INTEREST RATE VOLATILITY AND EXPECTATIONS ABOUT THE BUSINESS CYCLE

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Abstract: One explanation for the usefulness of financial variables as tools for economic forecasting is that they embody the expectations of economic agents about the future state of the economy. In this paper, we test whether interest rate volatility contains information on the expectations of agents which are directly measured by confidence indicators. For the sake of robustness, we use several different expectation indicators for the two countries we analyze, the US and Germany: the Conference Board Consumer Confidence Index, the Philadelphia Fed's Business Outlook Survey and the Purchase Management Index for the US and the Economic Sentiment Indicator, the IFO Business Climate and ZEW Indicator of Economic Sentiment for Germany. We propose using a forward-looking measure of volatility: the implied volatility of one year cap options. We find that implied volatility adds explanatory power to the yield spread and to changes in the short rate, which are typical predictors of the business cycle, and outperform realized volatility.

Keywords: implied volatility, cap options, sentiment indicators, expected growth

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INTEREST RATE VOLATILITY AND EXPECTATIONS ABOUT THE BUSINESS CYCLE

1. Introduction

Assessing the link between financial variables and the expectations of economic agents about the business cycle is an important task. Not in vain is the forward-looking nature of financial markets one of the possible explanations for their role in predicting economic activity. If we could provide evidence that the prices of financial assets embody the expectations of agents about future macroeconomic conditions we would be able to give empirical support to the expectation-based explanation of the leading indicator properties of financial variables.

The difficulty of testing this hypothesis is in making expectations measurable. Most papers on the predictive content of financial markets rely on the rational expectations hypothesis and use ex-post measures of economic growth. On the contrary, in this paper, confidence indicators elaborated from surveys (such as the IFO Business Climate Index or the Conference Board Consumer Confidence Index) are used as direct measures of expectations about macroeconomic growth. These sentiment indicators can be considered good proxies for agent expectations since they are based on surveys in which respondents express their opinion about whether economic conditions are going to improve or worsen.[1]

We test whether some financial variables, particularly, interest rates and their volatilities contain useful information about the expectations of economic agents which are directly measured by confidence indicators. The final objective of this paper is to empirically assess the validity of the expectation-based explanation of the usefulness of these financial variables in anticipating macroeconomic growth.

According to both empirical and theoretical models, there is a link between financial variables and expectations of economic agents. For instance, Harvey (1988) derived a model in which expectations about future consumption growth can be explained by the yield spread, the real short rate and a third term related to interest rate volatility, although he assumed this last factor to be constant in order to obtain a linear model.

[1] Moreover, several papers have provided evidence of the sentiment indexes' predictive power on economic activity (see for example Fuhrer, 1993, Carroll, Fuhrer and Wilcox, 1994; Matsusaka and Sbordone, 1995; Bram and Ludvigson, 1998, Vuchelen, 2004, Ludvigson, 2004, Lemmon and Portniaguina, 2006 and Gelper y Croux, 2010).

Although there is a strand of literature that relates stock returns and stock market volatility to the business cycle, we consider that interest rate variables are much more adequate to capture the expectations of economic agents. Interest rates are without doubt the main financial variables in any economy and the decisions concerning investment and consumption of all economic agents are spectacularly dependent upon them. Moreover, interest rates determine the base from which of all other financial instruments are valued. Moreover, interest rates directly affect the consumption and investment decisions not only of firms but also of households, government, as well as other financial variables such as stock returns, exchange rates, etc…In fact the yield spread and the change in the short interest rate have been shown to be quite consistent predictors of economic growth.

On the other hand, quite recently the literature concerning tools for economic forecasting has focused on the second moment of financial asset returns, and has shown the countercyclical nature of the systematic movements in financial volatility, that is, volatility is higher during harsh times. In particular, Bansal and Zhou (2002), Sun (2005) and Gerlach, Ramaswamy and Scatigna (2006) document the countercyclical behavior of interest rate volatility. Moreover, Andreou, Osborn and Sensier (2000), Annaert, De Ceuster and Valckx (2001), Fornari and Mele (2009) and Chauvet, Senyuz and Yoldas (2012) have shown its leading indicator properties.

