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FINANCIAL ECONOMICS | RESEARCH ARTICLE

A contribution to the study of the German treasury bills market

Emanuel R. Leao^{1*} and Sergio C. Lagoa¹

Abstract: We study the yields in the German treasury bills market. We take a detailed look at the yield banks require to buy treasury bills in the primary market, and we also examine the yield households and nonbank firms demand to buy these bills in the secondary market. We use data from real world tenders to show that the bids set by banks are in accordance with the predictions of our theoretical framework. In particular, we show that current monetary policy and the market's expectations regarding the future path of monetary policy can be used to define an interval in which the bids from banks lie. Our theoretical predictions for the secondary market also match the data.

Subjects: Economics, Finance, Business & Industry; Macroeconomics; Monetary Economics

Keywords: treasury bills; interest rates; monetary policy; interbank loans market

AMS subject classifications: E43; E52; G12; H63

1. Introduction

German Treasury Bonds are generally considered to be one of the least risky assets available in the market. They are therefore a benchmark against which most other investments are compared. In particular, investors compare the expected rate of return on a given risky investment to what they would obtain if they bought Germany Treasury Bonds instead.

In this paper, we look at the determinants of the interest rate on German Treasury Bills, studying in great detail the linkages between this interest rate, interbank interest rates and current and future monetary policy.

The issuing of government bonds in the primary market has been widely studied. Several authors have examined the relation between the federal funds (FF) interest rate and the T-Bills interest rate in the US. These two variables are linked by the expectations hypothesis, with the T-Bills rate being

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PUBLIC INTEREST STATEMENT

We study the prices and yields in the German treasury bills market. First, we examine how banks behave when they go to a tender to buy government bills (the price they are willing to pay and the implied yield). Second, we analyse the behaviour of households and nonbank firms when they go to a bank to buy government bills (the price they are willing to pay and the implied yield). We show that, in both cases, the behaviour is rational in the sense that the prices they in fact are willing to pay are similar to the prices we would rationally expect given the economic fundamentals prevailing at the moment when the purchase occurs.

equal to the expected FF rate up to the maturity of the T-Bills plus a risk premium (Sarno & Thornton, 2002). The study by Cook and Hahn (1989) was one of the first to find that the FF rate had a strong effect on T-Bills interest rates in the 1974–79 period. Using a larger sample covering for the 1974–99 period, Sarno and Thornton (2002) found a long-run relation between these two rates, which remains stable across different monetary policy regimes. Elder (2001) found that positive shocks to the FF rate increase T-Bills rates but also lead to an increase in the volatility of T-Bills prices. However, the author does not find a relation between the volatility of the FF rate and the risk premiums of T-Bills' returns.

Even though there is an extensive evidence of the FF rate's effect on T-Bills rates, there is a little empirical support for the expectation hypothesis applied to T-Bills. Guidolin and Thornton (2008) argue that the failure of the expectation hypothesis is caused by investors' inability to correctly predict short-term rates.

Apart from policy rates, the literature has studied other factors that affect T-Bills rates. Wingenber (2011) shows that unexpected changes in the FF rate have a significant effect on risk premiums, and that the impact is different for changes made at scheduled or unscheduled FOMC meetings. Fleming (2002) looks at the relation between the size of treasury bond issues in the US and their liquidity. Amihud and Mendelson (1991) empirically show that, as expected, yields are smaller for bills with higher liquidity. Anderson (1997) uses error correction models to study how transaction costs affect yield movements in the primary US treasury bill market. Duffee (1996) studies segmentation in the US treasury bill market. Cammack (1991) compares T-Bills auction prices with contemporaneous secondary market prices in the US to assess the amount of imperfect information that is present in the market. Balduzzi, Elton and Green (2001) examine how the price of government bonds reacts to scheduled releases of macroeconomic news in the US. Garbade and Ingber (2005) study how recent advances in communications and information-processing technologies have affected the way in which auctions are carried out and prices. Carson (1959), Brimmer (1962), Bolten (1973), Boatler (1975) and Smith (1996), among others, discuss the treasury bill auction procedures in the US with the goal of determining which procedure would maximize government revenues. Nyborg, Rydqvist and Sundaresan (2002) examine how the bidders' behaviour is affected by increased uncertainty at the time of bidding in Swedish treasury bond auctions.

