that the theoretical assumptions hold differently depending on the forecasting horizon and the market we are considering.

In general the EH gains favour when we increase the forecasting horizon, reaching its best at the medium term, i.e. forecasting the change in spot rates three and four years ahead. It's is poorer in the very short term, where instead it is presented that the forwards are more able to predict excess returns confirming the fact that the spot rates follow a random walk process and the term premium hypothesis.

There is also a consistent difference between the Italian and the German market. The EH works much better in the German market and fares not so well in the Italian one. What I found, as it will presented in the next sections, is that term premium, in bonds is mainly driven by the inflation risk premium. Countries as Germany, which has always displayed lower level and lower uncertainty of inflation, are perceived to be less risky in duration extension, thus requiring a lower compensation for longer maturities and giving value to the EH.

Looking at the tests' results, the German Government bonds and the BTP-Bund spread behave completely different and seem to be disconnected. If we measure the correlation from 2008 to 2016 between the spread and the yields at 10 year maturity, we have 0.51 for the 10-year BTP and -0.46 for the 10-year Bund. The Spread can be fairly assumed to represent a measure of credit risk embedded in the Italian rates, thus the BTP's curve can be decomposed in two parts (Bund's yield plus the spread) which are guided by different drivers and moves in opposite directions when it comes to our tests.

1.1 Basic Yield Curve Concepts

Simply stated an interest rate defines the amount of money a borrower promises to pay the lender in a certain future date. The interest rate applicable in a situation depends on the credit risk. This is the risk that there will be a default by the borrower of funds, so that the interest and principal are not paid to the lender as promised. The higher the credit risk, the higher the interest rate that is promised by the borrower.

Most bonds pay coupons to the holder periodically while the bond's principal (which is also known as par value or face value) is paid at the end of its life. The theoretical price of a bond can be calculated as the present value of all the cash flows that will be received by the owner of the bond. Sometimes bond traders find easier to use the same discount rate for all the cash flows underlying a bond, consequently we call *yield to maturity* the single discount rate that equates the present value of a bond's cash flows to its market price. Thus, a *yield curve* is a graph of bond yields against their maturities or, alternatively, against their durations.

While the yield to maturity is a synthetic measure of a bonds expected returns, the use of a single rate to discount multiple the cash flows can present some problems unless the yield curve is flat. First of all, each cash flow of a given bond is discounted at the same rate, despite the yield curve slope may suggest that different discount rates are appropriate for different cash flow dates. Second, it is assumed the possibility to reinvest the cash flows paid at a given date at a rate that equals the yield to maturity of the bond which the cash flows are attached, which clearly is not always possible.

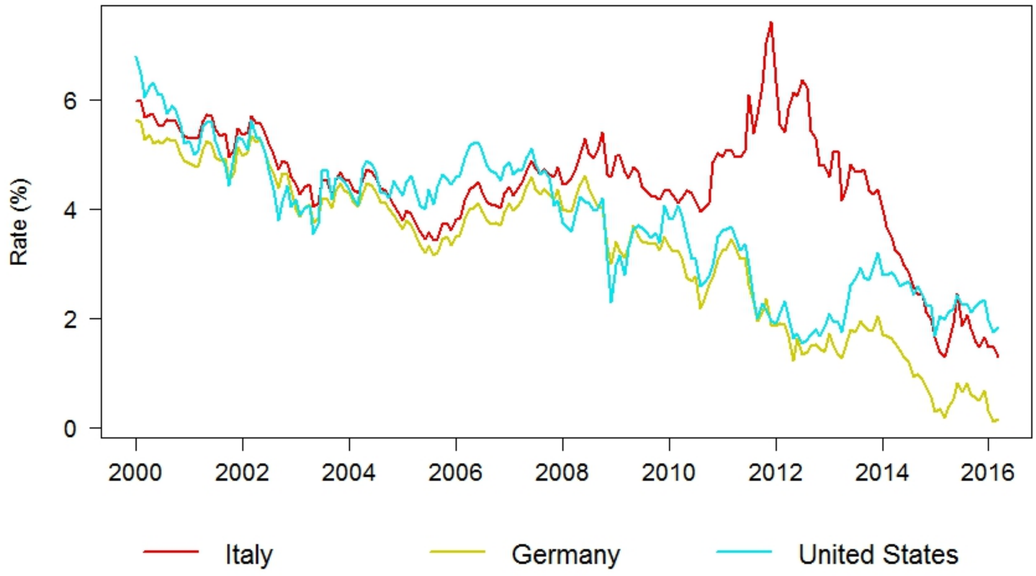
A coupon bond can be viewed as a bundle of zero-coupon bonds (zeros), that means it can be unbundled into a set of zeros, which can be valued separately. A *zero coupon yield* , or a *spot rate* , is the interest rate on a "spot loan". This is a loan with only one cash flow, composed by interests and principal, that occurs on the redemption date. There are no intermediate payments.

In the rest of the paper we will identify the spot rates with the notation $r_{n;t}$, referring to the discount rate of a bond with \$100 face value and n years to maturity at time t. Symbols before a colon are the maturities that define the variable. The symbol after the colon is the time the variable is observed. Since most of the empirical variables are annual, time is measured in annual increments.
Using the continuous compounding, the Equation (1.1) shows the simple relation between an n-year zero's price P_n and the annualised n-year spot rate $r_{n;t}$.

$$P_n = e^{-(r_{n;t})\cdot n} \tag{1.1}$$

For example, if you lend out \$100 in the form of a ten years spot loan today, at an interest rate of $r_{10;t}$, then the repayment will happen in ten years and amount to $100 \cdot e^{(r_{10;t})\cdot 10}$. The yield $r_{10;t}$ on a 10-year bond is called 10-year spot rate.

Figure 1.1: 10-year Spot Rate, r_{10}



Source: Bloomberg, 2000 - 2016

From the spot rates, we can derive the *forward rates*, defined as the interest rate for a loan between any two dates in the future, contracted today. Looking from a different perspective, the former definition is equivalent to say that a forward rate is the yield set at time t on a discount bond with face value of \$100 and n years to maturity purchased at time $t + x - n$. Indeed, any forward rate can be "locked in" today by buying one unit of the n-year zero at price $P_n = e^{-(r_{n;t}) \cdot n}$ and by shortselling P_n/P_x units of the x-year zero at price $P_x = e^{-(r_{x;t}) \cdot x}$.
That being said, a given term structure of spot rates implies a specific term structure of forward rates. If the x-year and n-year spot rates are known at time t, the annualised forward rate between maturities x and n, $f_{n-x,x;t}$, is computed from Equation (1.2).

$$f_{n-x,x;t} = \frac{r_{n;t} \cdot n - r_{x;t} \cdot x}{n - x} \tag{1.2}$$

Using the former equation we can unbundle the discount rate of a zero coupon bond into a product of multiple discount rates of shorter maturity such that, combined all together, they cover the overall maturity of the zero. The simplest building blocks in a term structure of interest rate is the *one-year forward rate*, $f_{1,n-1;t}$ and it represents a special case of Equation (1.2) in which $x = n - 1$.[1] In this very case the Equation (1.2) can be simplified to

[1] Some examples are the 1-year forward rate one year ahead, $f_{1,1}$, or the 1-year forward rate four years ahead, $f_{1,5}$, or the 1-year forward rate nine years ahead, $f_{1,9}$.

$$f_{1,n-1;t} \approx r_{n;t} + (n-1) \cdot (r_{n;t} - r_{n-1;t}). \tag{1.3}$$

Equation (1.3) shows that the forward rate is equal to an n-year zero's one year horizon return given an unchanged yield curve scenario. It is a sum of the initial yield and the rolldown return, that is the zero's duration at horizon $(n-1)$ multiplied by the amount the zero rolls down the yield curve as it ages. Thus, the one-year forward rates are a proxy for near-term expected returns if the yield curve is expected to to remain unchanged.

Instead of a ten years spot loan, we can also start by lending money for one year at an interest rate of $f_{1,0;t}$.[2] At the end of one year, we will receive $e^{f_{1,0}}$ and we can then lend out this balance for a second year at an interest rate of $f_{1,1;t}$. At the end of two years, we will have a balance of $e^{f_{1,0}} \cdot e^{f_{1,1}}$. We can repeat this process ten times to match the investment horizon of the spot loan. If we are indifferent between the 10-year spot loan and rolling 1-year loans ten times, it must be true that

$$e^{r_n \cdot 10} = e^{f_{1,0}} \cdot e^{f_{1,1}} \cdot \ldots \cdot e^{f_{1,9}} \quad \Longrightarrow \quad r_{n;t} = \frac{f_{1,0} \cdot f_{1,1} \cdot \ldots \cdot f_{1,9}}{10} \tag{1.4}$$

As can be seen, under continuous compounding, a zero coupon yield is the arithmetic average of forward rates. So that, the forward rate curve magnifies any variation in the slope of the spot curve. One-year forward rate measures the marginal reward for lengthening the maturity of the investment by one year, while the spot rates measure an investment's average reward from today to maturity n.

After we stated the basic building blocks of the yield curve, we define some measure that will be crucial in our paper.

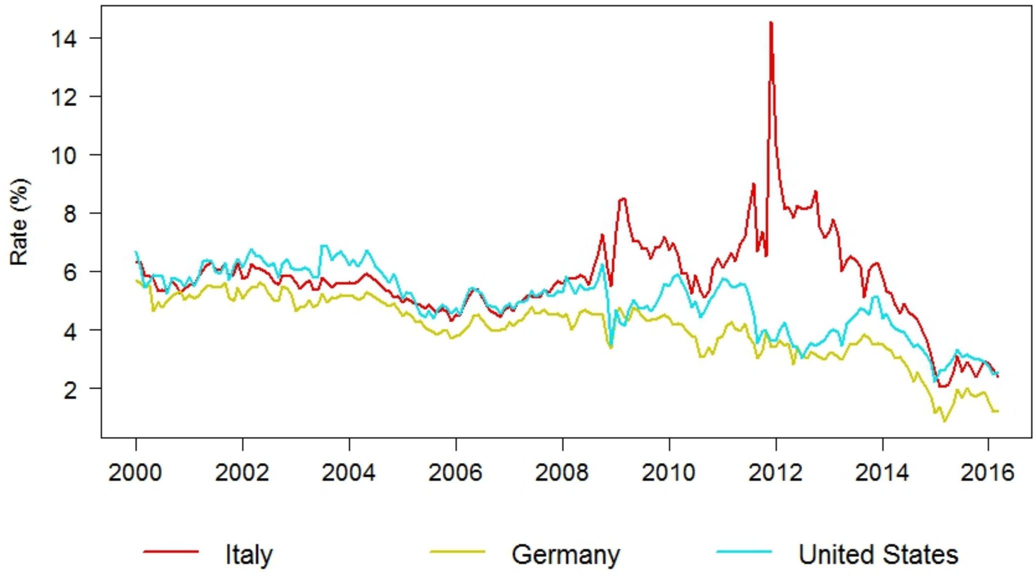
We will call *forward-spot spread* or *forward-spot premium*, $FPS_{n,x;t}$, the difference at time t between the n-year maturity forward rate x years ahead and the n-year maturity spot rate.

$$FPS_{n-x,x;t} = f_{n-x,x;t} - r_{n;t} \tag{1.5}$$

Another essential tool of term structure analysis is the *realized bond return* or *holding period return*, $HPR_{n;t+x}$. It is the return on buying an n-year zero coupon bond at time t and selling it, as an $(n-x)$-year zero, at time $t+x$. We will focus our attention on the one period or one year holding period return we set our reference unit to one year.

[2] The spot rates represent another special case of Equation (1.2) in which $x = 0$, thus $r_n = f_{n,0}$.

Figure 1.2: 1-Year Forward Rate Nine Years in the Future, $f_{1,9}$



Source: Own calculations.

The Equation (1.6) shows that the holding period return over the next year has two components: the initial yield income earned over time and a capital gain or loss due to yield changes which is approximated by the product of the zero's year-end duration and its realized yield change.

$$HPR_{n;t+1} = r_{n;t} + Duration_{n-1} \cdot (r_{n;t} - r_{n-1;t+1}) \tag{1.6}$$

If we subtract the return of the one-period (presumed) riskless asset, $r_{1;t}$ and take the expectations, we get the *expected excess returns* over the riskless rate for next year, a variant of ex-ante near-term bond risk premium.

$$Ex{-}Ante\ BRP_{n;t} = E_t[BRP_n] = E_t[rx_n] \approx (r_{n;t} - r_{1;t}) + Duration_n \cdot E_t[\Delta r_{n;t+1}] \tag{1.7}$$

In the following section we will see how these concepts interact and how can be exploited to analyse the term structure of interest rates.

1.2 The Term Structure of Interest Rates

In recent years, advances have been made in the theoretical and the empirical analysis of the term structure of interest rates. It has been argued that three main forces determine the term structure of forward and, consequently, spot rates: market's expectations, bond risk premia and the convexity bias.

The impact of rate expectations on today's yield curve shape can be summarized by the fact that if market expects rate to rise and long term bonds to suffer capital losses, these bonds must have an initial advantage over the one-period bond, in order to offset the expected capital losses. Therefore, expectations of rising rates tend to make today's yield curve upward sloping. Conversely, expectations of declining future rates tend to make today's yield curve inverted. In a similar, way, the market's expectations of future curve flattening or steepening influence the curvature of today's yield curve.

The *bond risk premium* or *term preimum* represents the extra expected return that risk-averse investors demand to compensate them for the possibility of capital losses on selling a long-term bond prior to its maturity and/or the risk of bond's value being eroded by inflation. Any change in long-term yields that is not accompanied by a corresponding shift in expectations of future short-term interest rate, must result in a change of the term premium. Thus, a yield curve that has a positive slope, might imply that investors demand a positive risk premium to induce them to hold long-term bonds.

The so called *convexity bias* arises because few fixed-income assets' values are linearly related to interest rate levels. Most bonds' price and yield curves exhibit positive or negative convexity. Market participants have long known that positive convexity can enhance a bond portfolio's performance, therefore, convexity differentials across bonds have a significant effect on the yield curve's shape and on bond returns. In fact, because of the value of convexity, for a given level of expected returns, investors are willing to accept lower yields for more convex bonds and bond positions. Noting that convexity characteristics increase as a function of duration, the convexity differentials have sensible effects mostly only in the long end of the curve tending to make it inverted or humped. This reason allows us to net out the convexity effect and omit it henceforth as is customary in the literature.

We now go far more in details discussing the two main theories which are used to assess and forecast the future movement and shape of the yield curve.

1.2.1 Expectation Hypothesis

Starting with Macaulay (1938), Hicks (1939), and Lutz (1940), the expectation hypothesis (EH) is the benchmark for term structure model and links yields, returns on bonds and forward rates of different maturities and periods. It gives us a simple

answer to the question: what can I expect to be the spot rates in the future?
In order to do so, we have to state the forward rates as "break-even" rates. Recalling the Equation (1.2), if we set the parameter $x = 1$ and letting n vary from 2 to 10, we compute a specific forward curve that represents, at time t, the interest rate of $n-1$ maturity starting one year in the future. It seems reasonable to name this term structure as the implied spot rate curve one year forward.[3]

Table 1.1: Italian BTP Interest Rate Curves at 30/03/2016

A Spot Rate Today		B One-Year Forward Rate		C Implied Spot Rate One Year Forward		D = C - A Implied Change in the Spot Rate	
r_1	-0.074%	$f_{1,0}$	-0.074%	$f_{1,1}$	0.06%	Δf_1	0.134%
r_2	-0.007	$f_{1,1}$	0.06	$f_{2,1}$	0.127	Δf_2	0.134
r_3	0.06	$f_{1,2}$	0.194	$f_{3,1}$	0.261	Δf_3	0.201
r_4	0.177	$f_{1,3}$	0.528	$f_{4,1}$	0.465	Δf_4	0.289
r_5	0.357	$f_{1,4}$	1.077	$f_{5,1}$	0.689	Δf_5	0.332
r_6	0.562	$f_{1,5}$	1.587	$f_{6,1}$	0.901	Δf_6	0.339
r_7	0.762	$f_{1,6}$	1.962	$f_{7,1}$	1.121	Δf_7	0.359
r_8	0.972	$f_{1,7}$	2.442	$f_{8,1}$	1.328	Δf_8	0.356
r_9	1.172	$f_{1,8}$	2.772	$f_{9,1}$	1.447	Δf_9	0.275
r_{10}	1.295	$f_{1,9}$	2.402				

The numbers in column D in Table 1.1 - the difference between the implied spot curve one year forward and today's spot curve - show that "the forwards imply rising rates". Just note that this statement does not necessarily mean that the market expects rising rates. Instead, the forwards tell how much the spot curve needs to change over the next year to make all bonds earn the same holding period return. For example, if today's spot curve is upward sloping, longer-term bonds have a yield advantage over the one-period bond. To equate holding-period returns across bonds, longer bonds have to suffer capital losses that offset their initial yield advantage. Forwards show exactly how much the yield of a longer-term bonds has to increase to cause such capital losses. Stated in terms of rate levels instead of rate changes, the implied spot rates one year forward (column C in Table 1.1) are such future spot rates that would make all government bonds earn the same holding-period return over the next year. Moreover, this same return must be the return of the one-year zero, which is already known today.

The expectation hypothesis, in its strong form, called pure expectation hypothesis, claims that all government bonds, regardless of their maturity, have the same near-term

[3] It is crucial to distinguish the curve of constant maturity one-year forward rate, that it is computed as in the Equation (1.3), and the implied spot curve one year forward, computed as discusses above.

expected return, and so, market's rate expectations are the *only* determinant of the yield curve shape. The motivation is that the market prices of bonds are set by risk-neutral traders, whose activity eliminates any expected return differentials across bonds. Investors care only about expected outcomes (means of probability distributions) and will be indifferent between two assets with the same expected retur but different level of uncertainty.

If all government bonds have the same near-term expected return, any yield differences across bonds must imply expectations of future rate changes (so that expected capital gains or losses offset the impact of initial yield differences). For example, if investors expect rates to rise and long-term bonds to lose value, they require higher initial yields for long-term bonds than for short-term bonds, making today's yield curve upward sloping. This kind of break-even argument is similar to the one used above, except that now the expected (as opposed to realized) returns are being equalized across bonds.

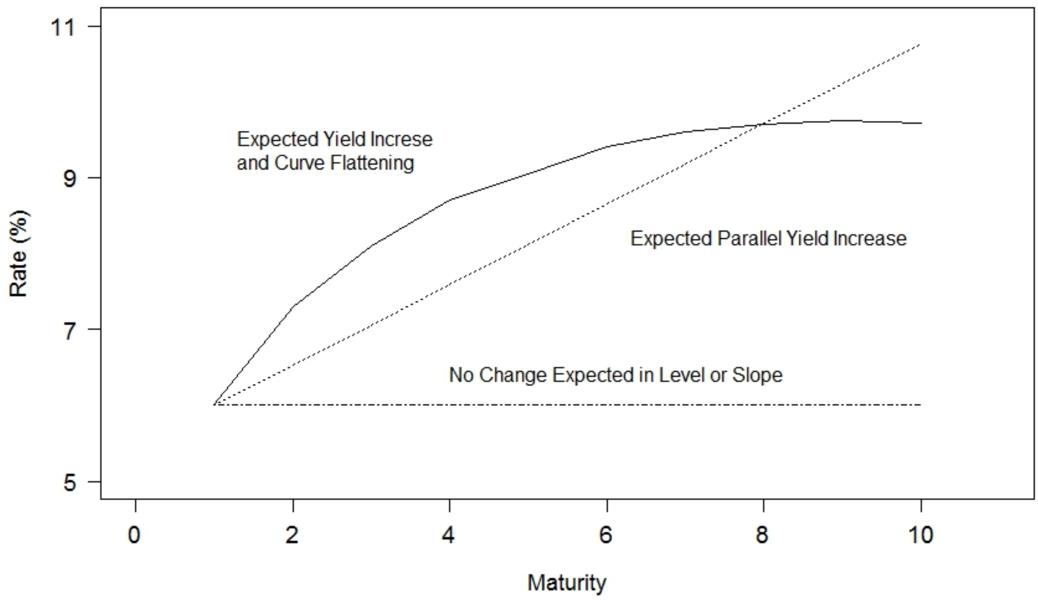
We can analyse how different type of expectations influence today's spot curve, if there are no expected return differences across bonds.

- If the market expects *no rate changes*, today's spot curve is flat because no expected gains or losses need to be offset by an initial yield spread
- If the market expects rates to *rise in a parallel fashion*, longer-term bonds are expected to earn greater capital losses than shorter-term bonds. An initial yield advantage must offset these expected losses. Because the expected capital losses are proportional to duration, the yield advantage is also proportional to duration. Therefore, today's spot curve is linearly upward sloping. In a similar way, expectations of declining future rates make today's spot curve inverted.
- If the market expects the curve to flatten in the future, barbells and other curve-flattening positions are expected to earn capital gains. An initial negative carry must offset these expected capital gains. Therefore, today's spot curve is concave, and barbell portfolios have lower yields and rolling yields than duration-matched bullet bonds. In a similar way, expectations of future curve steepening tend to make today's spot curve convex, and barbells have higher yields than bullets.