One possible explanation of the predictive content of interest rate volatility about future economic conditions is that volatility can reflect the uncertainty of investors with regard to the economic situation. Since uncertainty is higher when the economy is expected to become weaker, the relation between interest rate volatility and agent expectations of economic growth is likely to be negative.

All the papers mentioned above use historical volatility. One of the purposes of this paper is to explore whether an alternative measure of volatility, the implied volatility of cap contracts, provides a better measure of uncertainty than realized volatility. The reasoning behind such a hypothesis is that caps implied volatility can be considered as a forward-looking measure of the volatility of interest rates, a measure of *ex-ante* economic and financial uncertainty, so it is likely to be a more appropriate variable to explain and capture expectations than realized

volatility, which mainly accounts for the past behavior of interest rates[2]. Cap option implied volatility has another advantage: it is an observable variable, since caps are quoted in terms of implied volatilities[3].

Hence, in this paper, we test whether implied volatility contains additional information on agent expectations about future economic activity (measured by confidence indicators) which is not contained in interest rates, in particular, the yield spread and the change of the short rate, which are typical predictors of economic growth. We also compare the explicative content of implied volatility with that of historical volatility.

For the sake of robustness, we use several different expectation indicators for the two countries we analyze, the US and Germany: the Conference Board Consumer Confidence Index (CCI), the Philadelphia Fed's Business Outlook Survey (BOS) and the Purchase Management Index (PMI) for the US and the Economic Sentiment Indicator (ESI), the IFO Business Climate and ZEW Indicator of Economic Sentiment for Germany. We use data ranging from February 1995 to August 2012 and split the series into two sub-periods, before the eruption of the crisis and afterwards, in order to assess the stability of the results.

In a sense, this paper can be understood as a way of analyzing the determinants of confidence indexes and hence, our research discusses if confidence is boosted by low interest rates and low uncertainty. In this regard, it is important to highlight that since all these indexes are released during the second fortnight of the month, we construct the explanatory variables of the model as the average of the daily data only of the first fortnight of the month, consistent with the period of collection of the survey data.

In short, to the best of our knowledge, this is the first paper that tests the explanatory power of interest rate volatility on agent expectations. One of the contributions of this article is the use

[2] In fact, according to Annaert *et al*. (2001) "the most forward looking volatility estimate is the implied volatility from options" (p. 8), but they don't test its forecast performing because of the lack of a long enough series.

[3] Caps are interest rate derivatives consisting of concatenated caplets with the same strike. A caplet can be defined as an option on a forward rate agreement. So it generates a cash flow on maturity if a reference interest rate (mainly LIBOR or Euribor) is greater than the strike of the caplet. Hence, in the case of a cap, cash flows are generated periodically up to the maturity of the cap as long as the reference index is greater than the cap strike. Quotations of caps are given in terms of implied volatilities in a similar way that bond quotes can be given in terms of yields instead of prices. Cap prices are then recovered applying the well-known Black's formula. See, for instance Díaz, Meneu and Navarro (2009) for a short review of caplets and the Libor Market Model which is used to obtain the cap price from volatility.

of direct measurements of these expectations, since we employ survey-based sentiment indicators. On the other hand, regarding interest rate volatility, most papers first need to deal with the problem of its estimation since it is a non-observable variable. However, in this study we use implied volatilities from the cap (floor) market which can be directly obtained from the market, and besides can be considered a forward-looking measure of interest rate volatility, which is very relevant to capture expectations.

In Ferreira, Martínez, Navarro and Rubio (2008), we provided evidence that yield spreads were able to explain the Economic Sentiment Indicator elaborated by the European Commission as representative of agent expectations in the seven European countries we analyzed. With respect to Ferreira *et al*. (2008) the innovation of this paper is twofold. First, in this paper we include in the model an additional variable, interest rate volatility, as well as the change in the short rate, to explain economic expectations. Second, we test the ability of this extended specification of the model to explain several confidence indicators (not just the ESI) with the objective of discovering which expectations (consumer, firm, analyst) are best explained by the interest rate variables.