In this paper, we focus on the issuing of Treasury Bills (T-Bills) by the German government, making two contributions to the literature.

First, we explore the relation between the T-Bills interest rate, interbank interest rates and ECB monetary policy. Under normal circumstances, when banks go to an auction where the government is to issue short-term bonds¹, they require a similar yield to the return they could obtain by lending to other banks in the interbank loans market for the same maturity. This is because in normal times (i.e. outside crisis periods), banks regard both investments as relatively safe. In this paper, we try to make a more precise estimate of the yields banks require in order to buy short-term German T-Bills in the primary market. We do this by considering the whole spectrum of maturities available in the interbank loans market and the way monetary policy affects interbank interest rates.

Using the days when treasury bill auctions actually took place, we compared the interest rates that banks set in their bids to the rate our framework would predict. To do so, we used *Bundesbank* data on six-month treasury bills auctions and data on interbank loan rates. In all cases, the average yield set by banks in the auctions conforms to what our theory predicted.

A second contribution of this paper is to examine the secondary market for German T-Bills and the way the interest rate is determined in this market.

The structure of the article is as follows. Section 2 reviews some basic notions about the valuation of financial assets. In Section 3, we look at the rationale behind banks' decisions on the yield they

require to be willing to buy German T-Bills in the primary market. Section 4 examines the yield that households and nonbank firms demand to buy treasury bills in the secondary market. Section 5 concludes.

2. General principles

As mentioned above, in this paper, we address two questions: (I) how do banks decide the yield they require to be willing to buy German T-Bills in the primary market (i.e. in the auctions where the German government first issues the T-Bills); and (II) how do households decide the yield they require to be willing to buy German T-Bills in the secondary market (i. e., when they go to a bank to purchase these bills).

Before going to the specifics of the two cases, let us recall that, in general, economic agents decide on the average rate of return they require to buy a certain security based on the following principle.

Each security has certain characteristics related to liquidity, market risk and default risk. By liquidity, we mean the average time and transaction costs involved in selling the security. By market risk, we mean the risk that the price of the security could be low if we suddenly needed to sell. By default risk, we mean the risk that the issuer of the security may not deliver the payouts.

If, after comparing the liquidity and risk characteristics of two securities (A and B), a certain economic agent decides he/she prefers security A to security B, then he/she will only be willing to buy security B if the expected rate of return of B is higher. In other words, if:

$$\text{Expected rate of return of B} = \text{Expected rate of return of A} + \text{RLP}$$

where RLP denotes a risk and liquidity premium.

3. Primary market: the yield banks require to be willing to buy government bills

Our main goal in this section is to devise a framework to explain the yield banks require to be willing to buy German government bills in the primary market. As an example, we will look at bonds with face value €10, zero coupon rate and maturity within six months. The German government announces today the issuance of 50,000 bonds with these characteristics. A tender is organized in which each bank makes a bid, i.e. it indicates the number of bonds it would like to buy and the price it would be willing to pay for each bond. The German government then decides which bids it wants to accept (it may end up selling less than the 50,000 bonds originally announced).

To determine the price they will set in their bids – i.e. the price they are willing to pay for each bond with those characteristics – banks follow three steps:

Step 1 Estimation of the pay-offs that the bond entitles its owner to receive;

Step 2 Computation of the rate of return it makes sense to require in order to be willing to buy the bond (taking into account its risk and liquidity characteristics);

Step 3 Combine steps 1 and 2 to obtain the price.

Note that the answer to Step 2 corresponds to what we are looking for in this section of the paper.

Let us then follow the three steps.

3.1. Step 1. Estimate of pay-offs

In Step 1, banks make an estimate of the payments that the bond entitles them to receive. Since these are zero-coupon bonds, they only entitle their owner to receive the face value (€10) at maturity (see Figure 1):

Figure 1. Expected pay-offs of the T-Bill.