Figure 1.3 shows graphically what just stated, expectations of unchanged future rates lead to a horizontal spot curve, rising rate expectations lead to a linearly upward-sloping spot curve and curve-flattening expectations lead to a concave curve shape.

More formally, we can express the expectation hypothesis as three equivalent statements about the pattern of yield across maturities:

Figure 1.3: Spot Curves Given the Market's Various Rate expectation



1. Forward rates equal expected future spot rate

$$f_{1,1;t} = E_t[r_{1;t+1}]\,; \quad f_{5,5;t} = E_t[r_{5;t+5}]\,; \quad \cdots \quad f_{n-x,x;t} = E_t[r_{n-x;t+x}] \tag{1.8a}$$

   Intuition: Investors can choose between locking-in a forward contract right now versus waiting and borrowing/lending at the then prevailing spot rate. Risk-neutral investors will load up on one contract or the other until the expected returns are all the same. Any two ways of getting money from $t+n$ to $t+n+1$ must give the same expected return.

2. N-period yield is the average of expected future one-period yields

$$(1 + r_{n;t})^n = (1 + r_{1;t}) \cdot (1 + r_{1;t+1}) \cdot (1 + r_{1;t+2}) \cdot \ldots \cdot (1 + r_{1;t+n}) \tag{1.8b}$$

   Intuition: This equation reflects a choice between two ways of getting money from t to $t+n$. Operators can buy an n-period bond or roll over n times the one-period bonds. Risk neutral investors will chose one over the other strategy until the expected n-period return is the same.

3. Expected holding period returns are equal on bonds of all maturities.

$$E_t[HPR_{n;t+x}] = r_{n;t} + Duration_n \cdot (r_{n;t} - f_{n-x,x;t}) = r_{1;t} \tag{1.8c}$$

   Intuition: Risk neutral investors will adjust positions until the expected one-period returns are equal across all bonds.

It is worth emphasizing that the expectation hypothesis is nothing more than a theory and not an exact rule or a trading strategy. We will investigate the accuracy of these statements in the empirical section of this chapter.

1.2.2 Term Premium Hypothesis

According to the expectation hypothesis in its strong form, the long-term bond yield is the average of the expected short-term rates. Though the expectation hypothesis provides a simple and intuitively appealing interpretation of the yield curve, it makes the strong assumption of risk-neutral investors and ignores interest rate risks. Indeed, except if calculated until maturity, the nominal return on a long-term bond is uncertain and investors may require compensation for this risk. What we call *term premium* (TP) or *bond risk premium* (BRP) refers to such compensation and any other sources of deviation from the expectations theory.[4]

The BRP hypothesis makes the opposite extreme statement of the expectation hypothesis: an upward-sloping yield curve only reflects required compensation for bearing duration risk and does not contain any information at all about market's rate expectations.

In the term premium hypothesis, long-term bonds earn a positive risk premium as a compensation for their return volatility. The demand of extra expected returns needed to remunerate for the possibility of a capital loss on selling long-term bond prior to maturity is based on the assumption of risk-averse investors that try to avoid short-term fluctuation in returns. There are some popular theories that try to explain this risk aversion in the capital markets.

- *Liquidity Premium:* Borrowers would prefer to borrow long in order to hedge the their future supplies of loan capital (Hicks, 1939). Second, lenders have strong incentive to lend short in order to have free hands against economic fluctuation. Finally, the speculators can offset the gap of supply and demand but ask for compensation for the risk they endure.[5]
- *Preferred Habitat:* Derived from the Modigliani and Sutch's (1966) theory on the market segmentation, it implies that investors have their preferred security duration, natural habitat. For instance, pension funds usually prefer longer duration than

[4] A weak form of the expectation hypothesis allows for a constant maturity term premium, which nonetheless requires that changes in yield fully reflect changes in expected short rates.

[5] A more subtle argument states that most investors have a vague investment horizon. If the horizon is so uncertain that it does not guide an investor's decision-making and if he is more averse to price risk than to reinvestment risk, he is likely to bias the portfolio toward a short duration. Public accountability makes many investors more averse to price risk than to reinvestment risk. Moving toward a too-short duration exposes an investor "only" to reinvestment risk, which brings to an opportunity cost. Erring toward a too-long duration exposes an investor to price risk, which is visible and, if realized, is more likely to cause a public outcry.

shorter due to the fact that it matches the duration of their liabilities. According to the preferred habitat, investors will only be tempted out of their natural habitat by the lure of higher expected returns or unless their own habitats change into other horizons. Perhold and Sharpe (1989) argued that the investors with long-term horizon are minority in the market leading to a positive trend of risk premium associating with duration.

- *Asset Pricing Models:* The compensation demanded for holding long-term bonds can depend on both the amount of risk and the price of that risk, either of which can change over time due to variable fundamentals, rather than to investment horizons and the relative importance of different investor groups. What does matter is the covariance of the returns from investments with the marginal utility of money. During economic recessions, the marginal utility is higher than in expansions and assets that perform poorly in "bad times" should earn a positive risk premium while good hedgers against recession, like long-term bonds, might even earn a negative risk premium. Thus, the covariance of bond returns with marginal utility must be negative.

In order to capture the yield curve relationship with the term premium, we can rewrite the previous expectation hypothesis statements adding a time-varying risk premium component. At the same time we gain, even more clearly, a portfolio interpretation:

1. Forward rates equal expected future spot rates *plus a forward risk premium.*

   $$f_{n-x,x;t} = E_t[r_{n-x;t+x}] + rpf_{n;t} \tag{1.9a}$$

   Intuition: Forward risk premium is the expected return from holding a n-year bond to maturity, while simultaneously shorting an (n-1)-year bond followed by the sale of a one-year bond in the final year.

2. Long-term yield is the average of expected future one-period rates *plus a yield risk premium.*

   $$(1 + r_{n;t})^n = (1 + r_{1;t}) \cdot (1 + r_{1;t+1}) \cdot (1 + r_{1;t+2}) \cdot ... \cdot (1 + r_{1;t+n}) + rpy_{n;t} \tag{1.9b}$$

   Intuition: Yield risk premium can be captured by buying an n-year bond, while selling one-year bonds for n consecutive years.

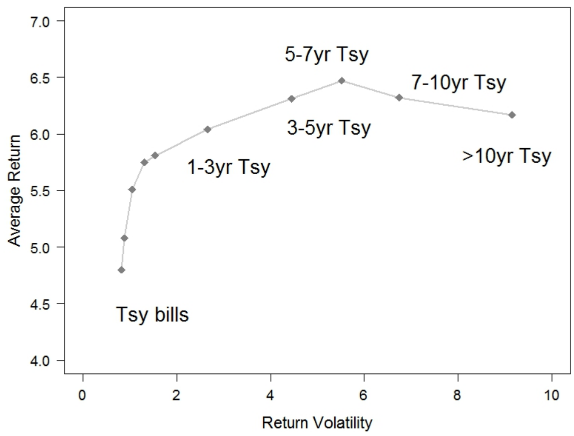
3. Expected holding period return on long-term bonds equals the expected return on short-term bond *plus a return premium.*

   $$E_t[HPR_{n;t+x}] = r_{n;t} + Duration_n \cdot (r_{n;t} - f_{n-x,x;t}) + rpr_{n;t} = r_{1;t} + rpr_{n;t} \tag{1.9c}$$

Intuition: Return premium is the premium from holding a n-year bond for one year, financed with a one-year bond.

As underlined by the different theories on the term premium, even if horizons and subjective risk preferences vary across investors, the risk premium offered by the market will depend on the characteristics of the marginal investor. Empiricism suggests that the long-term bonds are perceived riskier than the short-term bonds, thus investors should earn a positive risk premium linearly increasing in duration or return volatility. Studying deeper the relation between BRP and bonds' duration, Ilmanen (2011) used historical yield and return data to estimate the average risk premium. He presented the history of monthly returns for a set of maturity subsector portfolios of U.S. Treasury bills and bonds which is reported in the Figure 1.4. The sample ranges from 1952 to 2009 which is assumed to be a reasonably neutral period (bond yields ended the period at roughly the level at which they started), thus average return differences largely reflect ex ante yield spreads rather than unexpected yield changes. Clearly, the risk-reward relation is positive but more interesting is quite non-linear, showing a concave shape, very steep at short maturities and flatter thereafter.

Figure 1.4: Long run reward, 1952-2009



Duration	Annual Return
1 - 3 mo	5.08
3 - 6 mo	5.51
6 - 9 mo	5.75
1 - 3 yr	6.04
3 - 5 yr	6.31
5 - 7 yr	6.47
7 - 10 yr	6.32
10 yr +	6.17

Source: Ilmanen A., "Expected Returns" (2011)

1.2.3 Clash of two theories

Here we want to compare the two main theories of term structure and analyse their differences in opposite assumptions and implications.

Recalling the definition of the one-year forward rate in the Equation (1.3) and the definition of the holding period return over the next year in the Equation (1.6), we note that they are much similar, except the forward rate is computed using the spot rates at time t while the HPR takes in account the n-1 year spot rate prevailing one year hence, $r_{n-1;t+1}$.

If the yield curve follows a random walk, the best forecast for $r_{n-1;t+1}$ is $r_{n-1;t}$, so the today's n-1 year spot rate. Therefore, the n-year zero's expected holding period return equals the one-year forward rate in Equation (1.3). Conversely, if interest rates follow the expectation hypothesis, the best forecast for future spot rates are the current forward rates. The key question is whether it is more reasonable to assume that the current spot rates are optimal forecasts of future spot rates than to assume that forwards are the optimal forecasts.

Rearranging the previous formulas we can approximate the yield change implied by the forwards with the expected change in the n-1 year spot rate over the next year, $E[\Delta r_{n-1}]$ and a bond risk premium (that is he expected return of an n-year bond over the next year in excess of the riskless one-year rate):

$$f_{n-1,1;t} - r_{n-1;t} \approx E[\Delta r_{n-1}] + BRP_{n;t} \tag{1.10}$$

Equation (1.10) helps in contrasting different assumptions about the yield curve behaviour. One can think of $f_{n-1,1;t} - r_{n-1;t}$ loosely as a measure of the yield curve steepness. Thus, the equation says that the curve steepness reflects market's future rate expectation, or expected return differentials across bonds, or some combination of the two. We can see how there are two polar theories:

1. The pure EH assumes that BRP=0. All government bonds have the same near-term expected returns as the riskless asset and forwards reflect only the market's expectations of future rate change. Thus, forward rates are the optimal predictors of future spot rates.
2. The term premium hypothesis assumes that $E[\Delta r_{n-1}] = 0$. Thus, the spot rates follow a random walk process and forwards reflect only the near-term expected return differential across bonds.

As it is easy to think neither of the two extreme assumptions is strictly correct. The answer lies somewhere between and the components are not directly visible in the markets. Just note that the interpretation of the forwards as break-even rates is valid whether they reflect market's expectations of future rate, risk premia, or both.
In order to have a comprehensive perspective of the two theories, the Table 1.2 tries to summarize the main results.

After having presented and compared, we will try empirical tests to see how they behave applied to our sample of government bonds.

Table 1.2: Implications about the Yield Curve Behaviour

	Pure Expectation Hypothesis	**Risk premium Hypothesis**
What is the information in forward rates?	Market's rate expectations	Required risk premia
What future event should forward rate forecast?	Future rate changes	Near-term returns differential
What is the best forecast of an n-year zero's one-period expected return?	One-period riskless rate	One-period forward rate ($f_{1,n-1}$)
What is the best forecast of next period's spot curve?	Implied spot curve one year forward	Current spot curve
CORR ($FPS_{n-x,x;t}$, $\Delta r_{n-1;t}$)	Positive	0
CORR ($FPS_{n-x,x;t}$, $Realized\, BRP_{n;t+1}$)	0	Positive

1.3 Yield Curve Regression Test

In order to get empirical evidence on the assumptions of the expectation and term premium hypothesis, we will follow the approach described by Fama and Bliss (1987) assessing whether the informations embedded in forward rates can express something about future interest rates or current realized excess returns. Since market's expectations and bond risk premia are not directly observable within the market, we will implement some tests using OLS regression to gain a better overview of basic components of the term structure. Many previous literatures used the regression test to check up the validity of the expectation hypothesis in practice. Among them, Campbell and Shiller (1991) and Fama and Bliss (1987) have been the two most influential works in the field of the expectation hypothesis testing. The two papers are very similar, however Fama and Bliss work suits better our answers: *Do forward rates reflect the market's expectations, required risk premia or both? Are forwards or current spot rates better forecasts of future spot rates? Are bonds returns equal across maturities?*

These questions are important, both for forecasting interest rates and for interpreting shifts in the yield curve. If the expectations theory is an adequate description of the term structure then expectations of future interest rates are the dominant force determining current long-term interest rates. On the other hand, if the expectations theory is very far from accurate, then predictable changes in excess returns must be the main influence moving the term structure.

Our goal is to implement a significant analysis to test the expectation hypothesis and the term premium hypothesis updating the Fama and Bliss results and, most of

all, assess whether these results are valid whatsoever or might have some degree of variability based on the market or on the Country we apply. The dataset used here consists of zero coupon yields from the German and Italian government bond's market. It will be considered also the intra-EMU spread between the Italian BTP and the German Bund for the accounting of the different credit risk embedded in the bonds. These yields are measured over a period from January 2000 to April 2016 at the end of each month. We will present results for the spot rates of 1, 3 and 5 years maturity projected in a forecasting scenario ranging from 1 to 5 years in the future. The yields are derived from the coupon bonds' market quotation provided by the Bloomberg Terminal and interpolated by the Bloomberg internal system.[6]
For each Country and for the spread, we will perform two different tests, one assessing the expectation hypothesis and the other the term premium hypothesis. As presented before, the theories are two opposite characterization of the reality, thus, they will give answer to two questions that can be considered mutually exclusive. The first test will be a regression of subsequent change in interest rates on current forward rates, thus trying to extrapolate evidence of the EH. As for the second test, we will examine the Random Walk Hypothesis by running a simple regression of realized excess returns on the current forward rates.

1.3.1 Expectation Hypothesis Test

The first test we perform, studies the relation between forward rates and expected future spot rates. If the forwards equals the expected future spot rates, then we expect a strong and positive relation between the forward-spot premium[7] and the subsequent changes in the n-year spot rate over the next period. Likewise the relation between the forward-spot premium and the realized bond risk premium, should be zero.
We can model this statement using the following equation:

$$r_{n;t+x} - r_{n;t} = \alpha_1 + \beta_1 \left(f_{n-x,x;t} - r_{n;t}\right) + \epsilon_{1;t+x} \qquad n = 1,3,5 \ ; \ x = 1,...,5 \quad (1.11)$$

For each of the Countries and the spread, we run a simple regression of the subsequent change in the spot rates on the FPS for a maturity of one, three and five years over different forecasting horizons that go form one to five years ahead. Given the value of the adj-R^2 ($\bar{R}^2$) and the significance of the coefficients, the evidence that a value of β_1 greater than zero means that the FPS observed at time t has power to forecast the

[6] See Appendix A for details about the Bloomberg tickers.

[7] Recall the definition of forward spot premium, $FPS_{n,x;t}$, namely the difference between the forward rate of n-year maturity that begins x years in the future and the n-year maturity spot rate $(f_{n-x,x;t} - r_{n;t})$, the first test

change in the n-year spot rate x years ahead. In particular, a value close to 1 implies great evidence in favour of the EH. The results will be presented in summary tables and it will be showed graphically the case in which the EH works best and in which fares worst.

Italian Case

For the Italian bond market, we can see that the EH has little evidence and can be rejected for each maturity at short forecasting horizons as well as long ones. It seems to be not relevant even for medium horizons.

Table 1.3: Regression Forecast of Change in Spot Rates - Italian Case

$$r_{n;t+x} - r_{n;t} = \alpha_1 + \beta_1 \left(f_{n-x,x;t} - r_{n;t}\right) + \epsilon_{1;t+x}$$

Maturity (n)	Horizon (x)	Coefficient (β_1)	p-value	$\bar{R}^2$	Correlation
1	1	−0.090	0.541	−0.003	−0.045
1	2	0.328	0.027	0.022	0.169
1	3	0.634	0.00	0.115	0.347
1	4	0.387	0.00	0.066	0.27
1	5	0.485	0.00	0.138	0.28
3	1	−0.376	0.14	0.007	−0.11
3	2	0.129	0.546	−0.004	0.046
3	3	0.429	0.045	0.019	0.159
3	4	0.265	0.149	0.008	0.12
3	5	−0.025	0.855	−0.007	−0.016
5	1	−0.826	0.021	0.024	−0.17
5	2	0.13	0.665	−0.005	0.033
5	3	0.704	0.009	0.036	0.205
5	4	0.338	0.111	0.011	0.132
5	5	−0.474	0.003	0.058	−0.225

For the much part of the time Table 1.3 shows insignificant coefficients and correlations closer to 0 than to 1 (even negative sign) and lows $\bar{R}^2$. Anyhow the evidence in favour of the EH increases as the horizon goes up to 3 years and then decreases afterwards. In any case, even at their hikes the coefficients remain far to what the theory predicts and the correlation are small. This means that, for the BTP, forward rates of each maturity 1 to 5 years out seem to have no predictive power whatsoever for changes in the future spot rate 1 and 5 years from now. The situation improves somewhat for forward at 3 years horizons.

Based on the results of the test, we present graphical example of the subsequent change in spot rates and the forecasting power of the forward rates. I selected the forecasting case of the 5-year maturity spot rate three years in the future as best scenario and the 1-year maturity spot rate one year in the future as worst scenario.

Figure 1.5: BTP 5-Year Spot Rate 3 Years Forecasting Horizon

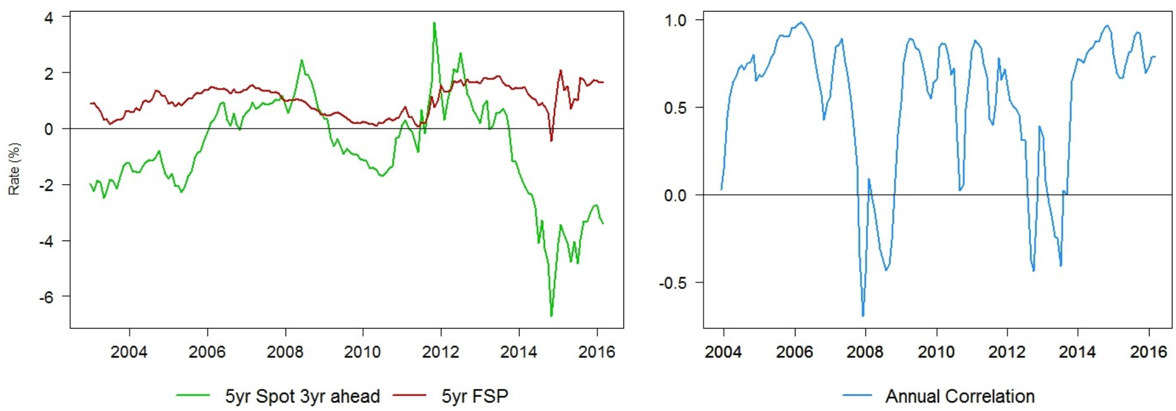
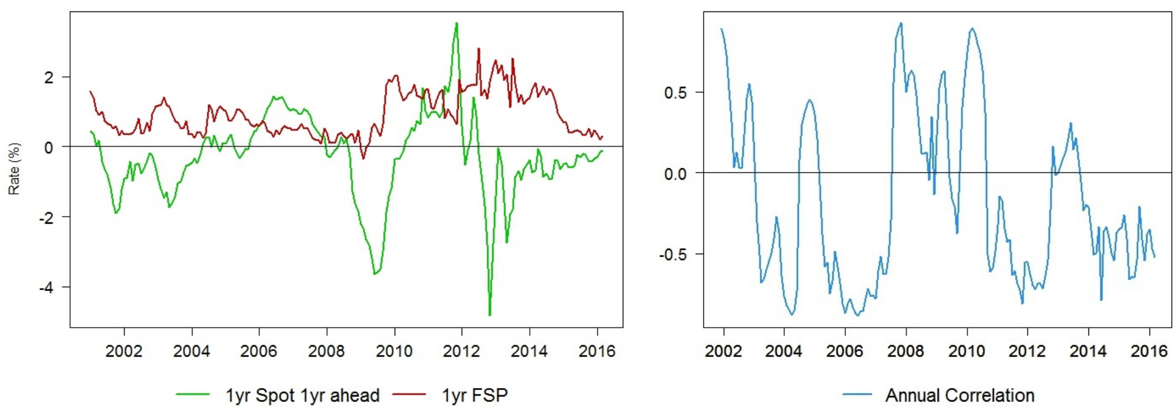


Figure 1.6: BTP 1-Year Spot Rate 1 Year Forecasting Horizon



It is possible to see how the prediction up to three years follows the path of the subsequent realized change better than the prediction for the next year. Up to a certain degree, the 5-year forward 3 years head caught even the falling of yields during the EZ crisis. The same facts can be found in the rolling annual correlation time series, which stay more in the positive area in one case and in the negative for the other. Anyhow, we can not conclude that the EH offers a good structure for the Italian bond market.