The rest of the paper is structured as follows: Section 2 presents the literature review; section 3 describes data and methodology, section 4 presents the results. Section 5 concludes.

2. Related literature

There is a huge body of literature about the usefulness of financial variables for predicting economic growth. The most consistent leading indicator of the business cycle seems to be the slope of the yield curve, this is, the difference between the yields of a long-term and a short-term bond. A very extensive literature has documented its predictive ability on real economic activity in different countries and time periods [4] and has shown it to be a stronger predictor than stock market returns (Harvey, 1989; Chen, 1991; Hu, 1993; Estrella and Miskin, 1997; Bange, 1996; or, more recently Henry, Olekalns and Thong, 2004).[5]

According to some authors, the yield spread contains investor expectations about future economic growth when deciding their optimal consumption and investment plan . Thus, if

[4] See Wheelock and Wohar (2009) and Kuosmanen and Vataja (2011) for a review.

[5] Also credit spreads have been shown to have predictive power on real economy (see Bleaney, Mizen and Veleanu, 2013 for a literature review).

investors expect a downturn, they will try to hedge by buying bonds which mature when consumption is expected to be lower. So, investors will be disposed to sacrifice part of their current wealth in order to hedge against the reduction of income that a recession entails. The higher demand of long-term bonds will give rise to an increase in their price and therefore a decrease in their yield. The opposite effect will take place with short term bonds, so the term spread will decrease in advance of an expected economic slowdown, and vice versa.

Also the short interest rate change, as a representative of monetary policy, has been shown to be an indicator of the future path of the economy (Bernanke and Blinder, 1992; Dotsey, 1998; Hamilton and Kim 2002). In general, the predictive power of the yield spread remains almost invariable when the short rate change is included as an explanatory variable, leading to the conclusion that "the information in the slope of the yield curve is mostly about variables other than current monetary policy" (Estrella and Hardouvelis,1991).[6] However, Ang, Piazzesi and Wei (2006) argue that the short-term rate has larger marginal predictive power than the yield spread in the US.

Moreover, the joint forecasting ability of the yield spread and the short interest rate on economic growth has been consistently demonstrated by the financial literature in different countries.

Nevertheless, literature on the predictive ability of financial volatility is much more limited. Bansal and Zhou (2002), Sun (2005) and Gerlach *et al.* (2006) provide evidence of the countercyclical behavior of interest rate volatility[7]. Thus, Bansal and Zhou (2002) provide evidence for the United States. Sun (2005), in investigating the possibility of regime shifts in short rate volatility, finds that in the United Kingdom and in the US, interest rate volatility regime is negatively correlated with real Gross Domestic Product growth rate. Finally, Gerlach *et al*. (2006), who use data from eight countries, find a negative correlation between the output gap and bond market volatility.

If interest rate volatility is countercyclical, it can be expected to contain information on the expectations of economic agents with regard to the future path of the real economy.

[6] Plosser and Rouwenhorst (1994), Moersch (1996a, b), Kozicki (1997), Estrella and Mishkin (1997), Dotsey (1998) and Ivanova, Lahiri and Seitz (2000) provide evidence in several countries.

[7] The first papers about the countercyclical nature of financial volatility focused on stock return volatility See Schwert (1989), Hamilton and Lin (1996) and Campbell, Lettau, Malkiel and Xu (2001) for the United States and Andreou *et al*. (2000) and Bittlingmayer (1998) for other countries.

Nevertheless, quite limited empirical research has been devoted to the relationship between interest rate volatility and macroeconomic variables. In fact we are aware of only four studies that address this issue. [8]

Andreou *et al.* (2000) analyze the behavior of certain financial variables and their volatilities over the business cycle in the US, the UK, and Germany from 1970 up to 1998. They find that interest rate volatility leads production in the two European countries but not in the USA. Annaert *et al.* (2001) analyze the extra information content of interest rate volatility and stock return volatility over two traditional leading indicators of the business cycle, the yield spread and stock returns, in the US, Germany and Japan. Results in this study show that interest rate volatility adds significant explanatory power about the probability of future recessions in the three countries, whereas stock market volatility only provides consistent results for Japan. As expected, higher interest rate volatility increases the probability of entering a recession.