3.2. Step 2. Compute the expected annual rate of return banks require

In order to decide the average rate of return they require to buy the bonds, banks will compare the bonds' liquidity and risk characteristics with the liquidity and risk characteristics of alternative high liquidity/low risk investments for which they already know the rate of return. These alternative investments are:

- (a) A six-month loan in the interbank market. In this case:
 - the liquidity of the application is zero (the funds lent will only be recovered at maturity);
 - market risk is zero (in a loan to another bank, the amount and interest rate involved are set at the beginning and so the amount paid out at the end is known from the outset);
 - default risk is low if the investment horizon is only a few months (if a bank is near bankruptcy, we can usually see several months before that this is imminent).
- (b) A succession of overnight loans in the interbank market during the next six months. In this case:
 - liquidity is high because these are overnight loans;
 - market risk is low, because the overnight interbank rate is linked to the central bank interest rate which normally changes smoothly over time;
 - default risk is low because a normal bank does not go bankrupt from one day to the next.
- (c) Making deposits in the overnight deposit facility of the central bank – which is possible at least in the case of the ECB – during the next six months. In this case:
 - liquidity is high because these are overnight deposits;
 - market risk is low, because the central bank normally changes its interest rates smoothly over time;
 - default risk is low – almost zero – because if necessary, the central bank can print money to pay its debts (the only limit would be the fear of causing inflation through excessive money printing).

The rates of return of alternatives (a), (b) and (c) all stem from present and expected central bank interest rates.

We next describe the risk and liquidity characteristics of the German T-Bills we are studying:

- liquidity is high because T-Bills can normally be sold to a bank without much difficulty or cost;
- market risk is low because, if we want to sell before maturity, the amount a bank will pay us depends on the alternative application available to this bank for the same funds, i.e. making an interbank loan with the same maturity. The interest rate on this interbank loan fluctuates very little because it originates from the central bank repo rate which usually evolves in a

stable manner. As a result, it is easy to predict with only small errors the amount one can expect to obtain from selling the T-Bill at any date before maturity, i. e. market risk is low;

- default risk is low because the issuer is the German government.

We are now in a good position to compare the risk and liquidity characteristics of the T-Bills with the risk and liquidity characteristics of alternatives (a), (b) and (c)². In practice, alternative (c) is ignored because it has a much lower rate of return than (a) and (b)—and so banks would not really consider it.

We therefore proceed by first comparing the risk and liquidity characteristics of the T-Bills with those of alternative (a). In terms of risk of default, they are similar (very low). Their market risk is also similar (if held to maturity, the T-Bills have no market risk, and loans to another bank also have no market risk). However, there is a big difference in liquidity: T-Bills are very liquid, whereas loans to other banks for six months are not liquid at all. This makes it preferable to buy six-month T-Bills – i.e. lending to the German government for six months—as opposed to lending to other banks for six months. As a consequence, banks will require a lower rate of return for buying the six-month T-Bills than the six-month rate available in the interbank money market (IMM). Mathematically:

$$R_{6M}^{T-Bills} < R_{6M}^{IMM} \quad (1)$$

Secondly, we compare the risk and liquidity features of the T-Bills with the risk and liquidity characteristics of alternative (b). The default risk is very similar and both are very liquid. The major difference lies in the market risk. If we hold the T-Bills to maturity, we will receive the face value; if, on the other hand, we opt for a succession of loans in the overnight interbank market for six months, there is no guarantee of how much we will receive (because the central bank may unexpectedly lower its key rates in the middle of the six months, thereby making the interbank overnight rate drop). As a consequence, banks will demand a lower rate of return for buying the T-Bills than the rate they would receive by making successive loans in the overnight interbank market for six months. Mathematically:

$$R_{6M}^{T-Bills} < \text{average of overnight interbank interest rates expected over the next 6 months} \quad (2)$$

The problem with this equation is that the ‘average of the overnight interbank interest rates expected over the next six months’ cannot be directly observed as it is an expectation. To overcome this weakness, we will try to obtain an equation that relates the rate of return banks want on the T-Bills to today’s overnight interbank interest rate (a value that can be observed). To do this, we need to make assumptions about the banks’ expectations of monetary policy during the next six months.