German Case

Regarding the German bond market, we can argue that the EH can not be rejected light hearted. Instead, we can find evidence that confirm what the theory states. Note that the estimated coefficients from the 1-year spot rate are all greater than 1, except at one year horizon (which anyway is close to the referring value). The other coefficients are close to the unit and still confirm the fact that the forecasting power is stronger at the medium-term horizon, still sustained even at the five years horizon.

Table 1.4: Regression Forecast of Change in Spot Rates - German Case

$$r_{n;t+x} - r_{n;t} = \alpha_1 + \beta_1 \left(f_{n-x,x;t} - r_{n;t}\right) + \epsilon_{1;t+x}$$

Maturity (n)	Horizon (x)	Coefficient (β_1)	p-value	$\bar{R}^2$	Correlation
1	1	0.764	0.00	0.085	0.299
1	2	1.211	0.00	0.214	0.467
1	3	1.198	0.00	0.325	0.574
1	4	1.248	0.00	0.527	0.728
1	5	1.035	0.00	0.436	0.664
3	1	−0.057	0.808	−0.005	−0.018
3	2	0.834	0.00	0.106	0.333
3	3	0.991	0.00	0.214	0.468
3	4	1.074	0.00	0.352	0.597
3	5	0.978	0.00	0.355	0.60
5	1	−0.269	0.339	0.00	−0.071
5	2	0.439	0.032	0.021	0.164
5	3	0.657	0.00	0.088	0.306
5	4	0.83	0.00	0.186	0.438
5	5	0.902	0.00	0.219	0.474

The rejection of the null hypothesis happens if we look at very short-term horizon. In fact, we see how, at the one year horizon, the coefficients and the correlations are negative, high p-values and small $\bar{R}^2$.
Compared to Italy, we get values much more positive for the EH with respect to each maturity and to each horizon. That could arise because the risk premium embedded in the Bunds' market is less prevailing than in the BTPs', thus the forwards are a stronger proxy for the change in the spot rates.

Figure 1.7: Bund 1-Year Spot Rate 4 Years Forecasting Horizon

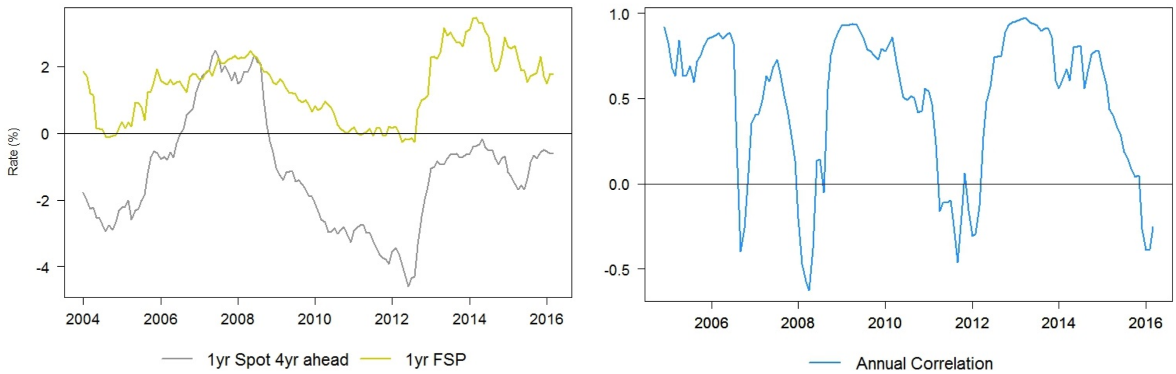
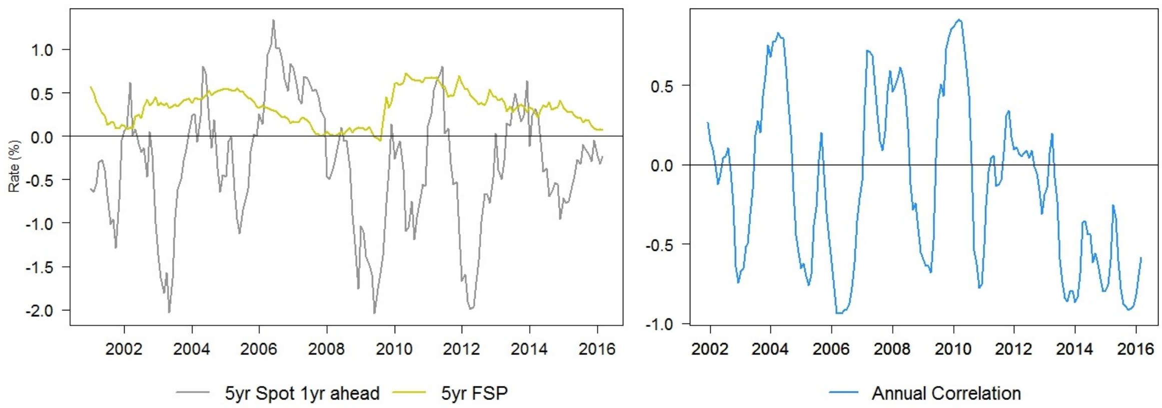


Figure 1.8: Bund 5-Year Spot Rate 1 Year Forecasting Horizon



BTP - Bund Spread

The reasons of performing a test on the spread between Italy and Germany lie in the willing of decomposing the Italian yield in two basic components: the risk-free rate and the added credit risk. What we want to assess is if the behaviour of the Italian yields is driven more from the German floor or by the spread, and then if the credit risk component can be predicted or if it gains value from the fundamentals of the term structure theory. [8] In order to do so, I performed the same test and I will compare the results with the cases in which the EH worked best within the other Countries.

From the evidence presented in Table 1.5 we can barely see any proof in favour of the EH. In general, all the results show negative coefficients and negative or zero correlation. There are few cases in the 3 and 5 year maturity rates at long forecasting horizon, where the numbers look in line with the theory. This mixed face and a graphical analysis of the time series help to understand that those numbers are more a statistical output than a logical implication of the variables.

Table 1.5: Regression Forecast of Change in Spot Rates - BTP-Bund Spread

$$r_{n;t+x} - r_{n;t} = \alpha_1 + \beta_1 \left(f_{n-x,x;t} - r_{n;t}\right) + \epsilon_{1;t+x}$$

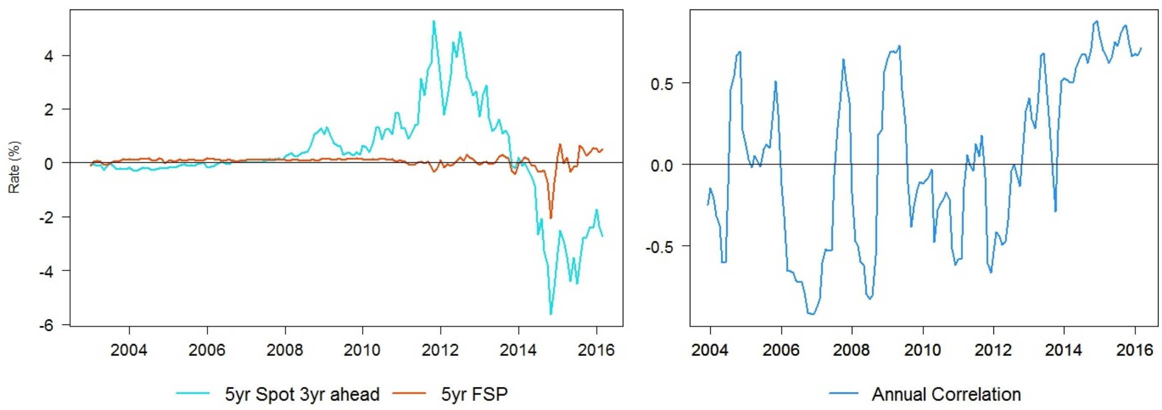
Maturity (n)	Horizon (x)	Coefficient (β_1)	p-value	$\bar{R}^2$	Correlation
1	1	−0.53	0.00	0.101	−0.326
1	2	−0.598	0.00	0.166	−0.414
1	3	−0.689	0.00	0.131	−0.369
1	4	−0.619	0.002	0.055	−0.249
1	5	−0.113	0.79	−0.007	−0.023
3	1	−1.791	0.00	0.188	−0.439
3	2	−1.973	0.00	0.286	−0.538
3	3	−1.523	0.00	0.111	−0.342
3	4	1.098	0.017	0.317	0.196
3	5	2.112	0.003	0.003	0.251
5	1	−3.302	0.00	0.208	−0.461
5	2	−2.123	0.00	0.082	−0.296
5	3	1.103	0.055	0.017	0.153
5	4	2.733	0.00	0.291	0.544
5	5	0.814	0.237	0.003	0.102

Moving to the comparative analysis between the bond and the spread, it is presented in Figure 1.9 the same maturity and forecasting horizon which worked the best for the

[8] For a detailed study about the relation between the intra-EMU spread and fundamental analysis see Di Cesrare A., Grande G., Manna M. and Taboga M., *"Recent estimates of sovereign risk premia for euro-area countries"*, Banca d'Italia, 2012

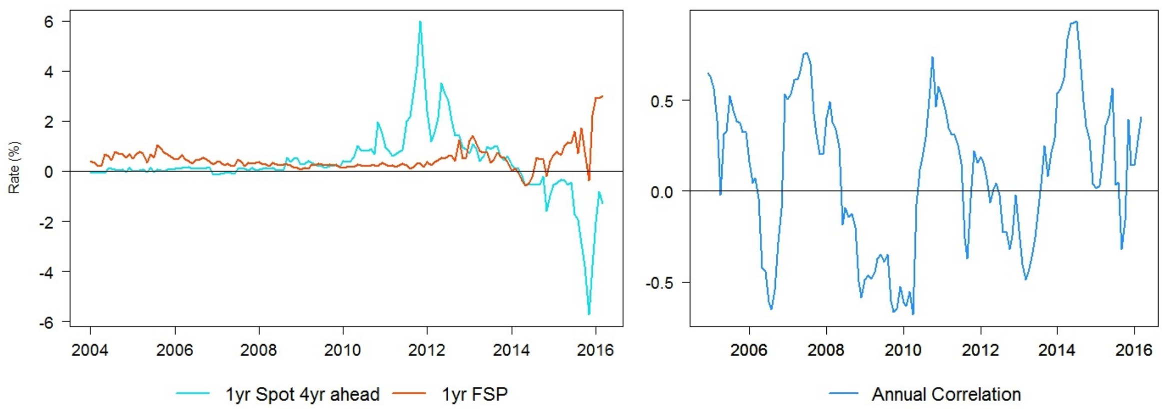
BTP. In the case of the spread, the graphical analysis suggests that the values predicted by the FSP are effective, in the sense of the EH, in the last three years (see the time series of the annual correlation remains in a strong positive area since 2013). It might not seem a great result, but if we exclude the years when the spread was close to 0 bps (until 2008) and the years of the crisis, it can be argued that the forecasting power of the Italian forward rates derives from the capability of prediction of the spread. Since the spread is a risk-reward component, nominally the required compensation for bearing an Italian bond with respect to the riskless German bond, this sounds much like the forward can predict an excess in the returns rather than the change in rates of the fundamental component.

Figure 1.9: BTP-Bund 5-Year Spot Rate 3 Years Forecasting Horizon



This concept is reinforced by the facts presented in Figure 1.10. Where the German forward could predict best the future spot rate, the same model related to the spread has very modest result. This evidence underline the fact that, clearly, the risk-free rate and the credit spread are driven by different underlying factors.

Figure 1.10: BTP-Bund 1-Year Spot Rate 4 Years Forecasting Horizon



1.3.2 Term Premium Hypothesis Test

After we reviewed the expectation hypothesis and its implication, we can assess the other fundamental theory of the term structure. The term premium or bond risk premium hypothesis asserts that the interest rates behave as a random walk, so the best forecast of next period's spot curve is the current spot curve. This is equivalent to state that forwards embed informations only about the required risk premium and can forecast the near-term excess return across different maturities.

If the forward rate are optimal predictors of near-term expected returns we expect a strong and positive relation between the forward-spot premium and the realized one period (here one year) return of a n-year bond in excess of the one-year bond. Likewise the relation between the forward–spot premium and the change in the n-year spot rate should be zero.
As in previous test, we can implement a regression model following the equation:

$$HPR_{n;t+1} - r_{1;t} = \alpha_2 + \beta_2 \left(f_{1,n-1;t} - r_{1;t}\right) + \epsilon_{2;t+1} \qquad n = 2, ..., 6 \; ; \qquad (1.12)$$

For each of the Countries and the spread, we will run simple regressions of the realized one year excess returns of a long-term bond, with a maturity going from two to six years, over the one-year bond on the FPS of one-year maturity and n-1 years ahead. Given the value of the adj-R^2 ($\bar{R}^2$) and the significance of the coefficient, the evidence that a value of β_2 greater than zero implies that the FSP observed at time t has the power to forecast excess one-period returns rather than the yield change. In particular, a value close to 1.0 implies that the interest rate are perfect random walks, whereas the EH predicts a value of 0.0 since the forward rates should predict the expected future spot rate and give no signal on the expected risk premium. The results will be reported in summary table and it will be presented a graphical example where the term premium hypothesis works best.

Italian Case

Testing the term premium hypothesis in the Italian market reveals a complete different situation than the EH. Indeed, it is possible to see that all the coefficients are above 1.0, with hikes of 1.8, and all highly significant. The $\bar{R}^2$ is modestly high and the total-sample correlation are in the range of 0.3-0.5. In addition, the best results in term of correlation are in the short-term of forecasting.
This is in line with the recent literature, where the evidence suggests that when forward-spot spreads are viewed as a proxy of near-term expected excess returns, variation in the current spread is mostly variation in the term premia in current

one-year expected returns, and forward-spot spreads do not predict yield changes one year ahead.

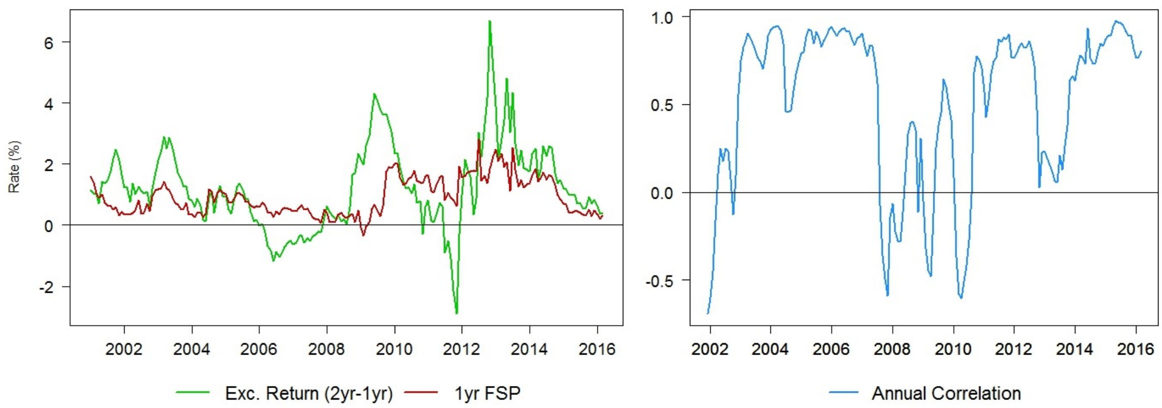
Table 1.6: Regression Forecast of Excess Returns - Italian Case

$$HPR_{n;t+1} - r_{1;t} = \alpha_2 + \beta_2\,(f_{1,n-1;t} - r_{1;t}) + \epsilon_{2;t+1}$$

Maturity (n)	Horizon (n-1)	Coefficient (β_2)	p-value	$\bar{R}^2$	Correlation
2	1	1.090	0.00	0.228	0.482
3	2	1.302	0.00	0.179	0.428
4	3	1.376	0.00	0.135	0.374
5	4	1.647	0.00	0.167	0.415
6	5	1.826	0.00	0.123	0.357

In the graphical example, we can see how the time series behave. The realized excess returns are more sensible to the market's fluctuations, in fact the time series displays a huge volatility between 2008 and 2014. The forward time series is less volatile, but keeps a decent forecasting power. The annual correlation is most of the time in the strong positive area, except the periods of high volatility.

Figure 1.11: BTP Excess Return (2yr-1yr) 1 Year Forecasting Horizon



German Case

As expected, in the Bund's term curve, we obtain the opposite situation of the previous test on the EH. The results in Table 1.7 present a path of coefficients which is controversial, they goes from slightly above 0.0 and non significant up to a value of 1.2 and highly significant. The $\bar{R}^2$ is poor and, except in one case, below than 10%. Also the total-sample correlation is not very high and gain evidence in longer maturities.

A reasonable explanation is the role assumed by the forward rate. In a market considered riskless, the term premium component is so squeezed that, even across different maturities, it is almost impossible for the model to catch. The forward will, more likely, predict the yield change than the excess returns.

It is relevant that where the term premium hypothesis fails, the expectation has its best results.

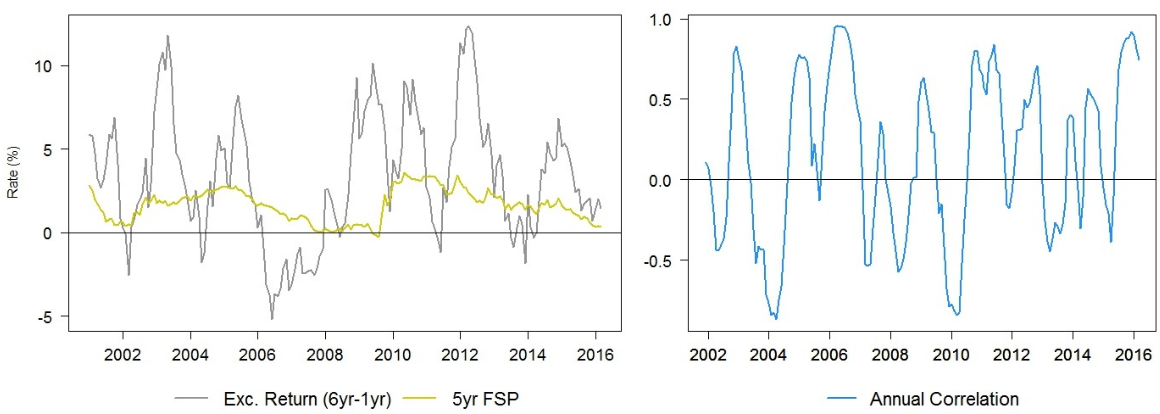
Table 1.7: Regression Forecast of Excess Returns - German Case

$$HPR_{n;t+1} - r_{1;t} = \alpha_2 + \beta_2 \left(f_{1,n-1;t} - r_{1;t}\right) + \epsilon_{2;t+1}$$

Maturity (n)	Horizon (n-1)	Coefficient (β_2)	p-value	$\bar{R}^2$	Correlation
2	1	0.236	0.194	0.003	0.096
3	2	0.677	0.003	0.179	0.215
4	3	1.057	0.00	0.097	0.319
5	4	0.898	0.00	0.061	0.259
6	5	1.269	0.00	0.097	0.319

Graphically it is very clear to see that the FSP can not follow the path of the realized excess returns which are too sensible to market's fluctuation. Same story for the annual correlation. Even if the overall value is 0.319, the plot the 12-month rolling correlation shows the failure of the model.

Figure 1.12: Bund Excess Return (6yr-1yr) 1 Year Forecasting Horizon



BTP - Bund Spread

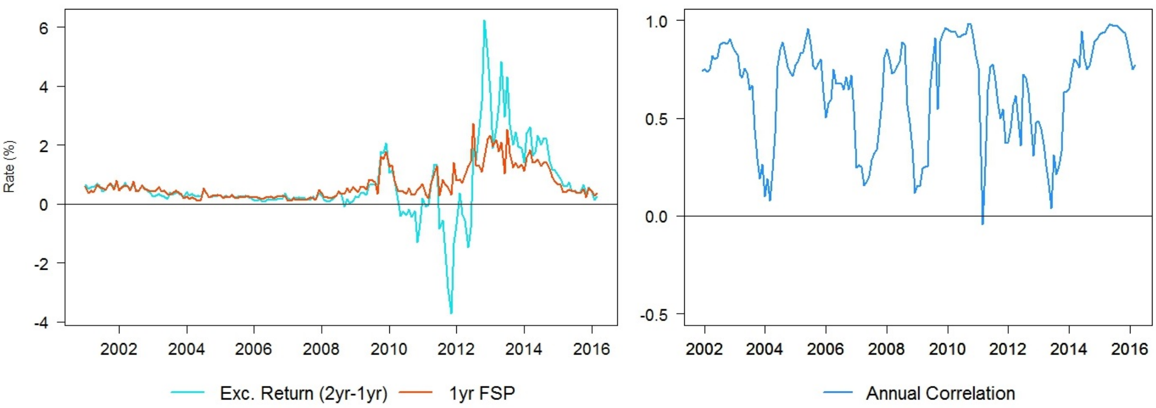
The results from the regression test on the BTP-Bund spread display a great evidence in favour of the random walk hypothesis. All the coefficients are well above the unit and all highly significative. The $\bar{R}^2$ are the highest in respect to Italy and Germany as well as the whole sample correlation.
Once more, the credit spread represent a pure risk component, thus it is more reasonable to think of it as a source of returns rather than a predictor of future change in yields.