More recently, Fornari and Mele (2009) analyze the forecasting power on industrial production growth of a wide set of macroeconomic and financial variables and their volatilities (including the yield spread) in the US for the period 1957-2008. They obtain that in-sample forecasts of up to two-year growth in industrial production based on the volatility of the spread between the ten-year government bond yield and the three-month Treasury bill rate outperform forecasts based on stock market volatility. Finally, Chauvet *et al.* (2012) find that a combination of stock and bond volatility provides the best forecasts. So it seems that not only the level of interest rates but also their variability, contain useful information with which to anticipate the business cycle.[9]

This paper, however, differs from this prior literature in the fact that it tries to reveal the relationship between financial and economic variables through the link or ability of the former to capture the expectations of economic agent about the future stance of the economy. The role of the implied volatility of interest rates would be to reflect the uncertainty about the future behavior of interest rates and thus of all the economic and financial variables that depend on them. In particular, we provide empirical evidence on the link between interest rate volatility and expectations of the business cycle. More specifically, we test whether interest

[8] As for the relationship between stock return volatility and future economic growth, some papers have shown the poor marginal predictive ability of stock return volatility (see Kuojmanen and Vataja, 2011 and Espinoza, Fornari and Lombardi, 2012)

[9] Stock and Watson (2012) find that "the main contributions to the decline in output and employment during the recession are estimated to come from financial and uncertainty shocks." (p. 26).

rate volatility contains additional information to other financial variables which are already used to predict or explain the business cycle such as yield spreads or short term interest rates. An important issue of this paper is that we use volatility implied volatilities as a measure of interest rate, instead of historical volatilities, to capture the level of uncertainty of agent expectations regarding future economic activity. One advantage of the former being that it is an observable variable whereas realised volatility must be estimated and may depend dramatically on the model used to estimate it. The other advantage of implied volatility is that it is a forward looking measure of the interest rate behaviour while realized volatility only takes past data into account.

Finally, another contribution of this paper is the use of sentiment Indicators as a direct measure of the expectations of economic agents allowing us to avoid the usually controversial problem of modelling expectations.

So the goal of this article is to answer the following questions:

- Can the uncertainty about the future interest rates explain agent expectations about the future state of the economy?
- Is the information contained in interest rate volatility additional to that contained in the yield spread and the short rate change?
- Does implied volatility contain more information than historical or realized volatility?

3. Data and methodology

3.1 Data

This study is performed on US and Germany data ranging from February 1995 to February 2013. We have monthly observations of several confidence indexes which are well known and broadly followed by the markets.

In the case of the US, we use the following indicators:

- The Conference Board Consumer Confidence Index (CCI)
- The Philadelphia Fed's Business Outlook Survey (BOS)
- The Purchasing Managers Index (PMI)

And for Germany, we use:

- The Economic Sentiment Indicator (ESI)
- The IFO Business Climate (IFO)

- The Centre for European Economic Research (ZEW) Indicator of Economic Sentiment

The Conference Board Consumer Conference Index (CCI) is based on a survey conducted on approximately 3,000 consumers who are asked for an assessment of current conditions and their expectations about the evolution of business conditions for the next six months[10]. This index is published during the last week of the month.

The Philadelphia Fed's Business Outlook Survey (BOS) is a survey whose respondents are manufacturers from the Philadelphia, New Jersey, and Delaware region. They are questioned on their opinion about the change in general business conditions. The report is released on the third Thursday of every month.

The Purchasing Management Index (PMI) is elaborated by the Institute for Supply Management which conducts a survey on purchasing managers of private sector companies. Respondents report their opinion about the improvement or deterioration of current business with respect to the previous month. The PMI is published during the third week of the month.