3.2.1. Scenario A. Banks expect the central bank to keep its reference rates unchanged for the next six months

As we know, the interbank overnight interest rate tends to be very close to the main policy rate of the central bank. So, if banks expect the central bank rate to remain unchanged over the next six months, then the average of the overnight interbank rates expected for the next six months will be roughly equal to today’s interbank overnight rate, i.e.

$$R_{o/n}^{IMM} = \text{average of overnight interbank interest rates expected over the next 6 months} \quad (3)$$

Combining Equation (3) with Equation (2), we conclude that under Scenario A:

$$R_{6M}^{T-Bills} < R_{o/n}^{IMM} \quad (4)$$

3.2.2. Scenario B. Banks expect the central bank to lower its reference rates during the next six months

If banks expect the central bank to reduce its reference rates over the next six months, then the average of the overnight interbank rates expected for the next six months will be less than today’s overnight interbank rate, i.e.

$$R_{o/n}^{IMM} > \text{average of overnight interbank interest rates expected over the next 6 months} \quad (5)$$

Combining Equation (5) with Equation (2), we conclude that under Scenario B:

$$R_{6M}^{T-Bills} < R_{o/n}^{IMM} \quad (6)$$

3.2.3. Scenario C. Banks expect the central bank to increase its reference rates during the next six months

If banks expect the central bank to increase its reference rates over the next six months, then the average of the overnight interbank rates expected for the next six months will be higher than today's interbank overnight rate, i.e.

$$R_{o/n}^{IMM} < \text{average of overnight interbank interest rates expected over the next 6 months} \quad (7)$$

The Equations (7) and (2) do not allow us to reach any conclusion about the relationship between $R_{6M}^{T-Bills}$ and $R_{o/n}^{IMM}$. However, note that in a world without uncertainty, the only advantage of the six-month T-Bills over a succession of interbank overnight loans would evaporate (in a world with 100% certainty, banks could compute with certainty the amount they would receive by investing successively in the overnight market for six months). So in a world with 100% certainty, instead of Equation (2), we would have:

$$R_{6M}^{T-Bills} = \text{average of overnight interbank interest rates expected over the next 6 months} \quad (8)$$

Combining Equation (7) with Equation (8), we would obtain the following relation between $R_{6M}^{T-Bills}$ and $R_{o/n}^{IMM}$:

$$R_{6M}^{T-Bills} > R_{o/n}^{IMM} \quad (9)$$

Thus, under Scenario C, all we can say is: if the uncertainty surrounding economic developments in the next six months is low, then Equation (9) probably holds. The more uncertain the environment in the next six months is, the more likely it is that this inequality '>' will switch to '<'.

3.2.4. Real world examples

Let us now look at some of the auctions that actually took place and see if the rate asked by the banks conforms to what our reasoning would predict. In what follows, the data on six-month 'Bubills'—Treasury Bills of the Federal Republic of Germany—were kindly supplied by the Bundesbank. The interbank overnight and six-month interest rates were obtained from the site www.global-rates.com.

Example 1: Markets expecting a decrease in central bank rates over the next six months

As a first example, consider the auction made by the German government in July 2001.

During July 2001, the average value of the six-month Euribor rate (six-month interbank rate) was 4.387%. Equation (1) tells us that:

$$R_{6M}^{T-Bills} < R_{6M}^{IMM} \Leftrightarrow R_{6M}^{T-Bills} < 4.387\% \quad (10)$$

Between 6 October 2000 and 6 June 2003, the ECB lowered interest rates several times. So, it can be argued that in July 2001, we were under Scenario B (markets expecting a decrease in central bank rates³). Equation (6) therefore tells us that banks will set their bids, so that:

$$R_{6M}^{T-Bills} < R_{o/n}^{IMM}$$

Given that the average Eonia (interbank overnight rate) in July 2001 was 4.505%, we can write the previous equation as⁴:

$$R_{6M}^{T-Bills} < 4.505\% \quad (11)$$

Combining (10) and (11), we would predict that banks require the following interest rate to be willing to buy the Bubills:

$$R_{6M}^{T-Bills} < 4.387\%$$

In the July 2001 Bubills auction, the average yield was:

$$R_{6M}^{T-Bills} = 4.3\%$$

In short, the actual average yield in the July 2001 Bubills auction conforms to our prediction.

Example 2: Markets expecting unchanged central bank rates over the next six months

Let us now consider the auction made by the German government in October 2004.