Table 1.8: Regression Forecast of Excess Returns - BTP-Bund Spread

$$HPR_{n;t+1} - r_{1;t} = \alpha_2 + \beta_2 \left(f_{1,n-1;t} - r_{1;t}\right) + \epsilon_{2;t+1}$$

Maturity (n)	Horizon (n-1)	Coefficient (β_2)	p-value	$\bar{R}^2$	Correlation
2	1	1.530	0.00	0.495	0.705
3	2	1.917	0.00	0.369	0.61
4	3	2.791	0.00	0.363	0.605
5	4	3.460	0.00	0.375	0.615
6	5	4.303	0.00	0.311	0.561

Figure 1.13: BTP-Bund Excess Return (2yr-1yr) 1 Year Forecasting Horizon



In conclusion of this chapter is possible to state that the empirical evidence between the expectation and the risk premium hypothesis is much more controversial than what might seems from the theory. From our results it's clear that the assumptions hold differently depending on the forecasting horizon and the market we are considering.

In general the EH gains favour when we increase the horizon, reaching its best at the medium term predicting the subsequent change in spot rates three and four years ahead. It's effect is poorer, though, in the very short term, where instead it is shown that the forwards are more able to predict excess returns confirming the fact that the spot rates follow a random walk process as presumed by the term premium hypothesis. In addition, there is a big difference in the evidence from the two European markets. The EH works much better in the Germany and fares not too well in the Italian one. What I found, as it will presented later, is that the risk premium in bonds is mainly driven by the inflation risk premium. Countries as Germany, which has always displayed lower level of inflation and lower inflation uncertainty, are perceived to be less risky in duration extension, thus requiring a lower compensation for bearing longer maturities and giving value to the EH.

Chapter 2

Estimating ex-ante Term Premium

After we showed that it is impossible to make extreme assumptions and it is not trivial to decide empirically which has a larger influence on the yield curve's shape, our next step is an attempt to disentangle the two forces from forward rates, subtracting the rate expectation component and estimating the ex-ante term premium.

In this section I carry out an analysis on the Italian and German Government bonds, adding the U.S. Treasury market as a reference for the results and for comparison with previous literature. The sample period starts in January 2000 until the last data available in 2016.

For the purpose, I add three different measures that can proxy required ex-ante term premium and, exploiting their financial meaning, it is possible to analyse their relation with realized excess returns and subsequent yield change.

First of all, I introduce the slope or the steepness of the yield curve is the simplest and most popular proxy for the ex-ante risk premium, but still it is a too noisy measure reflecting both market's expectation of future rate changes and bond risk premium. Then, I come back to a statistical model found by Cochrane-Piazzesi (2005). They constructed a predictor loosely related to the yield curvature. They regress subsequent realized bond returns on a sequence of constant maturity forward rates and find that across maturities all bond returns seem to be predicted by the same single forecasting factor. Finally, I use the survey data, i.e. consensus forecast of future interest rates, which is the most direct and model-free way to assess the market's expectations. Simply subtracting this values from the current long-term yields should give a plausible estimate of the bond risk premuim.

2.1 Yield Curve Steepness

Historically, the slope of the yield curve has been a good leading indicator of economic activity. Because the curve can summarize where investors think interest rates are headed in the future, it can indicate their expectations for the economy.

A sharply upward sloping, or steep yield curve, has often preceded an economic upturn. The assumption behind a steep yield curve is interest rates will begin to rise significantly in the future. Investors demand more yield as maturity extends if they expect rapid economic growth because of the associated risks of higher inflation and higher interest rates, which can both hurt bond returns. When inflation is rising, the Central Bank will often raise interest rates to fight inflation.

A flat yield curve frequently signals an economic slowdown. The curve typically flattens when the Central Bank raises interest rates to restrain a rapidly growing economy. Short-term yields rise to reflect the rate hikes, while long-term rates fall as expectations of inflation moderate. A flat yield curve is unusual and typically indicates a transition to either an upward or downward slope.

An inverted yield curve can be a harbinger of recession. When yields on short-term bonds are higher than those on long-term bonds, it suggests that investors expect interest rates to decline in the future, usually in conjunction with a slowing economy and lower inflation.

For the reasons discussed above practitioners use the yield curve steepness as the simplest and most popular proxy for the ex-ante risk premium. Albeit its convenience, it is clearly a too noisy measure as it can not differentiate market's expectations of future rate changes and BRP. Nevertheless, due to its popularity, it is an exercise worth of doing to test the slope of the yield curve in connection with the change in the spot rates and realized returns.

Taking as a measure of the slope of the yield curve, the spread between the 10-year and 1-year spot rate, we recall that a long-term yield should be equal to the expected average of future short-term rates plus a risk premium. So we can write the equation of the yield curve steepness as:

$$
\begin{aligned}
SLOPE_{YC} &= (\, r_{10;t} - r_{1;t} \,) \\
&= [\, E_t(avg.\, r_{1;t}) - r_{1;t} \,] + BRP_{10;t} \\
&= E_t[\Delta avg.\, r_{1;t}] + BRP_{10;t}
\end{aligned}
\tag{2.1}
$$

We will ask if a steep yield curve reflects more expectations of rising yields or high required BRP and if the yield curve's slope is a good proxy of long-term ex-anteBRP. By doing so we will show which component is predominant in the different markets and state the yield curve's slope predictive ability by estimating its relation with the following indicators at one, three and five years horizon.

- Realized excess return for 10-year bonds
- 10-year bond yield changes over the next year
- 1-year bond yield changes over the next year

For a more accurate analysis it will be useful to considerate either the whole sample period (2000-2016) either a subperiod from 2009 to 2016. Indeed, plotting the time series of the considerate variables, it is in some cases observable a break up in the previous long-lasting trend, probably due to the effects of the financial crisis.

Italian Case

For the Italian bond market we see that the yield curve predicts future excess returns rather than future yield change. It is shown in Table 2.1 that the steepness of the YC has a quite strong positive correlation with future excess return for all horizons. The values of the correlation with the change in short-term rates are still positive but weak at short term horizon while stronger for the medium term. The last column shows all negative values, that means the slope of the YC is unable to forecast the subsequent changes in long-term yields and that happens for any horizon we can measure.

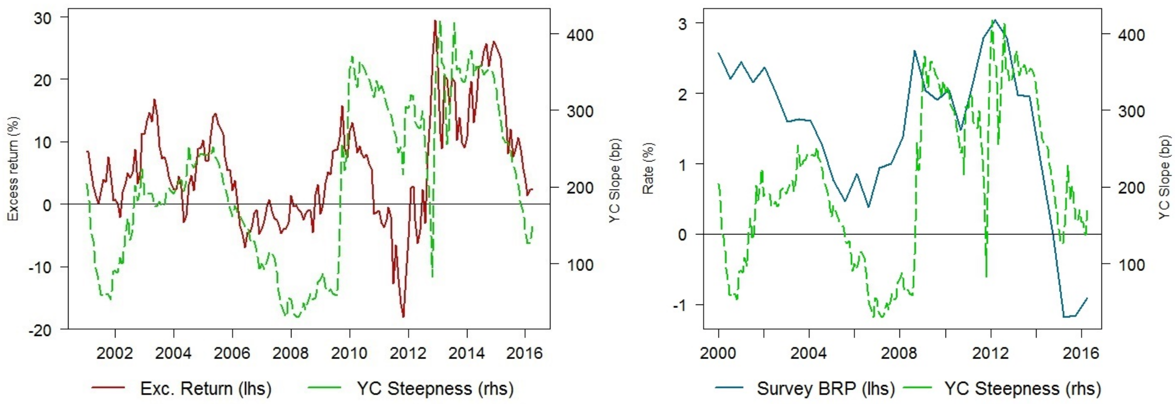
Table 2.1: Correlations with Future Returns and Yield Changes - Italian Case

Horizon	Excess Bond Returns	Change in 1-yr Rate	Change in 10-yr Rate
1 Year	0.467	0.161	−0.331
1 Year*	0.291	0.082	−0.277
3 Years	0.211	0.379	−0.553
5 Years	0.359	0.285	−0.216

* sub-period 2009-2016

We can try to plot, as Figure 2.1, the steepness of the Italian YC against another proxy for ex-ante risk premium estimated by using a survey approach (see Section 2.3). The two share mostly the same trend with a correlation of 0.63, thus confirming the role of the BTP's slope as good predictor of excess returns.

Figure 2.1: BTP Yield Curve Steepness



German Case

As for Germany the situation is quite different from Italy. Indeed, Table 2.2 reports that the slope can forecast the excess returns only for short-term horizons. When we increase the forecasting window, the sign of the correlation become negative. Instead, the correlation is strong when we measure the ability to predict short-term yield changes, a relation that grows as we increase the horizon to the medium term. Regarding the changes in long-term yield, the sign is in general negative or slightly positive at 5 years horizon. All summed up, accordingly with the results of the Fama-Bliss tests, the Bund's curve is a better predictor for future change in short-term rates rather than realized excess returns.

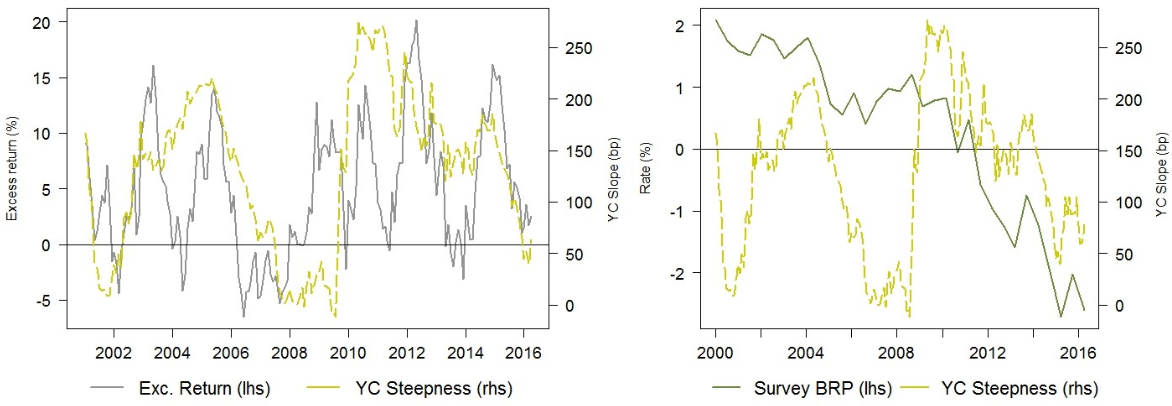
Table 2.2: Correlations with Future Returns and Yield Changes - German Case

Horizon	Excess Bond Returns	Change in 1-yr Rate	Change in 10-yr Rate
1 Year	0.407	0.305	−0.262
1 Year*	0.292	0.144	−0.214
3 Years	−0.025	0.686	−0.134
5 Years	−0.077	0.677	0.126

* sub-period 2009-2016

Again,as we would expect for the regression tests, in our longer sample the German YC's slope is quite a poor proxy for long-term BRP based on survey, with a correlation 0.07. Note that if we take into account the sub-period 2009-2016 the situation improves a lot because the correlation goes up to 0.65.

Figure 2.2: Bund Yield Curve Steepness



United States

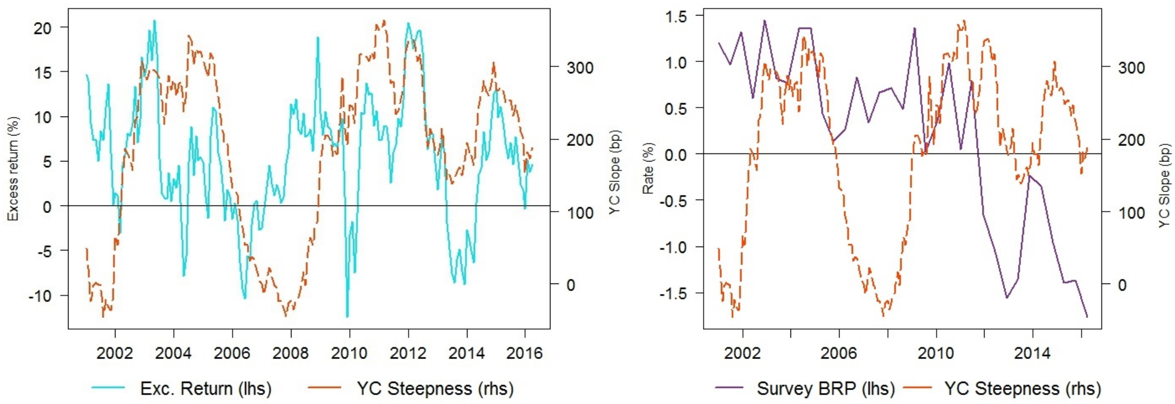
Because of the great difference we get from the results in Italy and Germany, we introduce the U.S. bond market to make a comparison. Even so the situation remains quite puzzling. Especially in U.S. we can see how much the financial crisis mixed up the trends. If we consider the whole sample (200-2016) the results are pretty much similar to Germany, where the YC can predict excess returns over short horizons and short-term yield changes even at medium horizons (the predictive power of long maturity yields is disputable and depending heavily on the forecasting horizon). Moreover the YC is a poor proxy for long-term survey BRP with a correlation of -0.03. Instead, if we consider the sub-period (2009-2016), the situation inverts. The correlation with realized excess returns almost triples in respect with the whole sample value, whereas the one with yield changes (either short and long-term) becomes deeply negative. The linkage with long-term survey BRP from negative speeds up to 0.82.

Table 2.3: Correlations with Future Returns and Yield Changes - United States

Horizon	Excess Bond Returns	Change in 1-yr Rate	Change in 10-yr Rate
1 Year	0.289	0.489	−0.078
1 Year*	0.758	−0.385	−0.701
3 Years	−0.254	0.833	0.301
5 Years	−0.193	0.774	0.463

* sub-period 2009-2016

Figure 2.3: U.S. Yield Curve Steepness



2.2 Cochrane-Piazzesi Term Premium

Cochrane and Piazzesi (2005) find an even better predictor of future bond returns than the YC's slope, loosely related to yield curve curvature. They run regressions of 1-year realized excess returns on five 1-year forward rates and find that across maturities all bond returns seem to be predicted by the same single return-forecasting factor, which we can call "CP Factor", that is a single linear combination of forward rates describing time variation evidence in expected returns. Most important, they find that the same linear combination of forwards predicts bond returns at all maturities, where Fama and Bliss, and Campbell and Shiller, related each bond's expected excess return to a different forward spread or yield spread.

Remember that under the EH, term premia are time-invariant, and so ex-ante expected excess returns should be constant. In addition all the coefficients of the forward rates used in the regression should jointly be equal to zero because the n-year forward rate is an optima forecast of the 1-year spot rate $n-1$ years from now, so no other variable should enter in that forecast. Once the EH is abandoned, so that returns are indeed forecastable, one can improve the previous Fama-Bliss model and generate economic models in which many forward rates are needed to forecast 1-year expected returns on bonds of any maturity.

Conchrane and Piazzesi, using smoothed data from the U.S. bond market, obtained a return-forecasting factor which is a symmetric, tent-shaped linear combination of forward rates and their model presents lower p-values a greater $\bar{R}^2$ than the Fama-Bliss model. Following their methodology I will try to reproduce the model and apply it to my European dataset, always keeping the U.S. market as reference.

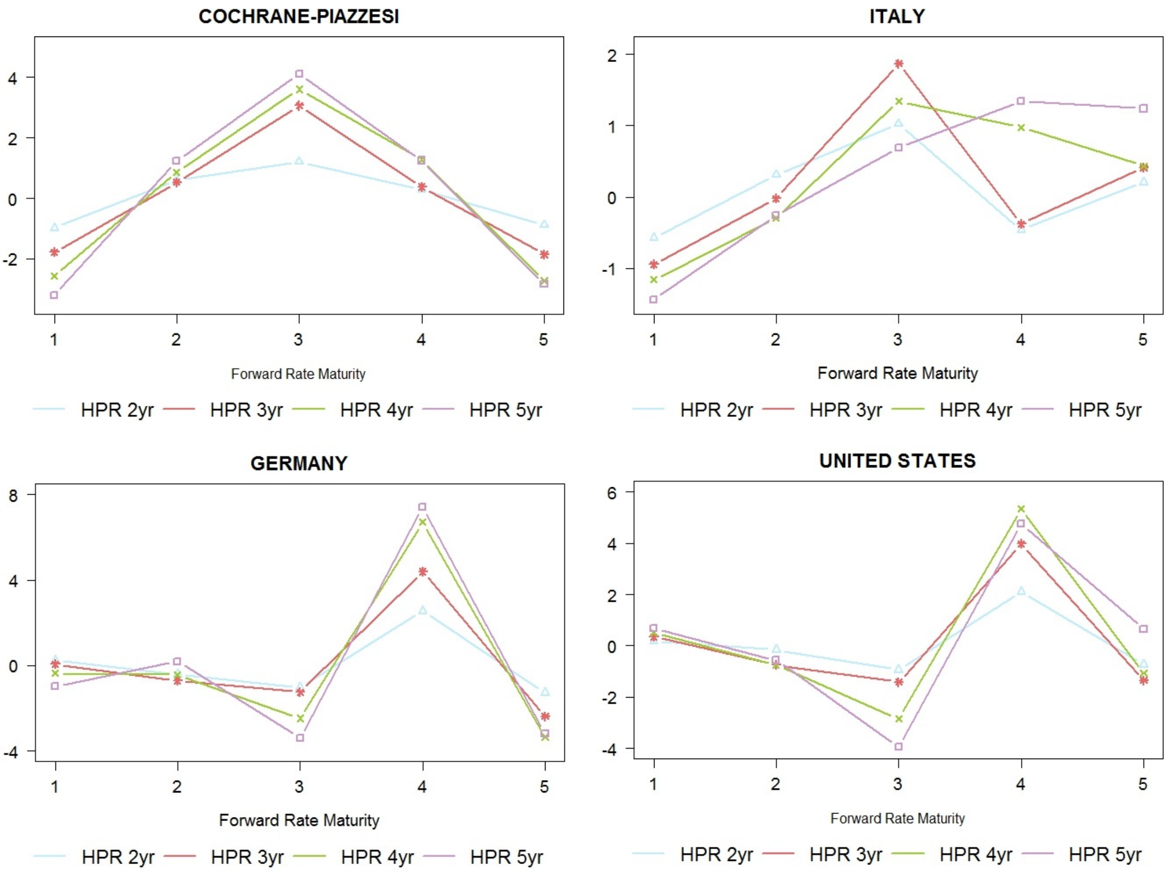
For the setting up of the model, I will proceed, as it follows, in three steps: first of all, I will investigate the shape of the return-forecasting factor checking if it is conceptually possible to implement the model and how much it differs from the symmetric tent-shaped form; then, I will estimate the single factor; finally, I will test the single factor model regressing the realized excess returns of bonds of all maturities.

As for the first step, we can estimate the shape of the single factor running a regression of bond excess returns at time $t+1$ on forward (and 1-year spot) rates at time t. Focusing on one-year return horizon, the same function of forwards forecasts holding period returns at all maturities. Longer maturities just have greater loadings on this same function.

$$HPR_{n;t+1} - r_{1;t} = \beta_0 + \beta_1\, r_{1;t} + \beta_2\, f_{1,1;t} + \beta_3\, f_{1,2;t} + \beta_4\, f_{1,3;t} + \beta_5\, f_{1,4;t} \qquad n = 2, ..., 5 \tag{2.2}$$

Unfortunately we did not get any perfect tent-shape (Figure 2.4).

Figure 2.4: Regression Coefficients Shape

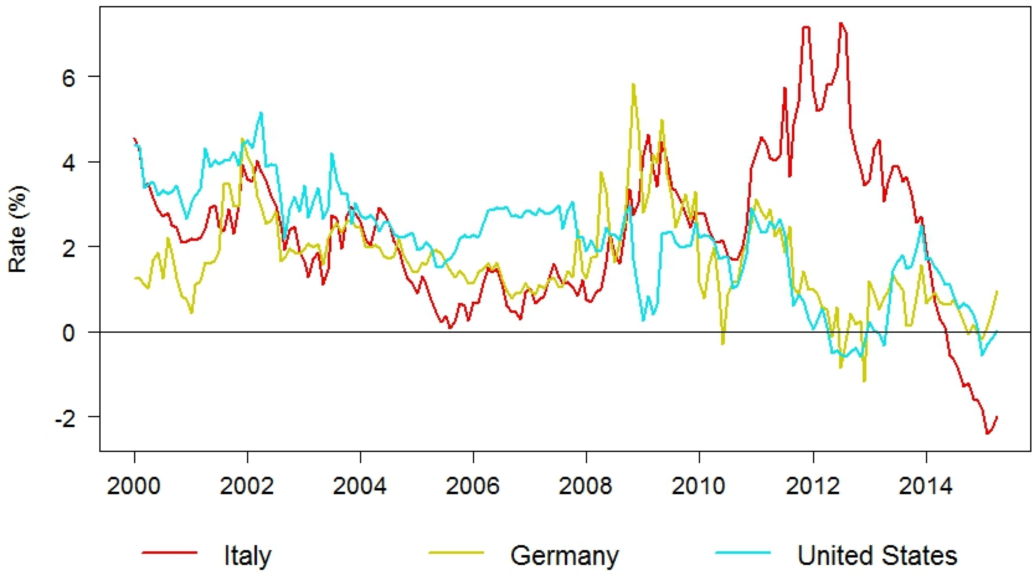


Nonetheless there are shown some trends. What we can learn is that the first three coefficients β_1 , β_2 and β_3, associated respectively with the 1-year spot rate and the 1-year maturity forward rate one and two years in the future, are in most cases ranging from 0 to deeply negative. That means that it is not the front end of the forward curve that is useful to forecast excess returns. Instead most of the work is carried out by β_4, the coefficient of the 1-year forward three years ahead and then again β_5 falls close to zero. Mind that in Italy β_3 and β_4 are both important and share the upmost point in different maturities. Anyway in general a possible meaning of this evidence is that what matters for excess return is not the steepness but the curvature of the forward term structure.

Having seen that the pattern of the coefficients shares the same trend across maturities, we will try to express it in terms of a single factor, as follows:

$$HPR_{n;t+1} - r_{1;t} = b_n \left[\gamma_0 + \gamma_1 \, r_{1;t} + \gamma_2 \, f_{1,1;t} + \gamma_3 \, f_{1,2;t} + \gamma_4 \, f_{1,3;t} + \gamma_5 \, f_{1,4;t} \right] \tag{2.3}$$

Figure 2.5: CP Factor across Countries - Time Series



We can estimate the γ_n running a multivariate regression of the average excess return across maturities on all the forward rates (2.4).

$$\frac{1}{4}\sum_{n=2}^{5}(HPR_{n;t+1} - r_{1;t}) = \gamma_0 + \gamma_1 \, r_{1;t} + \gamma_2 \, f_{1,1;t} + \gamma_3 \, f_{1,2;t} + \gamma_4 \, f_{1,3;t} + \gamma_5 \, f_{1,4;t} \tag{2.4}$$

Then we synthesize this information in a single return forecasting factor, Cochrane-Piazzesi Factor or CP BRP (2.5)[1].

[1] The bold characters reminds us of matrix form and inner product of matrices and vectors and the overbar notation of the mean expression.

$$\overline{rx}_{t+1} = \boldsymbol{\gamma^T} \, \boldsymbol{f_t} \; + \; \bar{\epsilon}_{t+1} \tag{2.5}$$

In Table 2.4 are reported the estimated coefficients we get from the regression with their standard errors and the $\bar{R}^2$. The loadings reflect the shape of the coefficients found before, with higher significant values for the coefficient γ_4 related to the 1-year forward three years ahead.

Table 2.4: Estimates of the Single Factor Model

$$\overline{rx}_{t+1} = \gamma_0 + \gamma_1 \, r_{1;t} + \gamma_2 \, f_{1,1;t} + \gamma_3 \, f_{1,2;t} + \gamma_4 \, f_{1,3;t} + \gamma_5 \, f_{1,4;t}$$

	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	$\bar{R}^2$
Italy	−3.952	−1.027	−0.065	1.232	0.372	0.573	0.308
	(0.93)	(0.44)	(1.01)	(1.34)	(0.83)	(0.59)	
Germany	0.502	−0.253	−0.335	−2.026	5.268	−2.540	0.263
	(0.53)	(0.47)	(0.94)	(1.09)	(0.83)	(0.57)	
United States	−2.324	0.424	−0.552	−2.281	4.045	−0.622	0.247
	(0.70)	(0.44)	(0.79)	(1.14)	(2.22)	(1.58)	

Note: Standard errors in parentheses "()"

In Figure 2.5 are plotted the time series of the single factor constructed as a linear combination of forward rates $\boldsymbol{\gamma^T} \, \boldsymbol{f_t}$. As we called CP BRP, it is a measure of ex-ante risk premium based on the forward curve, much related to and amplifying the shape of the spot curve. In fact, we can see in periods when the yield curve was flattening, the CP BRP is lower (if not negative) and when the yield curve was steepening, the CP BRP is higher. A clear example is the Italian case between the years of the Sovereign Crisis (2011-2013) and the subsequent falling of the yields.

We said how a single linear combination of forward rates $\boldsymbol{\gamma^T} \, \boldsymbol{f_t}$ is the state variable for time-varying expected returns of all maturities. Thus, after having computed the forecasting factor, we now move to test our intuition. We will run a simple regression of realized excess return for each maturity, from two to five years, on the single factor as it follows and make a comparison with the results we got from the second Fama-Bliss test.

$$HPR_{n;t+1} - r_{1;t} = b_n \, [\, \boldsymbol{\gamma^T} \, \boldsymbol{f_t} \,] + \epsilon_{n;t+1} \qquad\qquad n = 2, ..., 5 \tag{2.6}$$

Italian Case

From the Table 2.5, we can see that all the coefficients are all positive and highly significant, increasing with maturity as one could expect. The top value is around 1.5 for the excess return of the 5-year bond. From the previous test the $\bar{R}^2$ is stable between 0.3 and 0.4. The correlations, instead, are improved ranging between 0.5 and 0.6.

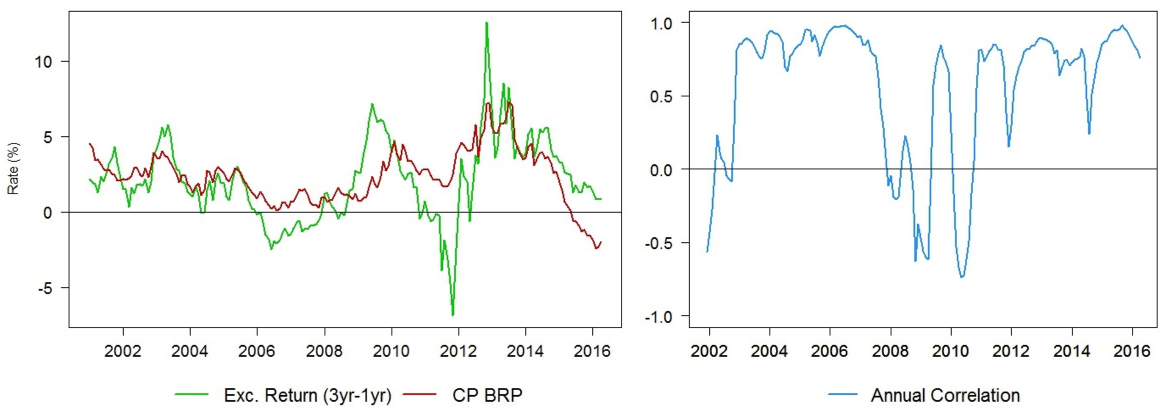
Table 2.5: Regression Forecast of Excess Returns - Italian Case

$$HPR_{n;t+1} - r_{1;t} = b_n \left[\gamma^T \boldsymbol{f_t} \right] + \epsilon_{n;t+1}$$

Maturity (n)	Coefficient (b_n)	p-value	$\bar{R}^2$	Correlation
2	0.468	0.00	0.370	0.611
3	0.882	0.00	0.346	0.591
4	1.176	0.00	0.301	0.552
5	1.473	0.00	0.293	0.544

I plotted the example of the excess returns referred to the 3-year maturity bond over the 1-year bond and there can be seen how the two time series are quite united and the annual correlation improves even if still has its flaws during the financial crisis between 2007-2010. Taken all in consideration, the EH can be rejected with more confidence.

Figure 2.6: CP Factor - Italian Case



German Case

Like the Italian case, the German bond market presents all positive and highly significant coefficients, which increase with maturity. Again the $\bar{R}^2$ is not improved much from the previous test and weaker than Italy. Same story for correlations.

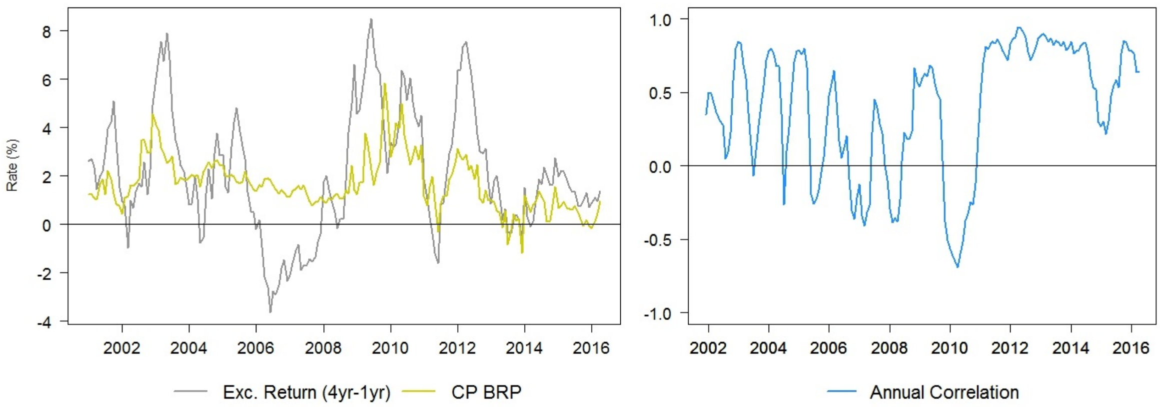
Table 2.6: Regression Forecast of Excess Returns - German Case

$$HPR_{n;t+1} - r_{1;t} = b_n\left[\gamma^T f_t\right] + \epsilon_{n;t+1}$$

Maturity (n)	Coefficient (b_n)	p-value	$\bar{R}^2$	Correlation
2	0.442	0.00	0.274	0.249
3	0.850	0.00	0.279	0.282
4	1.278	0.00	0.301	0.335
5	1.430	0.00	0.244	0.378

Although the values are positive, graphically we can still see some differences in the time series of the CP factor and the realized excess returns of a 4-year maturity bond. Even the annual correlation is discontinuous. From mid-2010 the situation improves drastically, a sign that the risk premium component increased its weight due to the EZ Crisis and the excess returns became more predictable.

Figure 2.7: CP Factor - German Case



United States

As for the U.S. Treasuries, we see the lowest values among the three here presented. Although the coefficients are all positive, highly significant and increasing with maturity, the $\bar{R}^2$ and the correlations remain substantially subdued. The U.S. case was not presented in the Fama-Bliss test, anyway surprisingly the situation does not improve much as found by Cochrane and Piazzesi.

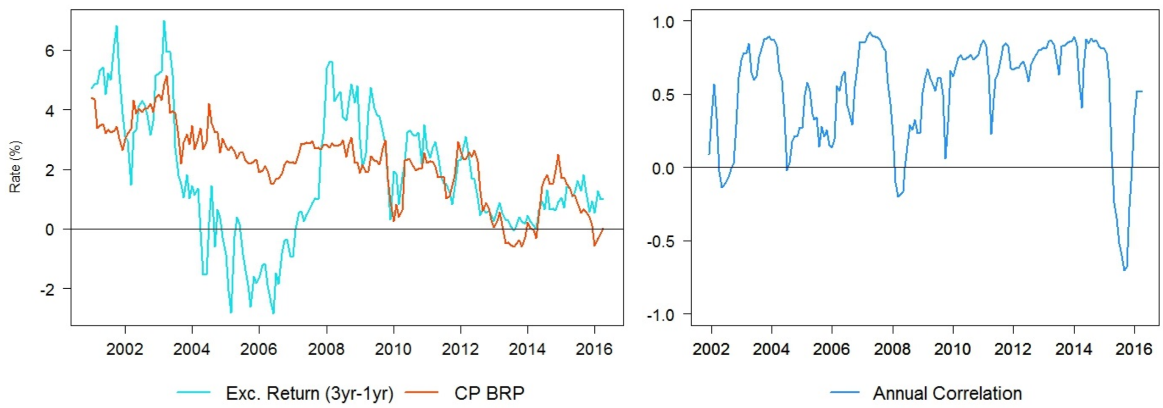
Table 2.7: Regression Forecast of Excess Returns - United States

$$HPR_{n;t+1} - r_{1;t} = b_n\,[\,\boldsymbol{\gamma}^T\,\boldsymbol{f_t}\,] + \epsilon_{n;t+1}$$

Maturity (n)	Coefficient (b_n)	p-value	$\bar{R}^2$	Correlation
2	0.455	0.00	0.236	0.110
3	0.826	0.00	0.235	0.102
4	1.193	0.00	0.257	0.124
5	1.526	0.00	0.270	0.123

Graphically there are some minor differences in the time series if we count from 2009 onwards. The previous path can share the main trend but fails especially between 2004-2009. As a result the twelve month rolling correlation is discontinuous but seldom goes negative. An important break up of the positive trend is presented from 2015 and the beginning of 2016 probably due to the uncertainty of the FED action setting monetary rates.

Figure 2.8: CP Factor - United States



2.3 Survey-Based Term Premium

Estimating term premia is a challenging task because the premia and their expectation counterparts are unobservable. Extracting interest rate expectations from the yield curve rests on the validity of necessary assumptions. We saw the expectation hypothesis, for instance, takes the current forward rate curve as the expected path of future spot rates by abstracting from the presence of any term premium, thus stating that the difference between the forward rate and the ex-post realized short rate should not be forecastable with ex-ante variables. If, in fact, ex-ante variables help to predict this difference, it would imply the presence of a term premium and the failure of the EH.

As reported in the previous sections, one approach that can be used to estimate the term premium from the YC is to apply a formal term structure model that can be based on simple regression (Fama-Bliss, Campbell-Shiller, Cochrane-Piazzesi) or flexible model parameter (Duffee, Kim-Wright,Diebold-Li). This generation of term structure model has shown considerable promise for capturing the dynamic behaviour of the yield curve, however, the empirical implementation of these models runs into problems that can invalidate their application. Two of the greatest problems that affect the analytical approach are the lack of robustenss of the estimation process that often exhibits implausible properties and highly persistent nature of interest rates. We can summarize noting that the persistent nature of interest rates reduces the effective size of the samples typically used in the analysis, causing term premia to be estimated very imprecisely. Then, conventional estimation techniques have the tendency to make stationary time series appear to revert to its long-run average faster than it does in reality. This evidence is crucial in recent times, where interest rates are so far from their long-run average that affine models' output predict a such great rise in the short and medium-term which is unthinkable to be true.

One way to overcome these empirical problems is to incorporate additional information into the estimation procedure. For the purpose we can use survey data from economists' long-term forecast to estimate the components of bond yields and identify the causes of changes in yields. The underlying idea is that surveys about forecasts of financial market participants are a valid proxy for the market's expectations implicit in the term structure when the survey is conducted.

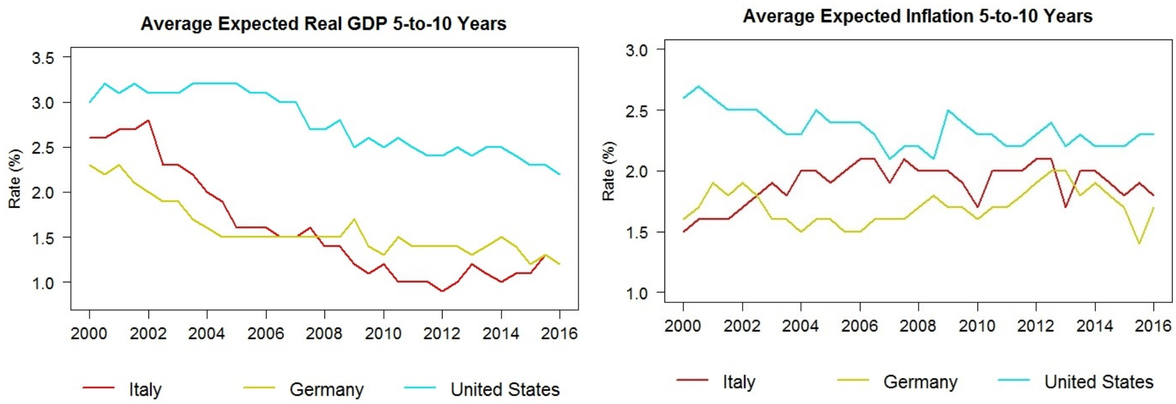
Using survey data of long-term forecast, we can decompose the long-term yields into the sum of expectations of future inflation and expectations of future real returns. if we add also the economists' long-term forecasts of the short-term money market rate, we could further decompose the real return into expectations of real short-term interest rates and a risk premium for investing in the long-term bond rather than short-term one. In other words, it is possible to estimate the term premium as the difference between an actual yield or a forward rate and the average of expected future short-term interest rates over the corresponding horizon. An ideal example is reported in the formula below:

$$YLD_{10;t} = E_t\,[\,INF_{10}\,] + E_t\,[\,RealTBILL_{10}\,] + E_t\,[\,BRP_{10}\,] \tag{2.7}$$

Nowadays there are several entities that are specialized in conducting surveys and publishing the responses. Some are under the control of Central Banks, like the ECB's or the FED of Philadelphia's Survey of Professional Forecasters (SPF), other are private companies, like the Blue Chip Economic Indicators (BC) or the Consensus Forecast (CF). Each of them provides the future values for sensible economic variables, as real GDP and inflation growth rate, unemployment, balance account, personal consumption, interest rates, etc. Though there could be some major differences between entities, regarding the number of Countries in object, the forecasting horizon, the frequency of the publishing or the variables themselves, usually the forecasts follow a monthly frequency for short-term horizons (until $t + 2$ years) and a lower frequency, generally semi-annually or annually, for longer horizons (until $t+10$ years). In addition, in some publishings of the year, there are some special information, like the analysis of the probability function of next-year inflation in the CF, that is provided on annual basis.

Since we are interested in estimating the term premium for European Countries such as Italy and Germany, we has to refer to the survey data provided by the Consensus Forecast. Other survey providers, principally the Blue Chip, focus only on the U.S. economy and lack data for the rest of the economies. Then, we want to look at the analysis of long-term market's expectations and long-term risk premium, thus we will take as reference the long-term forecasts for the variables that mostly drive the yield curve, the real GDP growth rate and the inflation rate. In Figure 2.9 I plotted the time series of forecasted average between 5 and 10 years of these two variables since the year 2000 until the most recent publishing in April 2016. It is shown that for the European Countries the expected inflation is lower, and close to the reference number of 2%, than it is for the United States. Instead, the trend of the real GDP growth rate is descending for all the Countries but with much lower values for Italy and Germany.

Figure 2.9: Consensus Forecast Long-Term Estimates



The first benefit of using survey data is that they are a direct, real-time and model-free way to address to latent variable. Secondly, compared with econometric

models, survey estimates do not suffer from model misspecification or structural breaks such long-run mean-reverting tendency and exclusion of shifts in long-run expectation. Although these benefits, we face some flaws as well. Aside from the problems of representativeness of the responders, fairness and timing of their answers, the major problems I found regards the disclosure of the publications and the rare frequency of some data. More than that, survey firms don't ask direct questions about term premium, but they just focus on macroeconomic or market variables which have their reference to market quotes. Thus, there are no such questions as "What is the term premium at the following horizon?" or " What compensation do you require to loan to the Treasury over longer as opposed to shorter periods?".
Even more, as mentioned above, not all the surveys forecast the same measures in relation with all the World Economies. That means it is not always possible to apply the same decomposition of long-term yields for every Country we want. For example, Consensus Forecast from 1989 polls monthly more than 700 economists for their forecast related to an international panel dataset, including Italy, Germany and United States and with semiannual frequency (in the months of October and April), it provides distant-horizon forecast for variables such as GDP and inflation but not for short-term interest rates. Other surveys, like Blue Chip and the FED's SPF, publish distant-horizon forecasts even for short-term interest rates but they are related only to the U.S. economy and they are not directly applicable to European Countries.

In order to overcome this disparity in available data, I will follow the approach presented by Wright (2008). He used the U.S. data of the distant-horizon forecast for short-term rates in order to measure the relation between the money-market rate and the real GDP and inflation. Then, he applied this relation to an international panel dataset estimating the Country specific term premium.
Analytically, let be r_{3m}^{BC}, π^{BC} and Y^{BC}, respectively the 3-month rate, the inflation YoY rate and the real GDP YoY growth rate estimates taken from the Blue Chip surveys. We can run the regression of the distant-horizon short-term interest rate forecasts on the forecasted GDP and inflation.

$$E_t\,[\,avg.r_{3m;5-10yr}^{BC}\,] = \beta_0 + \beta_\pi\,E_t\,[\,avg.\pi_{5-10yr}^{BC}\,] + \beta_Y E_t\,[\,avg.Y_{5-10yr}^{BC}\,] + \epsilon_t \tag{2.8}$$

It is possible to use the estimate of these coefficients, imposing the Fisher hypothesis restriction[2], to obtain prediction form Consensus Forecasts of a synthetic proxy of the average 3-month interest rate at five-to-ten horizon for the international data. Subtracting this value from the long-term forward rate, that account as the market's

[2] Thus imposing $\beta_\pi = 1$.