During October 2004, the average value of the six-month Euribor rate (six month interbank rate) was 2.191%. Equation (1) tells us that:

$$R_{6M}^{T-Bills} < R_{6M}^{IMM} \Leftrightarrow R_{6M}^{T-Bills} < 2.191\% \quad (12)$$

From 6 June 2003 until 6 December 2005, the ECB kept its reference rates unchanged. So, we may argue that in October 2004, we were under Scenario A (markets expecting no change in central bank rates). Equation (4) then tells us that banks will set their bids, so that:

$$R_{6M}^{T-Bills} < R_{o/n}^{IMM}$$

Since in October 2004 the average Eonia (interbank overnight rate) was 2.111%, we can write the previous equation as:

$$R_{6M}^{T-Bills} < 2.111\% \quad (13)$$

Combining (12) and (13), we would predict that the yield banks require to be willing to buy the Bubills would be:

$$R_{6M}^{T-Bills} < 2.111\%$$

In the October 2004 Bubills auction, the average yield was:

$$R_{6M}^{T-Bills} = 2.069\%$$

In short, the average yield which actually occurred in the October 2004 Bubills auction conforms to what our reasoning would predict.

Example 3: Markets expecting an increase in central bank rates over the next six months

As a final example, let us consider the auction made by the German government in January 2007⁵.

During January 2007, the average value of the six-month Euribor rate (six-month interbank rate) was 3.890%. Equation (1) tells us that

$$R_{6M}^{T-Bills} < R_{6M}^{IMM} \Leftrightarrow R_{6M}^{T-Bills} < 3.890\% \quad (14)$$

From 6 December 2005 until 9 July 2008, the ECB increased interest rates several times. So, it can be argued that in January 2007, we were under Scenario C (markets expecting increases in central bank rates⁶). Equation (9) then tells us that banks will probably set their bids, so that

$$R_{6M}^{T-Bills} > R_{o/n}^{IMM}$$

Given that the average Eonia (interbank overnight rate) in January 2007 was 3.563%, we can write the previous equation as:

$$R_{6M}^{T-Bills} > 3.563\% \tag{15}$$

Combining (14) and (15), we would predict that—to be willing to buy the Bubills—banks require a rate of return satisfying the following condition:

$$3.563\% < R_{6M}^{T-Bills} < 3.890\%$$

In the January 2007 Bubills auction, the average yield was:

$$R_{6M}^{T-Bills} = 3.716\%$$

Once again, the actual average yield in the January 2007 Bubills auction conforms to our prediction.

3.3. Step 3. Combine step 1 and step 2 to obtain the price banks are willing to pay

Combining the expected payment (€10), seen in step 1, with the average rate of return obtained in step 2, we obtain the price banks are willing to pay. In Example 1, using 4.3% as the required rate of return, that price would be:

$$\frac{10}{P^{T-Bills}} = (1 + 0.043)^{6/12} \Leftrightarrow P^{T-Bills} = \frac{10}{(1 + 0.043)^{6/12}} \Leftrightarrow P^{T-Bills} = 9.79$$

Using similar computations, we would arrive at prices for Example 2 and Example 3.

Note that in Step 2 above, we obtained what we were looking for in this section of the article (the yield banks require to be willing to buy the T-Bills).

4. Secondary market: the yield households and nonbank firms require to be willing to buy T-Bills from the banks

When households and nonbank firms go to a bank to buy T-Bills, a similar reasoning can be used to obtain the yield they require (in Step 2).

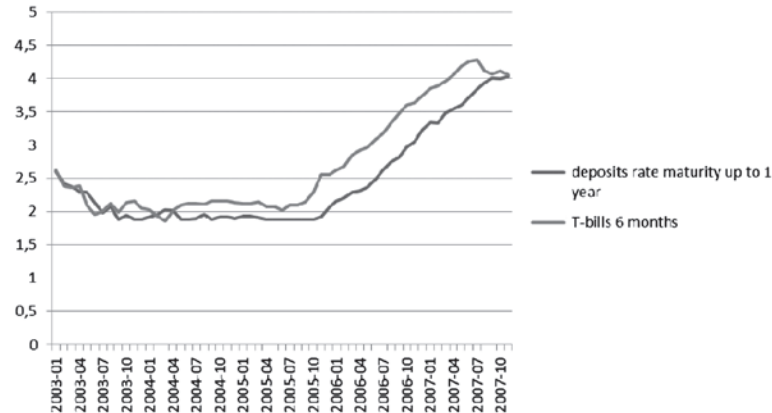
The only difference is that—from the point of view of households and firms—the alternative to buying T-Bills is making saving deposits in banks. This is because households and firms do not have access to the interbank loans market.