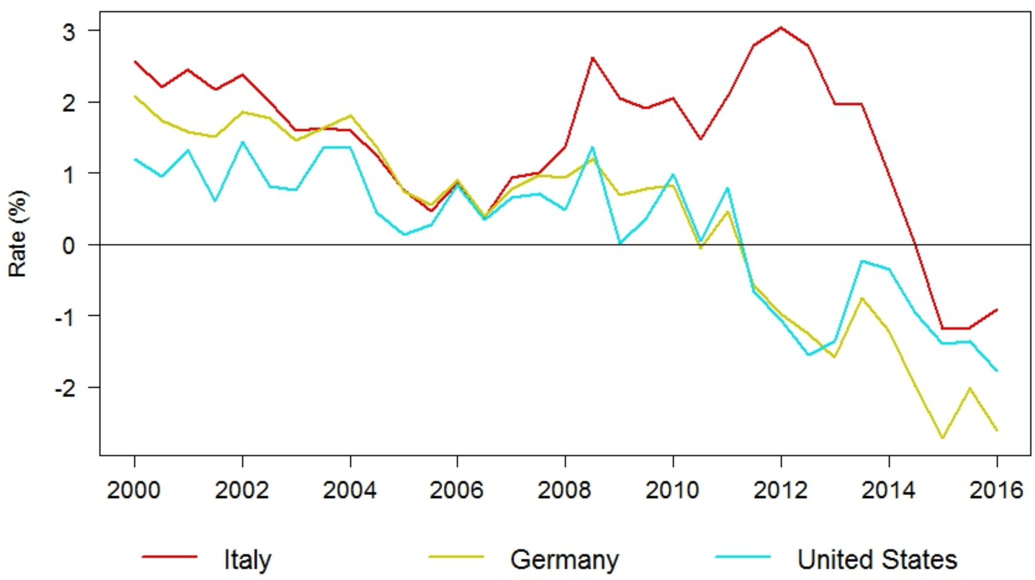
expectation on future short-term interest rates, gives rise to the Bond Risk Premium based on survey data "S-BRP".

$$S - BRP_{5-10yr} = f_{5,5;t} - (\hat{\beta}_0 + E_t[avg.\pi^{CF}_{5-10yr}] + \hat{\beta}_Y E_t[avg.Y^{CF}_{5-10yr}]) \quad (2.9)$$

In this formulation the underlying (strong) assumption is that the relationship between equilibrium real short-term interest rates and growth is constant across Countries.

Unfortunately I did not have at disposal the time series from the Blue Chip, thus I could not update the estimation of the coefficients $\hat{\beta}$ computed by Wright in his first equation. I used the coefficients stated in his paper[3] (referred to a sample period that goes from 1987 to 2007) assuming them still unbiased. They will be presented in the Appendix B.
Using the survey data from the Consensus Forecast for a sample period that goes from April 2000 to April 2016 and the long-term 5-year forward 5 years ahead, we can derive the S-BRP implied by the survey for the three Countries.

Figure 2.10: Expected S-BRP over 5-to10 Years - Time Series



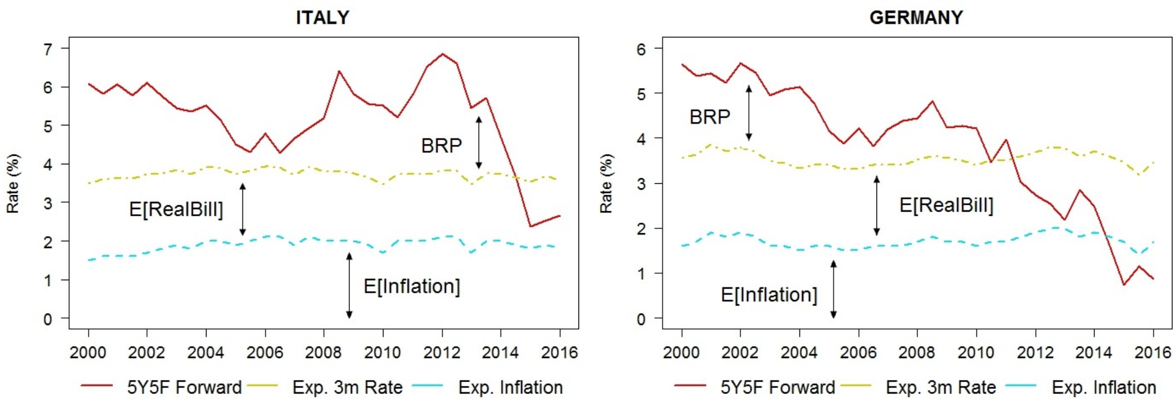
The first observation looking at the BRP time series is that clearly the assumption from the EH of a constant maturity risk premium is unreasonable. The downward trend can reflect both less risk in nominal bond – the level and uncertainty of inflation and yields have declined – and generally lower market price of risk – implied by higher equity

[3] Wright J., "Term Premiums and Inflation Uncertainty: Empirical evidence from an International Panel Dataset" (2008)

markets valuation and narrower credit spreads. For the EZ Countries has accounted also the strengthening of the Monetary Union, but since 2008 Italy and Germany have diverged. Here is confirmed the fact that the explosion of the BTP-Bund Spread was due mainly to riskier perception of Italian Govies with respect to the core European Countries. Since mid-2011 the spread in the risk premium accounted for an amount more than 300 bps until 2013 and the correlation between the Spread and the Italian S-BRP is close to 0.55 while with the German S-BRP is -0.76. In the last year (2015) the spread in risk premium is declining reaching the level of early 2000s. It si worth noting that since the beginning of 2016 the Italian S-BRP is looking upward while both the U.S. and German is still declining. A possible explanation is the continuous fear of the Euro brake up despite the huge intervention of the ECB quantitative easing, either for economical reasons (Greek debt, higher volatility in the markets) either political (war refugees, British referendum, populist forces).

After having isolated the three components of long-term nominal yields, i.e. inflation's expectations and ex-ante real short-term rate plus required risk premium, it is possible to represent these components again as one thing. The graphs show how the three component have trended in the last sixteen years.

Figure 2.11: Decomposition of Long-Term Nominal Yield



The expectation of inflation rate have followed the target of the ECB setting an inflation below but close to 2% over the medium-term. And in fact both in Italy and in Germany the expectations seem asymptotically reach the objective. Also the expected real three-month rate have remained constant, gaining just a bunch of bps. As we have seen in the previous graph it is the term premium that have brought the major difference. From the year 2000 until 2006, the Italian BRP have decreased more, closing the gap with the German, but the Sovereign crisis mixed all the situations in place. It is interesting that the German BRP became negative since mid-2011 while the Italian has reached the zero threshold in 2014 and just become negative in 2015.

In the next chapter we will analyse the reasons why the term premium had such evolution and I will argue that its main driver can be found in the level-dependant inflation uncertainty.

Chapter 3

Inflation Uncertainty and Term Premium

After having tried to estimate, with different techniques, measures of bond risk premium, a natural step further is to investigate the drivers of this premium in order to understand its behaviour and development through the years.
In this section we want to shed light on the relation between term premium and macroeconomic variables. In particular we will analyse the role of inflation process affecting the level of term premium. It is not claiming that inflation is the only driver for risk premia, but, among other macroeconomic variables, certainly inflation and a level-dependent inflation risk play a main role in the story.

We recall that a way to rationalize term premium in bond market is that bonds must be assets that pay off most in the states of the world where investors' marginal utility is low. In many simple economic models, the price of an asset depends on the covariance of its pay-off with real consumption growth. In this type of model, prices of nominal assets, such as nominal bonds, will therefore depend in part on the covariance of consumption and inflation. It is the sign of this covariance that determines the sign of the risk premium: if consumption growth covaries negatively with inflation, so that consumption growth tends to be low when inflation is high, then nominal assets are more risky and investors will demand a positive term premium to hold them. That is exactly what is needed for inflation risk to explain positive term premia. All else equal, lower inflation uncertainty should decrease the covariance between inflation and consumption growth and hence reduce the term premium.

The aim of this section is to provide empirical evidence on the relationship between longer-run inflation uncertainty and the term premium on nominal bonds. If there is a positive relationship indeed, then a decrease in long-run inflation uncertainty would naturally lead to a lower and more stable term premium facilitating the monetary policy transmission mechanism.

The last question arises looking to the current situation in financial markets. Against the concept of level-dependent inflation uncertainty, we will see that when inflation reaches values close to zero, the uncertainty of future inflation explodes signaling a sort of segmentation in the market, where some investors forecast a boost in future inflation while another part expects a period of persistent low inflation.

3.1 Inflation Risk Premium

At a first sight, a world with decreasing asset prices makes everybody richer. Actually, the only winners in that scenario are those holding cash. In an imperfectly indexed monetary world, inflation risk is one of the most important economic risks faced by consumers and investors alike. Inflation risk premia arise from the fact that investors holding nominal assets are exposed to unanticipated changes in inflation. In other words, the real pay-off, which is what investors ultimately care about, from holding a nominal asset over some period of time depends on how inflation evolves over that period. So that, investors will require a premium to compensate them for the risk associated with inflation fluctuations that they are unable to forecast.

In financial markets inflation developments are the main drivers for the performances of nominal asset classes such as fixed income instruments, but they also influence stock markets and other supposedly real assets. High or rising inflation also hurts equity markets, at least in the short-term, while few asset classes such inflation-linked bonds, commodities (especially energy-related products) and real estate benefit from higher inflation or, at least, are insensitive to it. Long-dated nominal Government bonds have the most consistent negative inflation sensitivity, in fact rising inflation hurts them, falling inflation helps them and deflation makes them excel.

In bond market the sensitivity to inflation, which ultimately lead to a presence of an IRP, is clear to present for realized returns: rising inflation expectations raises bond yields and reduce their prices. For ex-ante returns we can see that, empirically, bond yields contain a level-dependent inflation risk premium, indeed rising inflation expectations also boost required IRP and hurt current bond prices, beyond the mechanical rate expectation impact. Regarding unexpected inflation, it tends to increase inflation expectations and also pushes yields higher. Persistent upside surprises in inflation eat up the purchasing power of fixed cash flows and reduces bonds' market values. The flip side is that disinflation boosts bond prices, and if actual deflation materializes, bonds may be the only winning asset class.

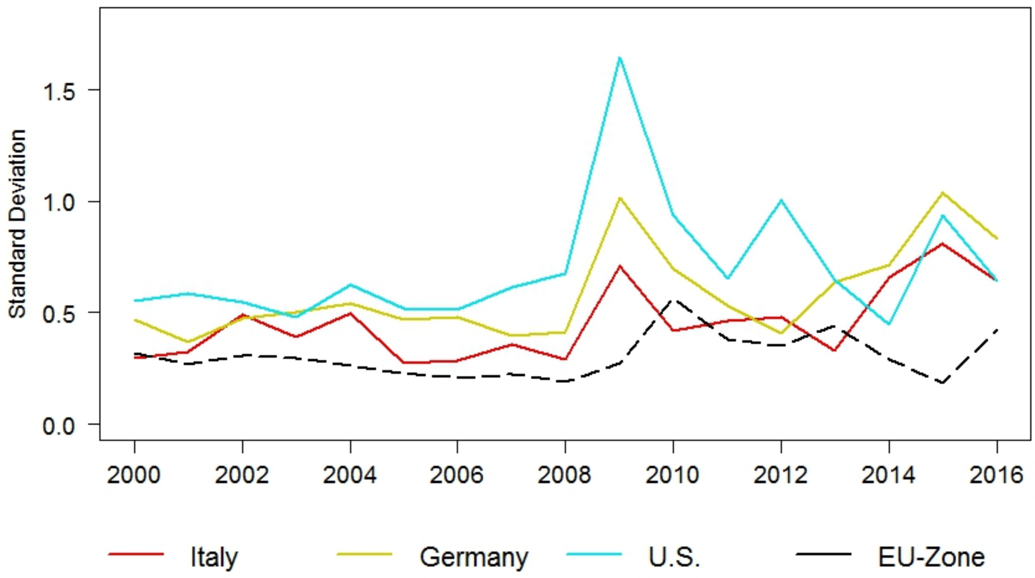
As we want to assess the relation between the BRP and a level-dependent inflation uncertainty, we now move to the construction of three different proxy of inflation uncertainty. These measures are based on the consensus responses in survey data and each of them accounts for a different perspective of uncertainty, the standard deviation of the probability function of future inflation given by survey respondents, a measure of the width of the aggregate distribution of respondents' forecasts through the time and a measure of the instability through the time of the consensus mean.
Unfortunately all of these proxies shares the same flaw. In fact they are calculated on the consensus estimate of short-term inflation while we would want a proxy that refers to a long-term inflation which is not provided by surveys' forecasts.

Implied Standard Deviation from Density Forecasts

Consensus Forecast (annual frequency) and ECB's Survey of Professional Forecasters (quarterly) ask respondents to assign their probabilities to current-year inflation falling in different buckets relative to different probabilities. These predictions can be averaged to obtain density forecasts, and then can be derived the implied standard deviation constructed as a summary statistic.

Conceptually, it would be the ideal measure of agents' inflation uncertainty but it has serious limitations. The main problem from the CF is the limited amount of data due to the annual frequency with which the density forecast are reported, while from the SPF, although the higher frequency, the problem is that it is not country-specific but the results are comprehensive for all the Euro-Zone. Anyway, both the surveys share the problem that the forecasts refer only to short-horizon inflation uncertainty measure.

Figure 3.1: Implied Standard Deviation from Density Forecasts

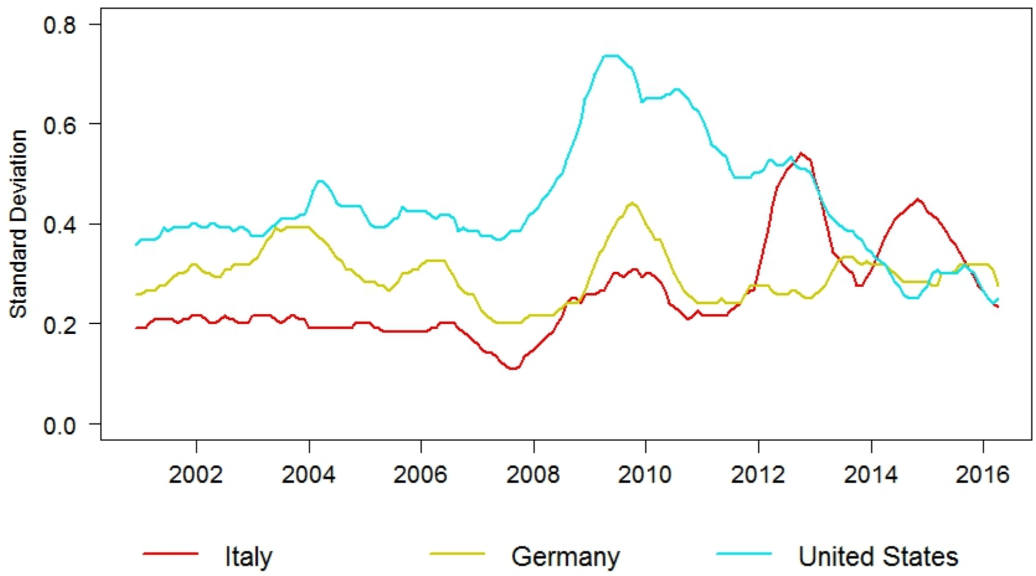


From the graph, it is possible to see that the standard deviation of expected inflation on average has been highest for the U.S. and lowest for Italy and the Euro-Zone (mind that the data for the Euro-Zone come from the ECB's SFP survey). The standard deviation for all the Countries peaked in 2009 due to the uncertainty brought by the financial and EZ crisis. Since 2012 there is an upward trend in uncertainty which has its top in 2015, one can think surprisingly, when inflation were basically zero.

Dispersion of Survey Forecasts

Every month Consensus Forecast reports not only the mean of contributors' forecasts for current and next year inflation but also the dispersion (the standard deviation) of those forecasts. Dispersion of forecast is often used as a proxy for uncertainty, though the two are different concepts.
To compute our proxy, we can take the 12-month moving average of the dispersion in next-year inflation forecasts and assume to be a rough measure of intermediate-to-long run uncertainty. It would have been preferable to have the dispersion of a longer-horizon inflation forecast, because the inflation rate for the next calendar year is surely influenced transitory factors and monetary policy. Anyway beliefs about long-term horizon should influence agents' view even at one year horizon.

Figure 3.2: 12-Month MA of Dispersion in Inflation Forecasts



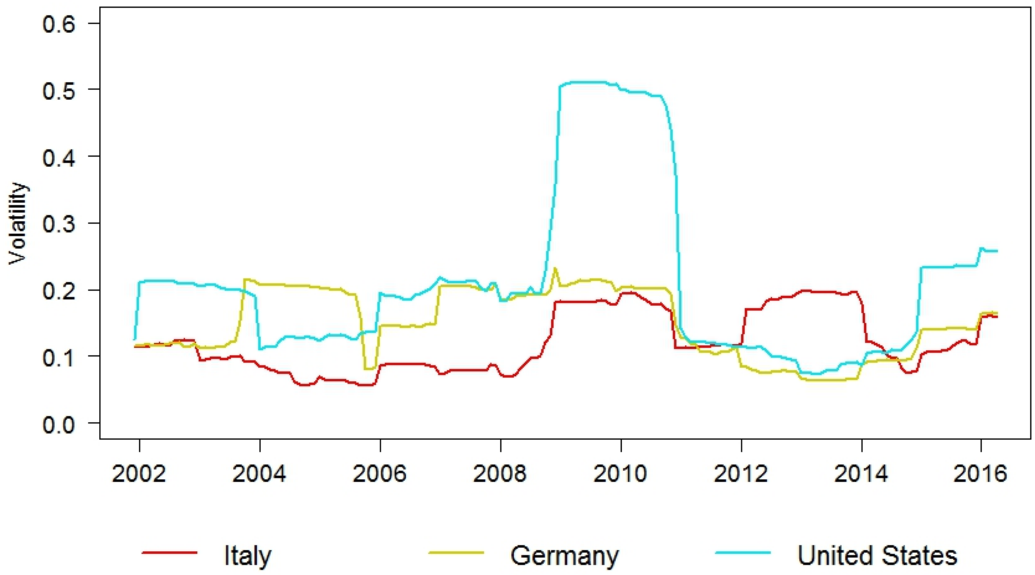
Again we have more uncertainty in the U.S. and sensibly less in Italy and Germany. The trend is stable for Italy and U.S. until 2008. After 2008 the dispersion exploded in the U.S. and decline thereafter until the end of 2014. In Italy,since 2008, began an upward trend with a major escalation during the Sovereign crisis; the trend of uncertainty is still present today. Germany is the only Country who have been for all the sample bound in his range even during the EZ Crisis and only suffering a little during the stagnation in 2003 and the financial crisis in 2009.

Mean Change Volatility of Survey Forecasts

The main objective of polling among economist agents is to sum all the information coming from each responder and report the average of the different predictions, thus

to equalize the vision of all the market. Our last proxy of inflation uncertainty has as underlying variables not the dispersion in the responses to a certain point in time, but how much the mean of the responses vary from one month to the other.
We can measure the two years rolling standard deviation of the month-to-month changes in the mean of next-year inflation forecasts assessing not the change in the width of the density function, but the variability of its mean through the time. Again, although this is still a distinct concept from inflation uncertainty, it would be natural to think of the two as being positive related.

Figure 3.3: 2-Year Rolling Volatility of Mean Change



The results are consistent with the previous measures. The variability of survey forecast has been stable until 2009. During the financial crisis exploded in U.S and became volatile in Italy with respect to the previous trend. What can be appreciated from this measure is that it shows clearly how the expectations have been more stable for the U.S. and Germany since 2011 with respect to Italy and how there has been an increasing in uncertainty since the first months of 2015 due to the deflationary forces mainly in energy products.

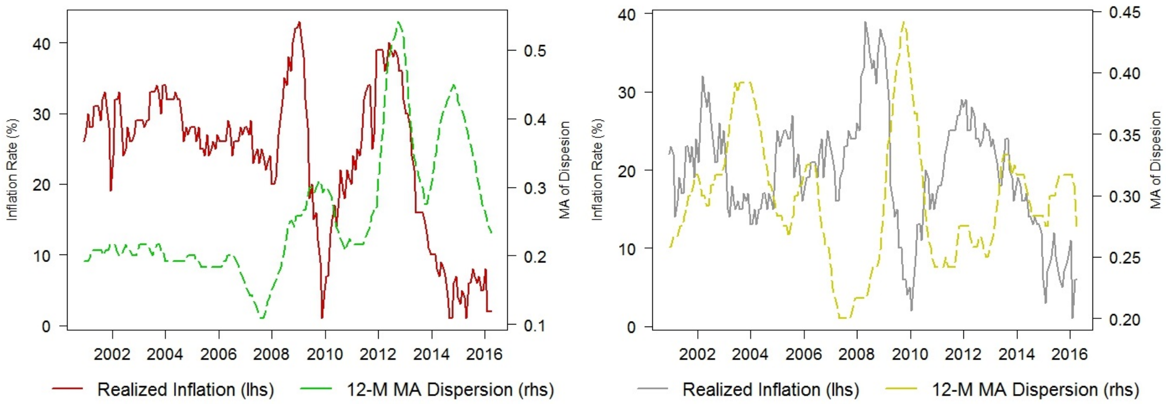
3.2 Level of Inflation and Inflation Uncertainty

Many papers, Friedman (1977), Ball, Mankiw and Romer (1988) and Mankiw, Reis and Wolfers (2003) have examined the relationship between the level of the actual or expected inflation and inflation uncertainty, and conclude that there is a strong positive relationship. Low inflation tends to be stable inflation, mainly because economies with high inflation tend to get rid of nominal rigidities, and so shocks affect more the prices than the output gap.

Ang, Bekaert and Wei (2007) show that survey measures of expected inflation provide better forecasts of inflation than any other alternative that they consider, including about a dozen variants each of Phillips curve and term structure models, as well as simple regime switching models. Thus, we can search for some evidence from our dataset of survey-based measures of inflation uncertainty and the realized inflation in Italy and Germany.

First, we can plot the time series of the realized inflation and the monthly dispersion measure of IRP, i.e. the standard deviation of survey forecast. This measure does not work really good, in fact It is easy to see that the correlation between the time series is all but 1-1 . In fact the major problems happen before and during the financial crisis in 2007- 2010 where the inflation was sustained but stable while the measure of uncertainty decrease and then rise significantly.

Figure 3.4: Realized inflation vs Forecast Dispersion

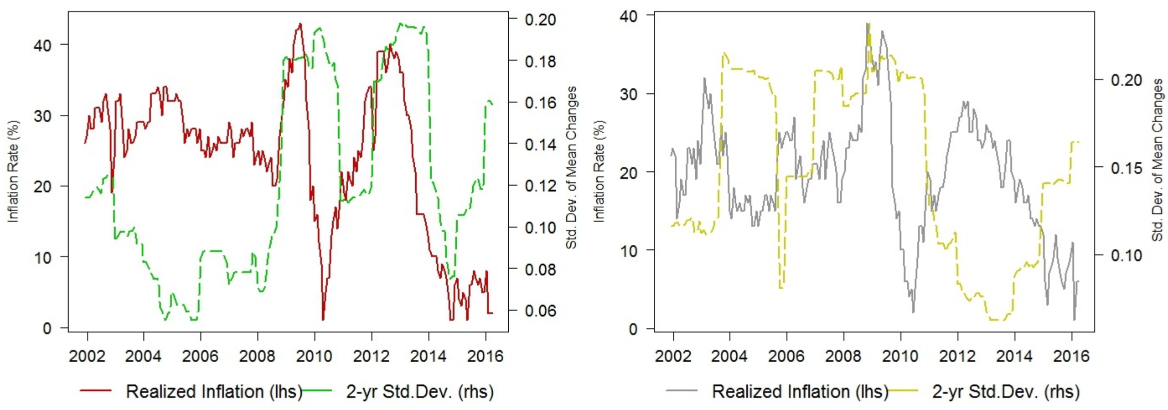


Another break down point is between the years 2014-2015 where the inflation went down but the uncertainty increased. As we have seen, in these years the inverse relation of inflation and IRP is recurrent, possibly meaning that when inflation approaches the zero level or even negative values, the uncertainty does not cancel out but instead increase reflecting the fact that some investors predict a new phases of inflation, while others predict a continuing period of inflation zero or deflation.

In turns we can represent the time series of the realized inflation and the other proxy measure of IRP, i.e. the monthly change in the mean of the forecasts. Graphically the correlation between the time series has improved, and the IRP follow much better the level of inflation, even if still not 1-1.

There are not great discrepancies, except the value in the year 2004-2006 for both Countries, yet it is interesting to note the same tendency of decoupling of the trend in

Figure 3.5: Realized inflation vs Forecast Variability



the near past. Thus, even taking the uncertainty through-the-time and not based on the width of the distribution, when inflation reaches very low levels, the relation with uncertainty became empirically negative.

3.3 Inflation Uncertainty and Term Premium

Although estimates of BRP and measure of inflation uncertainty are of interest in their own, it is certainly more important to study the relation between the two. Indeed there is good reasons to think that BRP could be importantly influenced by the compensation that investors demand for the risk of unexpected inflation, see Piazzesi-Schneider (2006).
Mind that also real long-term yields are quite volatile, probably too much to reflect shifts in expectations of future real short-term interest alone, so term premia surely do not reflect inflation risk alone. However inflation risk seems to be an important component of the explanation and measures of inflation uncertainty may be correlated with the real IRP. To investigate this possibility empirically, we can run panel data regressions of term premia on the different inflation risk measures in the form that follows:

$$S - BRP_{5-10yr;t} = a_1 + \boldsymbol{\beta}\, \boldsymbol{x_t} + \epsilon_t \tag{3.1}$$

with S-BRP the term premium based on survey data estimated with Wright model, a_1 a Country specific fixed effect and $\boldsymbol{x_t}$ a vector of inflation risk measures as constructed before.

I run both simple and multivariate regressions, plus a general correlation of the term premium based on survey data with the constructed proxy of IRP. From the value of the correlations we can already have an idea of the positive relation that links the BRP to the IRP confirming the existent literature. Indeed both measures for both Countries show positive and relatively high values, especially the measures of volatility that has a correlation of 0.75 in Italy and 0.61 in Germany. As for the regression, the results are confirmed again. In general the stronger variable is "volatility" which has higher coefficients and higher $\bar{R}^2$. Moreover it is the only significant regressor in the multivariate test. "Dispersion", despite positive coefficients in the multivariate test, it is not significantly different from zero and in Germany shows a negative coefficient in the simple regression. Aside from problems with our limited dataset and relative small sample, a possible explanation for this evidence is that the market is more sensible to the change in the overall mean of expected inflation than to the width of the distribution and its tails. Nevertheless we can confirm that the inflation risk premium accounts for a big share of the required Bond Risk Premium.

Table 3.1: Regression S-BRP on IRP - Italian Case

$$S - BRP_{5-10yr;t} = a_1 + \boldsymbol{\beta} \boldsymbol{x_t} + \epsilon_t$$

IRP Measure	**Coefficient ($\boldsymbol{b_n}$)**	**p-value**	$\bar{R}^2$	**Correlation**
Dispersion	2.543	0.047	0.098	0.322
Volatility	9.694	0.00	0.542	0.742
Dispersion	0.156	0.84		
+			0.487	
Volatility	11.237	0.00		

Table 3.2: Regression S-BRP on IRP - German Case

$$S - BRP_{5-10yr;t} = a_1 + \boldsymbol{\beta} \boldsymbol{x_t} + \epsilon_t$$

IRP Measure	**Coefficient ($\boldsymbol{b_n}$)**	**p-value**	$\bar{R}^2$	**Correlation**
Dispersion	−7.250	0.00	0.438	0.195
Volatility	11.036	0.00	0.369	0.613
Dispersion	2.088	0.63		
+			0.301	
Volatility	12.533	0.00		

3.4 Inflation Risk Premium Outlook

Looking carefully to our past, deflation (more than inflation) has played a central role in the worst economic meltdowns. Well anchored inflation expectations have kept IRP negligible for a decade, but the situation may change from the second half 2010s. In fact, in last year the ECB started his first QE due to a substantial decrease in inflation expectation, with the aim to boost inflation to its target over the medium term and to help the recovery providing new liquidity and lower interest rates. Deflation is clearly an economic tail risk with consequences as standalone risk (hurting all nominal assets except nominal bonds) and because of its covariance with other tail risks. In addition, deflation represents a more fearful equilibrium than hyperinflation because it is more sticky and monetary policy could not be enough (see Japan in last twenty years).

Speaking about Government bonds, deflation risk can be associated with credit risk because of the increasing difficulties of a sustainable debt, thus we can expect investors will require higher compensation for bonds that are perceived more risky and lower compensation or even losses (negative yields) for what is perceived safer.
With the available instruments we can try to test empirically this intuition. We have seen how uncertainty of expected inflation increased as the level of inflation went close to zero, so it is possible to ask if there is a segmentation in the markets in which the mean of the forecasts is not representative any more because some of the agents will predict rising inflation, while the other still periods of inflation zero. In this scenario became crucial not the mean of the forecast but the distributions. From the ECB's SPF we take as a proxy of expected deflation the left-side tail of the distribution in next-year inflation forecast, i.e. the sum of frequencies in the buckets related to a level of inflation equal or smaller than zero. We can measure the correlation with the S-BRP for Italy and Germany over a sample period from 2000 to 2016. As results I got a positive correlation of 0.26 in Italy and -0.47 in Germany. This means that for a bigger percentage of investors predicting deflation or inflation zero in the future (the heavier is the left-side of the distribution), higher term premium will be required to hold long-term Italian bonds, while lower one will be required for German bonds. One explanation is that deflation risk (and possible default risk) are priced differently between the two Countries, and that in worse European conditions the Bund will hold its value while the BTP will be more risky.

All summed up, these results provide support to the view that the risks in of severe macroeconomic shocks in which deflation or inflation zero occurs is closely related to tail risks in financial markets, such collateral revaluation risk, business cycle risk and, mostly in our case, sovereign default risk. However, inflation or disinflation dynamics are perceived in different ways by investors which react in other different manners, thus an analysis between tail risks and financial markets requires further investigation and attention. For us, at this moment, remains in general an open-handed question.

Conclusions

First I presented the main theories that drive the yield curve and tested them on the updated data of Italian and German Government bonds over a sample period from 2000 to 2016. From the results it became clear that the hypothesis regarding constant or zero term premium has to be rejected. Anyway in economies with stable inflation over the long-run, the Expectation Hypothesis has its upsides and the forward rates can forecast better than in other economies the future change in spot rates, especially in a long-term forecasting horizon. That is because with stable inflation, the required premium for holding long-term bonds is lower and the expectations on future short-term interest rates are more prominent.

After the finding of time-varying risk premia, I focused on disentangling the ex-ante bond risk premium from the expectations component, borrowing the practices of market's participants and academics. Firstly I used the yield curve steepness but I found it still a too noisy proxy of BRP. Then I used an econometric model exploiting the predictive ability of a linear combination of forward rates finding much better results than using a single forward rate. Finally I analysed in depth the more direct approach of using surveys from agents and market's participants. I overcame some difficulties in finding available data for the Eurozone Countries applying the model proposed by Wright (2008).

In the last section I questioned the data about the drivers of ex-ante risk premium. I constructed proxy measures of inflation uncertainty and tested their correlation with the estimates of term premium. I found the BRP mainly driven from inflation and level-dependent inflation uncertainty. Most of all I found that when inflation level goes in a range close to zero or in deflation area, the uncertainty, instead of being zero as well, increases revealing a segmented market in which some agents forecast a new period of higher inflation while others are insuring themselves against deflation tail risk by the protracted purchase of riskless assets even with deeply negative yields.

Appendix A

Data Sources

Rates and Realized Inflation Rate

All the spot rates and the realized inflation rates are available on the Bloomberg Financial Platform.

The zero-coupon rates refer to the interpolated zero-coupon indices derived from the on-the-run Sovereign Curve over a maturity that goes from 1-year to 10-year.

Bloomberg tickers:

- I040xxY Index (Italy)
- I0160xxY Index (Germany)
- I0250xxY Index (United States)

Substitute xx with the requested maturity 01 -> 10

The realized inflation rate refers to the change YoY time series on Bloomberg which sources are the national statistic institutions.

Bloomberg tickers:

- ITCPEY Index (Italy)
- GRBC20YY Index (Germany)
- CPI YOY Index (United States)

Survey Data

The publications of Consensus Forecast are provided by "Biblioteca Dipartimento Tesoro" (MEF), via XX Settembre, 00187 Roma.

The dataset form ECB Survey of Professional Forecasters are available at ECB website, page of "Statistical Data Warehouse": http://sdw.ecb.europa.eu/

Appendix B

Coefficients from Wright Model

Regression coefficients of Blue Chip Long-Horizon Three-Month Interest Rate Forecasts on corresponding Inflation and GDP Growth Forecasts

Intercept	1.98	1.56	
	(0.52)	(0.48)	
Inflation	0.93	1	(Imposed)
	(0.07)		
GDP Growth	0.10	0.17	
	(0.16)	(0.17)	
R-Square (percent)	71.33	71.03	

Note: The first column shows the results of regressing the Blue Chip semi-annual forecast of U.S. three-month average interest rates from five to ten years hence on the forecast of U.S. GDP growth and inflation from the same surveys. The regression uses surveys from march 1987 to October 2007, for a total of 42 observations. Standard errors are shown in parentheses. The second column reports the results form the same regression, but imposing a unit coefficient on inflation (the Fisher hypotheses).

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LUISS

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Cattedra: Fixed Income, Credit and Commodities

Market's Expectations and Bond Risk Premia on Italian and German Government Bonds

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ANNO ACCADEMICO 2015-2016

Introduction

This research paper provides empirical evidence on the role played by market's expectations and required risk premia in defining today's yield curve and their relation with Government bond performances. The following analysis will consider an international panel dataset, mainly focusing on the Italian and German Government bonds, adding the results from the U.S. Treasuries as a reference, during sample period that includes data from the year 2000 to the last available information of 2016.

Attempts of disentangling market's expectations and required risk premium have become even more crucial in a period of record low interest rate, where Central Banks struggle to boost inflation expectations in the medium term and investors are famish for returns on their investments. In this situation more refined statistical models show their flaws and limitations, due to assumptions on mean-reverting nature of interest rates and lack of robustness in the estimates. Inputs that are incoherent with those assumptions produce outputs that are highly biased and fail to represent reliable forecasts for ex-ante term premium and future interest rates. Because of that most practitioners are turning to the basics and using naive models. In this paper we can do so as well. I will try to overcome such errors in classic term structure models finding different way to analyse the forces underlying the yield curve. Starting from the basics, the following paper has three sections in which we will answer three different questions: what information can we gain from forward rates and how can that be used for our forecasting the future shape of the yield curve? ow can we disentangle the market's expectations and required bond risk premia and how can we estimate separately the two components? which are the main drivers for bond risk premium and how we can interpret the current situation?

Chapter 1

Understanding the Yield Curve

This section begins by reviewing the fundamental concepts of the yield curve, including the necessary "bond math", that will be used in the remainder of the paper.

After this summary, through the Fama-Bliss approach (1987), I assess the predictive power of forward rates on future spot rates testing the two most relevant alternative theories on bond yields, the Expectation Hypothesis (EH) and the Term Premium Hypothesis. The empirical evidence is much more controversial than what might seems from the theory and shows quite clearly that the theoretical assumptions hold differently depending on the forecasting horizon and the market we are considering.

In general the EH gains favour when we increase the forecasting horizon, reaching its best at the medium term, i.e. forecasting the change in spot rates three and four years ahead. It's is poorer in the very short term, where instead it is presented that the forwards are more able to predict excess returns confirming the fact that the spot rates follow a random walk process and the term premium hypothesis.

There is also a consistent difference between the Italian and the German market. The EH works much better in the German market and fares not so well in the Italian one.

Looking at the tests' results, the German Government bonds and the BTP-Bund spread behave completely different and seem to be disconnected. If we measure the correlation from 2008 to 2016 between the spread and the yields at 10 year maturity, we have 0.51 for the 10-year BTP and -0.46 for the 10-year Bund. The Spread can be fairly assumed to represent a measure of credit risk embedded in the Italian rates, thus the BTP's curve can be decomposed in two parts (Bund's yield plus the spread) which are guided by different drivers and moves in opposite directions when it comes to our tests.

1.1 Expectation Hypothesis

The expectation hypothesis, in its strong form, called pure expectation hypothesis, claims that all government bonds, regardless of their maturity, have the same near-term expected return, and so, market's rate expectations are the *only* determinant of the yield curve shape. The motivation is that the market prices of bonds are set by risk-neutral traders, whose activity eliminates any expected return differentials across bonds. Investors care only about expected outcomes (means of probability distributions) and will be indifferent between two assets with the same expected retur but different level of uncertainty.
If all government bonds have the same near-term expected return, any yield differences across bonds must imply expectations of future rate changes (so that expected capital gains or losses offset the impact of initial yield differences). For example, if investors expect rates to rise and long-term bonds to lose value, they require higher initial yields for long-term bonds than for short-term bonds, making today's yield curve upward sloping. This kind of break-even argument is similar to the one used above, except that now the expected (as opposed to realized) returns are being equalized across bonds.

1.2 Term Premium Hypothesis

According to the expectation hypothesis in its strong form, the long-term bond yield is the average of the expected short-term rates. Though the expectation hypothesis provides a simple and intuitively appealing interpretation of the yield curve, it makes the strong assumption of risk-neutral investors and ignores interest rate risks. Indeed, except if calculated until maturity, the nominal return on a long-term bond is uncertain and investors may require compensation for this risk. What we call *term premium* (TP) or *bond risk premium* (BRP) refers to such compensation and any other sources of deviation from the expectations theory.[1]

The BRP hypothesis makes the opposite extreme statement of the expectation hypothesis: an upward-sloping yield curve only reflects required compensation for bearing duration risk and does not contain any information at all about market's rate expectations.
In the term premium hypothesis, long-term bonds earn a positive risk premium as a compensation for their return volatility. The demand of extra expected returns needed to remunerate for the possibility of a capital loss on selling long-term bond prior to

[1] A weak form of the expectation hypothesis allows for a constant maturity term premium, which nonetheless requires that changes in yield fully reflect changes in expected short rates.

maturity is based on the assumption of risk-averse investors that try to avoid short-term fluctuation in returns.

1.3 Expectation Hypothesis Test

The first test we perform, studies the relation between forward rates and expected future spot rates. If the forwards equals the expected future spot rates, then we expect a strong and positive relation between the forward-spot premium[2] and the subsequent changes in the n-year spot rate over the next period. Likewise the relation between the forward-spot premium and the realized bond risk premium, should be zero.
We can model this statement using the following equation:

$$r_{n;t+x} - r_{n;t} = \alpha_1 + \beta_1 \left(f_{n-x,x;t} - r_{n;t}\right) + \epsilon_{1;t+x} \qquad n = 1,3,5\ ;\ x = 1,...,5 \quad (1.1)$$

For each of the Countries and the spread, we run a simple regression of the subsequent change in the spot rates on the FPS for a maturity of one, three and five years over different forecasting horizons that go form one to five years ahead. Given the value of the adj-R^2 ($\bar{R}^2$) and the significance of the coefficients, the evidence that a value of β_1 greater than zero means that the FPS observed at time t has power to forecast the change in the n-year spot rate x years ahead. In particular, a value close to 1 implies great evidence in favour of the EH.

Italian Case

For the Italian bond market, we can see that the EH has little evidence and can be rejected for each maturity at short forecasting horizons as well as long ones. It seems to be not relevant even for medium horizons.

For the much part of the time Table 1.3 shows insignificant coefficients and correlations closer to 0 than to 1 (even negative sign) and lows $\bar{R}^2$. Anyhow the evidence in favour of the EH increases as the horizon goes up to 3 years and then decreases afterwards. In any case, even at their hikes the coefficients remain far to what the theory predicts and the correlation are small. This means that, for the BTP, forward rates of each maturity 1 to 5 years out seem to have no predictive power whatsoever for changes in the future spot rate 1 and 5 years from now. The situation improves somewhat for forward at 3 years horizons.

[2] Recall the definition of forward spot premium, $FPS_{n,x;t}$, namely the difference between the forward rate of n-year maturity that begins x years in the future and the n-year maturity spot rate $(f_{n-x,x;t} - r_{n;t})$, the first test

Anyhow, we can not conclude that the EH offers a good structure for the Italian bond market.

German Case

Regarding the German bond market, we can argue that the EH can not be rejected light hearted. Instead, we can find evidence that confirm what the theory states. Note that the estimated coefficients from the 1-year spot rate are all greater than 1, except at one year horizon (which anyway is close to the referring value). The other coefficients are close to the unit and still confirm the fact that the forecasting power is stronger at the medium-term horizon, still sustained even at the five years horizon.
The rejection of the null hypothesis happens if we look at very short-term horizon. In fact, we see how, at the one year horizon, the coefficients and the correlations are negative, high p-values and small $\bar{R}^2$.
Compared to Italy, we get values much more positive for the EH with respect to each maturity and to each horizon. That could arise because the risk premium embedded in the Bunds' market is less prevailing than in the BTPs', thus the forwards are a stronger proxy for the change in the spot rates.

BTP - Bund Spread

The reasons of performing a test on the spread between Italy and Germany lie in the willing of decomposing the Italian yield in two basic components: the risk-free rate and the added credit risk. What we want to assess is if the behaviour of the Italian yields is driven more from the German floor or by the spread, and then if the credit risk component can be predicted or if it gains value from the fundamentals of the term structure theory. [3] In order to do so, I performed the same test and I will compare the results with the cases in which the EH worked best within the other Countries.

From the evidence presented in Table 1.5 we can barely see any proof in favour of the EH. In general, all the results show negative coefficients and negative or zero correlation. There are few cases in the 3 and 5 year maturity rates at long forecasting horizon, where the numbers look in line with the theory. This mixed face and a graphical analysis of the time series help to understand that those numbers are more a statistical output than a logical implication of the variables.