The risk and liquidity characteristics of saving deposits in banks are:

- liquidity is high because banks usually raise no objections to the conversion of saving deposits into checkable deposits;
- there is some market risk because if we make this conversion before the dates scheduled for interest payments, we will lose part of the interest;
- default risk is usually small for financially sound banks.

Figure 2. Deposits rate with maturity up to 1-year and 6-months T-Bills yields on the secondary market.

Source: Bundesbank.



On the other hand, as seen above, the risk and liquidity characteristics of the Treasury Bills are:

- liquidity is high because they can easily be sold to a bank;
- market risk is low (the price of T-Bills does not fluctuate greatly);
- default risk is low because the issuer is the German government.

In comparing these two alternative investments, households and firms see as the main difference the fact that if they decide to withdraw a savings deposit before maturity, the amount initially deposited will be received at the least. In the case of T-Bills, if they are sold before maturity, it is possible, although unlikely, that an investor will receive less than the amount initially paid for the bills. This makes households and firms prefer the risk/liquidity combination of savings deposits to that of T-Bills. As a consequence:

$$R_{6M}^{SD} < R_{6M}^{T-Bills} \tag{16}$$

Remember that the interest rate on savings deposits (R_{6M}^{SD}) is closely linked to interbank money rates, which means it is ultimately determined by current and expected central bank rates.

In order to test our prediction, we looked at the German data on deposits rates and T-Bills from January 2003 to November 2007 (this can be considered a period of ‘normality’, since the effects of the Subprime financial crisis were still mild during 2007⁷). We can see in Figure 2 that the inequality (16) was verified, with the T-Bills rate almost always above the deposits rate.

5. Conclusion

This article focused on studying the yield of German Treasury Bills in both the primary and the secondary markets. We devised a framework to predict what interest rate banks should rationally set in their bids when they go to a government bond auction to buy treasury bills. Using data from the German government bond auctions, we were able to correctly predict the range in which the bids were set. The empirical data for the secondary market also seem to match our predictions.

We believe it would be interesting in further research to try to gauge expectations of future monetary policy using surveys of a panel of banks (instead of using the perfect foresight strategy we adopted in this article). It would also be fruitful to examine to what extent our theoretical framework—or an adaptation of it—can be used in nonnormal times (such as the periods since the end of 2007).

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Notes

1. An auction procedure is used to issue Treasury Bills of the German Federal Government ('Bubills') in the primary market. The only institutions allowed to participate directly in the auctions are credit institutions, securities trading firms and securities trading banks that are members of the Bund Issues Auction Group. As of May 2014, these institutions were: ABN AMRO Bank N.V., Banca IMI S.p.A., Banco Bilbao Vizcaya Argentaria S.A., Banco Santander S.A., Bankhaus Lampe KG, Barclays Bank PLC, Bayerische Landesbank, BHF-Bank Aktiengesellschaft, BNP Paribas S.A., Citigroup Global Markets Limited, COMMERZBANK Aktiengesellschaft, Crédit Agricole Corporate and Investment Bank, Credit Suisse Securities (Europe) Limited, Danske Bank A/S, DekaBank Deutsche Girozentrale, DEUTSCHE BANK AKTIENGESELLSCHAFT, DZ BANK AG Deutsche Zentral-Genossenschaftsbank, Goldman Sachs International Bank, HSBC Trinkaus & Burkhardt AG, ING Bank N.V., Jefferies International Limited, J.P. Morgan Securities Ltd., Landesbank Baden-Württemberg, Landesbank Hessen-Thüringen Girozentrale, Merrill Lynch International, Mizuho International plc, Morgan Stanley & Co. International plc, Natixis, Nomura International plc, Norddeutsche Landesbank Girozentrale, Nordea Bank Finland plc, Rabobank International, Scotiabank Europe plc, Société Générale S.A., The Royal Bank of Scotland plc, Niederlassung Frankfurt, UBS Deutschland AG, and UniCredit Bank AG.
2. The purpose of this comparison is to determine the rate of return on the T-Bills that banks will require (before they are willing to buy).
3. The ECB actually decreased rates in August, September and November 2001.
4. The fact that at the time the Euribor was lower than the overnight rate signals that markets were expecting a decrease.
5. The first financial markets' concern about 'US subprime loans' were seen at the end of February 2007.

6. The ECB actually increased rates in March and June 2007.
7. The recession in the US economy started in December 2007, according to the NBER's Business Cycle Dating Committee.

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