[3] For a detailed study about the relation between the intra-EMU spread and fundamental analysis see Di Cesrare A., Grande G., Manna M. and Taboga M., *"Recent estimates of sovereign risk premia for euro-area countries"*, Banca d'Italia, 2012

1.3.1 Term Premium Hypothesis Test

If the forward rate are optimal predictors of near-term expected returns we expect a strong and positive relation between the forward-spot premium and the realized one period (here one year) return of a n-year bond in excess of the one-year bond. Likewise the relation between the forward–spot premium and the change in the n-year spot rate should be zero.
As in previous test, we can implement a regression model following the equation:

$$HPR_{n;t+1} - r_{1;t} = \alpha_2 + \beta_2 \left(f_{1,n-1;t} - r_{1;t}\right) + \epsilon_{2;t+1} \qquad n = 2, ..., 6 \; ; \tag{1.2}$$

For each of the Countries and the spread, we will run simple regressions of the realized one year excess returns of a long-term bond, with a maturity going from two to six years, over the one-year bond on the FPS of one-year maturity and n-1 years ahead. Given the value of the adj-R^2 ($\bar{R}^2$) and the significance of the coefficient, the evidence that a value of β_2 greater than zero implies that the FSP observed at time t has the power to forecast excess one-period returns rather than the yield change. In particular, a value close to 1.0 implies that the interest rate are perfect random walks, whereas the EH predicts a value of 0.0 since the forward rates should predict the expected future spot rate and give no signal on the expected risk premium. The results will be reported in summary table and it will be presented a graphical example where the term premium hypothesis works best.

Italian Case

Testing the term premium hypothesis in the Italian market reveals a complete different situation than the EH. Indeed, it is possible to see that all the coefficients are above 1.0, with hikes of 1.8, and all highly significant. The $\bar{R}^2$ is modestly high and the total-sample correlation are in the range of 0.3-0.5. In addition, the best results in term of correlation are in the short-term of forecasting.
This is in line with the recent literature, where the evidence suggests that when forward-spot spreads are viewed as a proxy of near-term expected excess returns, variation in the current spread is mostly variation in the term premia in current one-year expected returns, and forward-spot spreads do not predict yield changes one year ahead.

German Case

As expected, in the Bund's term curve, we obtain the opposite situation of the previous test on the EH. The results in Table 1.7 present a path of coefficients which is

controversial, they goes from slightly above 0.0 and non significant up to a value of 1.2 and highly significant. The $\bar{R}^2$ is poor and, except in one case, below than 10%. Also the total-sample correlation is not very high and gain evidence in longer maturities.
A reasonable explanation is the role assumed by the forward rate. In a market considered riskless, the term premium component is so squeezed that, even across different maturities, it is almost impossible for the model to catch. The forward will, more likely, predict the yield change than the excess returns.
It is relevant that where the term premium hypothesis fails, the expectation has its best results.

BTP - Bund Spread

The results from the regression test on the BTP-Bund spread display a great evidence in favour of the random walk hypothesis. All the coefficients are well above the unit and all highly significative. The $\bar{R}^2$ are the highest in respect to Italy and Germany as well as the whole sample correlation.
Once more, the credit spread represent a pure risk component, thus it is more reasonable to think of it as a source of returns rather than a predictor of future change in yields.

In conclusion of this chapter is possible to state that the empirical evidence between the expectation and the risk premium hypothesis is much more controversial than what might seems from the theory. From our results it's clear that the assumptions hold differently depending on the forecasting horizon and the market we are considering.
In general the EH gains favour when we increase the horizon, reaching its best at the medium term predicting the subsequent change in spot rates three and four years ahead. It's effect is poorer, though, in the very short term, where instead it is shown that the forwards are more able to predict excess returns confirming the fact that the spot rates follow a random walk process as presumed by the term premium hypothesis.
In addition, there is a big difference in the evidence from the two European markets. The EH works much better in the Germany and fares not too well in the Italian one.

Chapter 2

Estimating ex-ante Term Premium

After we showed that it is impossible to make extreme assumptions and it is not trivial to decide empirically which has a larger influence on the yield curve's shape, our next step is an attempt to disentangle the two forces from forward rates, subtracting the rate expectation component and estimating the ex-ante term premium.

In this section I carry out an analysis on the Italian and German Government bonds, adding the U.S. Treasury market as a reference for the results and for comparison with previous literature. The sample period starts in January 2000 until the last data available in 2016.

For the purpose, I add three different measures that can proxy required ex-ante term premium and, exploiting their financial meaning, it is possible to analyse their relation with realized excess returns and subsequent yield change.

First of all, I introduce the slope or the steepness of the yield curve is the simplest and most popular proxy for the ex-ante risk premium, but still it is a too noisy measure reflecting both market's expectation of future rate changes and bond risk premium. Then, I come back to a statistical model found by Cochrane-Piazzesi (2005). They constructed a predictor loosely related to the yield curvature. They regress subsequent realized bond returns on a sequence of constant maturity forward rates and find that across maturities all bond returns seem to be predicted by the same single forecasting factor. Finally, I use the survey data, i.e. consensus forecast of future interest rates, which is the most direct and model-free way to assess the market's expectations. Simply subtracting this values from the current long-term yields should give a plausible estimate of the bond risk premuim.

2.1 Cochrane-Piazzesi Term Premium

Cochrane and Piazzesi (2005) find an even better predictor of future bond returns than the YC's slope, loosely related to yield curve curvature. They run regressions of 1-year realized excess returns on five 1-year forward rates and find that across maturities all bond returns seem to be predicted by the same single return-forecasting factor, which we can call "CP Factor", that is a single linear combination of forward rates describing time variation evidence in expected returns. Most important, they find that the same linear combination of forwards predicts bond returns at all maturities, where Fama and Bliss, and Campbell and Shiller, related each bond's expected excess return to a different forward spread or yield spread.

Italian Case

From the Table 2.5, we can see that all the coefficients are all positive and highly significant, increasing with maturity as one could expect. The top value is around 1.5 for the excess return of the 5-year bond. From the previous test the $\bar{R}^2$ is stable between 0.3 and 0.4. The correlations, instead, are improved ranging between 0.5 and 0.6.

German Case

Like the Italian case, the German bond market presents all positive and highly significant coefficients, which increase with maturity. Again the $\bar{R}^2$ is not improved much from the previous test and weaker than Italy. Same story for correlations.

2.2 Survey-Based Term Premium

Estimating term premia is a challenging task because the premia and their expectation counterparts are unobservable. One way to overcome these empirical problems is to incorporate additional information into the estimation procedure. For the purpose we can use survey data from economists' long-term forecast to estimate the components of bond yields and identify the causes of changes in yields. The underlying idea is that surveys about forecasts of financial market participants are a valid proxy for the market's expectations implicit in the term structure when the survey is conducted.

Using survey data of long-term forecast, we can decompose the long-term yields into the sum of expectations of future inflation and expectations of future real returns. If we add also the economists' long-term forecasts of the short-term money market rate, we could further decompose the real return into expectations of real short-term interest rates and a risk premium for investing in the long-term bond rather than short-term one.

$$YLD_{10;t} = E_t\left[INF_{10}\right] + E_t\left[RealTBILL_{10}\right] + E_t\left[BRP_{10}\right] \qquad (2.1)$$

Since we are interested in estimating the term premium for European Countries such as Italy and Germany, we has to refer to the survey data provided by the Consensus Forecast. Other survey providers, principally the Blue Chip, focus only on the U.S. economy and lack data for the rest of the economies. Then, we want to look at the analysis of long-term market's expectations and long-term risk premium, thus we will take as reference the long-term forecasts for the variables that mostly drive the yield curve, the real GDP growth rate and the inflation rate. In Figure **??** I plotted the time series of forecasted average between 5 and 10 years of these two variables since the year 2000 until the most recent publishing in April 2016.

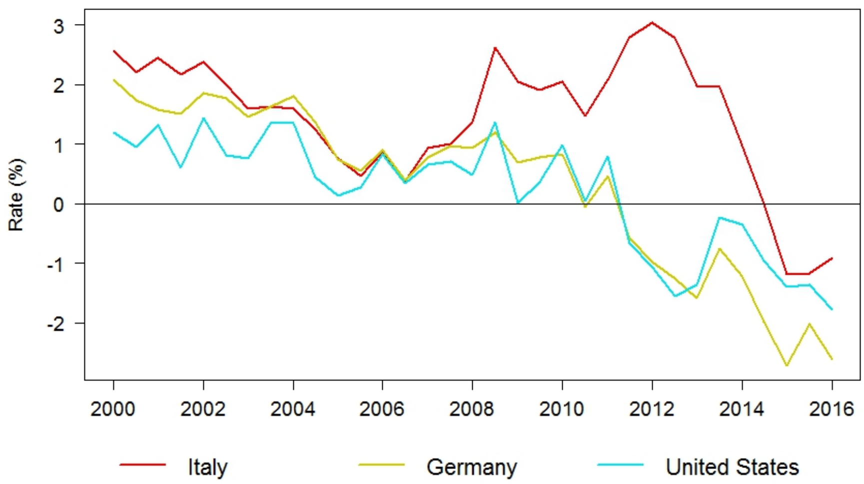
We can run the regression of the distant-horizon short-term interest rate forecasts on the forecasted GDP and inflation.

It is possible to use the estimate of these coefficients, imposing the Fisher hypothesis restriction[1], to obtain prediction form Consensus Forecasts of a synthetic proxy of the average 3-month interest rate at five-to-ten horizon for the international data. Subtracting this value from the long-term forward rate, that account as the market's expectation on future short-term interest rates, gives rise to the Bond Risk Premium based on survey data "S-BRP".

$$S - BRP_{5-10yr} = f_{5,5;t} - (\,\hat{\beta}_0 + E_t\,[\,avg.\pi^{CF}_{5-10yr}\,] + \hat{\beta}_Y E_t\,[\,avg.Y^{CF}_{5-10yr}\,]\,) \qquad (2.2)$$

Using the survey data from the Consensus Forecast for a sample period that goes from April 2000 to April 2016 and the long-term 5-year forward 5 years ahead, we can derive the S-BRP implied by the survey for the three Countries.

Figure 2.1: Expected S-BRP over 5-to10 Years - Time Series



[1] Thus imposing $\beta_\pi = 1$.

Chapter 3

Inflation Uncertainty and Term Premium

After having tried to estimate, with different techniques, measures of bond risk premium, a natural step further is to investigate the drivers of this premium in order to understand its behaviour and development through the years.

The aim of this section is to provide empirical evidence on the relationship between longer-run inflation uncertainty and the term premium on nominal bonds. If there is a positive relationship indeed, then a decrease in long-run inflation uncertainty would naturally lead to a lower and more stable term premium facilitating the monetary policy transmission mechanism.

3.1 Inflation Risk Premium

Inflation risk premia arise from the fact that investors holding nominal assets are exposed to unanticipated changes in inflation. In other words, the real pay-off, which is what investors ultimately care about, from holding a nominal asset over some period of time depends on how inflation evolves over that period. So that, investors will require a premium to compensate them for the risk associated with inflation fluctuations that they are unable to forecast.

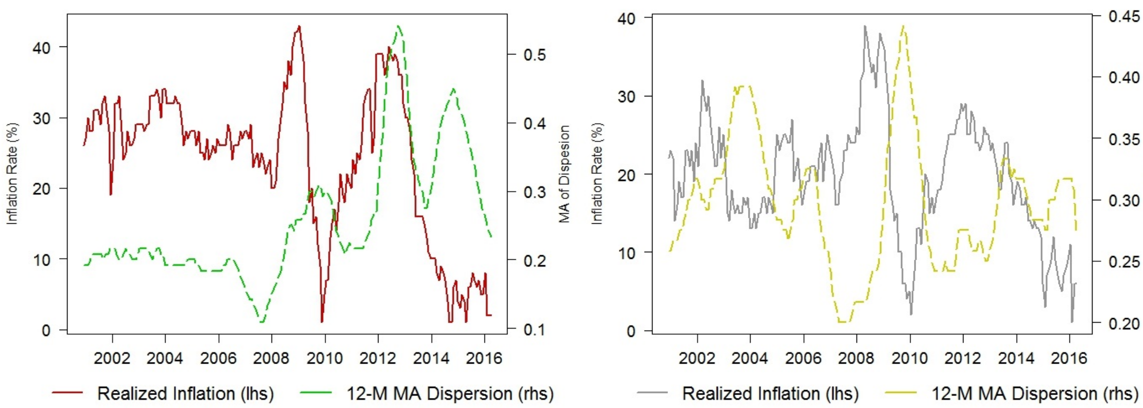
As we want to assess the relation between the BRP and a level-dependent inflation uncertainty, we now move to the construction of three different proxy of inflation uncertainty. These measures are based on the consensus responses in survey data and each of them accounts for a different perspective of uncertainty, the standard deviation of the probability function of future inflation given by survey respondents, a measure of the width of the aggregate distribution of respondents' forecasts through the time and a measure of the instability through the time of the consensus mean.

3.2 Level of Inflation and Inflation Uncertainty

Low inflation tends to be stable inflation, mainly because economies with high inflation tend to get rid of nominal rigidities, and so shocks affect more the prices than the output gap. We can search for some evidence from our dataset of survey-based measures of inflation uncertainty and the realized inflation in Italy and Germany.

First, we can plot the time series of the realized inflation and the monthly dispersion measure of IRP, i.e. the standard deviation of survey forecast. This measure does not work really good, in fact It is easy to see that the correlation between the time series is all but 1-1 .

Figure 3.1: Realized inflation vs Forecast Dispersion



Another break down point is between the years 2014-2015 where the inflation went down but the uncertainty increased.

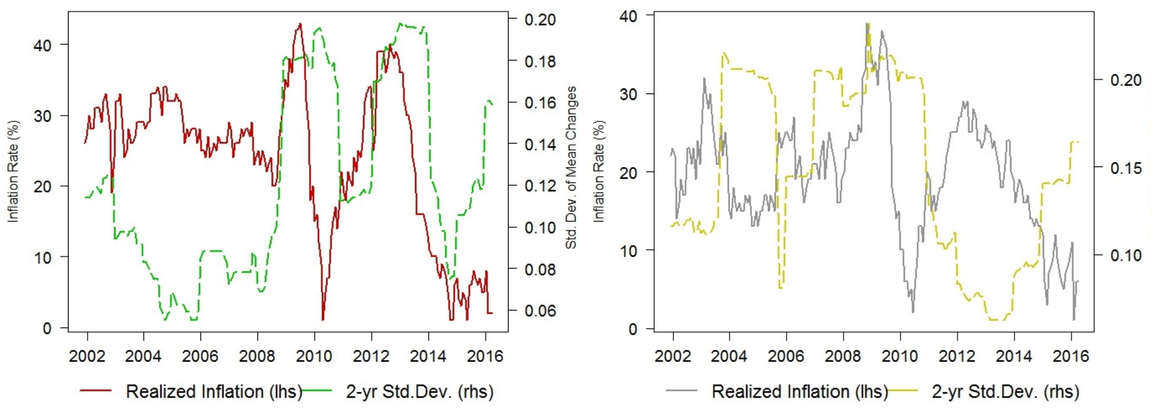
In turns we can represent the time series of the realized inflation and the other proxy measure of IRP, i.e. the monthly change in the mean of the forecasts. Graphically the correlation between the time series has improved, and the IRP follow much better the level of inflation, even if still not 1-1.

There are not great discrepancies, except the value in the year 2004-2006 for both Countries, yet it is interesting to note the same tendency of decoupling of the trend in the near past. Thus, even taking the uncertainty through-the-time and not based on the width of the distribution, when inflation reaches very low levels, the relation with uncertainty became empirically negative.

3.3 Inflation Uncertainty and Term Premium

Although estimates of BRP and measure of inflation uncertainty are of interest in their own, it is certainly more important to study the relation between the two. Indeed there

Figure 3.2: Realized inflation vs Forecast Variability



is good reasons to think that BRP could be importantly influenced by the compensation that investors demand for the risk of unexpected inflation, see Piazzesi-Schneider (2006).

To investigate this possibility empirically, we can run panel data regressions of term premia on the different inflation risk measures in the form that follows:

$$S - BRP_{5-10yr;t} = a_1 + \boldsymbol{\beta}\, \boldsymbol{x_t} + \epsilon_t \tag{3.1}$$

with S-BRP the term premium based on survey data estimated with Wright model, a_1 a Country specific fixed effect and $\boldsymbol{x_t}$ a vector of inflation risk measures as constructed before.

I run both simple and multivariate regressions, plus a general correlation of the term premium based on survey data with the constructed proxy of IRP. From the value of the correlations we can already have an idea of the positive relation that links the BRP to the IRP confirming the existent literature. Indeed both measures for both Countries show positive and relatively high values, especially the measures of volatility that has a correlation of 0.75 in Italy and 0.61 in Germany. As for the regression, the results are confirmed again. In general the stronger variable is "volatility" which has higher coefficients and higher $\bar{R}^2$. Moreover it is the only significant regressor in the multivariate test. "Dispersion", despite positive coefficients in the multivariate test, it is not significantly different from zero and in Germany shows a negative coefficient in the simple regression. Aside from problems with our limited dataset and relative small sample, a possible explanation for this evidence is that the market is more sensible to the change in the overall mean of expected inflation than to the width of the distribution and its tails. Nevertheless we can confirm that the inflation risk premium accounts for a big share of the required Bond Risk Premium.

3.4 Inflation Risk Premium Outlook

Looking carefully to our past, deflation (more than inflation) has played a central role in the worst economic meltdowns. Well anchored inflation expectations have kept IRP negligible for a decade, but the situation may change from the second half 2010s. In fact, in last year the ECB started his first QE due to a substantial decrease in inflation expectation, with the aim to boost inflation to its target over the medium term and to help the recovery providing new liquidity and lower interest rates. Deflation is clearly an economic tail risk with consequences as standalone risk (hurting all nominal assets except nominal bonds) and because of its covariance with other tail risks. In addition, deflation represents a more fearful equilibrium than hyperinflation because it is more sticky and monetary policy could not be enough (see Japan in last twenty years).

Speaking about Government bonds, deflation risk can be associated with credit risk because of the increasing difficulties of a sustainable debt, thus we can expect investors will require higher compensation for bonds that are perceived more risky and lower compensation or even losses (negative yields) for what is perceived safer.
With the available instruments we can try to test empirically this intuition. We have seen how uncertainty of expected inflation increased as the level of inflation went close to zero, so it is possible to ask if there is a segmentation in the markets in which the mean of the forecasts is not representative any more because some of the agents will predict rising inflation, while the other still periods of inflation zero. In this scenario became crucial not the mean of the forecast but the distributions. From the ECB's SPF we take as a proxy of expected deflation the left-side tail of the distribution in next-year inflation forecast, i.e. the sum of frequencies in the buckets related to a level of inflation equal or smaller than zero. We can measure the correlation with the S-BRP for Italy and Germany over a sample period from 2000 to 2016. As results I got a positive correlation of 0.26 in Italy and -0.47 in Germany. This means that for a bigger percentage of investors predicting deflation or inflation zero in the future (the heavier is the left-side of the distribution), higher term premium will be required to hold long-term Italian bonds, while lower one will be required for German bonds. One explanation is that deflation risk (and possible default risk) are priced differently between the two Countries, and that in worse European conditions the Bund will hold its value while the BTP will be more risky.

All summed up, these results provide support to the view that the risks in of severe macroeconomic shocks in which deflation or inflation zero occurs is closely related to tail risks in financial markets, such collateral revaluation risk, business cycle risk and, mostly in our case, sovereign default risk. However, inflation or disinflation dynamics are perceived in different ways by investors which react in other different manners, thus an analysis between tail risks and financial markets requires further investigation and attention. For us, at this moment, remains in general an open-handed question.

Conclusions

First I presented the main theories that drive the yield curve and tested them on the updated data of Italian and German Government bonds over a sample period from 2000 to 2016. From the results it became clear that the hypothesis regarding constant or zero term premium has to be rejected. Anyway in economies with stable inflation over the long-run, the Expectation Hypothesis has its upsides and the forward rates can forecast better than in other economies the future change in spot rates, especially in a long-term forecasting horizon. That is because with stable inflation, the required premium for holding long-term bonds is lower and the expectations on future short-term interest rates are more prominent.

After the finding of time-varying risk premia, I focused on disentangling the ex-ante bond risk premium from the expectations component, borrowing the practices of market's participants and academics. Firstly I used the yield curve steepness but I found it still a too noisy proxy of BRP. Then I used an econometric model exploiting the predictive ability of a linear combination of forward rates finding much better results than using a single forward rate. Finally I analysed in depth the more direct approach of using surveys from agents and market's participants. I overcame some difficulties in finding available data for the Eurozone Countries applying the model proposed by Wright (2008).

In the last section I questioned the data about the drivers of ex-ante risk premium. I constructed proxy measures of inflation uncertainty and tested their correlation with the estimates of term premium. I found the BRP mainly driven from inflation and level-dependent inflation uncertainty. Most of all I found that when inflation level goes in a range close to zero or in deflation area, the uncertainty, instead of being zero as well, increases revealing a segmented market in which some agents forecast a new period of higher inflation while others are insuring themselves against deflation tail risk by the protracted purchase of riskless assets even with deeply negative yields.