As for the German indexes, the Economic Sentiment Indicator (ESI) is elaborated by the Directorate General for Economic and Financial Affairs of the European Commission for every country of the European Union. The ESI is a composite indicator made up of five sectorial confidence indicators, including the Consumer Confidence Indicator. In particular it is computed with the Industrial Confidence Indicator (40%), the Services Confidence Indicator (30%), the Consumer confidence indicator (20%), the Construction Confidence Indicator (5%) and the Retail trade Confidence Indicator (5%). The ESI is published on the last working day of each month.[11]

The IFO Institute, or Institute for Economic Research, elaborates the IFO Business Climate Index with a survey addressed to 7,000 German business managers who are asked about the current and the expected future business conditions for the next six months. It is published the last week of the month.

[10] Data are obtained from Thomson Reuters.

[11] For a complete description of this indicator see the Joint Harmonised EU Programme of Business and Consumer Surveys User Guide

Finally, the ZEW Economic Sentiment is elaborated by the Centre for European Economic Research from a survey addressed to approximately 350 economists and analysts who are asked about their economic expectations for the next six months. The survey is conducted during the first fortnight of the month and the index is released during the third week of that month.

Table 1 shows the description of the expectation indexes. The last column reports the number of days that the publication of each index is delayed with respect to the 15th of each month and, therefore, the number of days that we can try to anticipate the value of the corresponding index.

Table 1. Description of Expectation Indexes

Expectation Index	Institution	Respondents	Release date	Publication delay with respect to the 15th of each month(1)
Panel A: USA				
Conference Board Consumer Confidence Index (CCI)	Conference Board	Consumers	During the last week of the month	+14
Business Outlook Survey (BOS)	Federal Reserve Bank of Philadelphia	Manufacturing firms	Third Thursday of every month	+2
Purchasing Managers Index (PMI)	Institute for Supply Management	Manufacturing firms	During the third week of the month	+9
Panel B: GERMANY				
Expectation Index	Institution	Respondents	Release date	Publication delay with respect to the 15th of each month(1)
Economic Sentiment Indicator (ESI)	European Commission	Industrial, services, construction and retailing firms, and consumers	End of month	+15
IFO Business Climate Index (IFO)	IFO Institute	Firms in manufacturing, construction, wholesaling and retailing	During the last week of the month	+10
ZEW Indicator of Economic Sentiment (ZEW)	Centre for European Economic Research	Analysts	During the third week of the month	+7

***Note:** (1) The publication delays are based on the data releases in January 2013; for example: +14 means that the publication date was 14 days after the 15th of January (this is January 29th)

So, these indexes represent expectations of consumers (CCI), firms (BOS, PMI, ESI and IFO) and analysts (ZEW). It would be of interest to know which ones are best explained by bond market variables.

An important point is that we use data of these indexes in levels. All these surveys ask the respondents about their opinion about the improvement or worsening of the economic situation and the indexes are elaborated from the balance of the answers, which suggests that the indicators are measures of change in sentiment (see Matsusaka and Sbordone, 1995).

Furthermore, as has been said above, all these expectation indexes are released during the second fortnight of each month, with data collected during the previous two or three weeks. For that reason, we construct the explanatory variables with data from the first fortnight of each month. This is therefore consistent with the period when the data of the survey are collected and besides it would allow another potential application of the model which is now-casting the indexes.[12]

As for interest rates, we collect daily data on 5-year and 3-month yields on US Treasury bonds and the 5-year yield on the German bond and the 3-month interbank interest rate from the Bundesbank. With the average of the daily data of the first fortnight for every month, we construct the yield spread, as the difference between the 5-year and the 3-month interest rates, and the monthly logarithmic change in the 3-month interest rate.

With regard to volatility, we calculate the mean absolute deviations, over a fortnight interval, of the daily logarithmic changes in the 3-month interest rate. We use the monthly change in the realized volatility as an explanatory variable to compare its information content to that of implied volatility.

As far as implied volatility is concerned, we have daily data of ATM one-year caps provided by Datastream. We calculate the average of the daily data from the first fortnight for every

[12] The term now-casting was used in finance for the first time by Giannone, Reichlin and Small (2008). Recently, Gilchrist and Zakrajsek (2012) have used it regarding the information content of credit spreads.

month and use the monthly logarithmic change of the one year cap prices, as a measure of the change in implied volatility.[13]

Table 2 and 3 present some summary statistics of the variables described above: the expectations indexes, the yield spread, the change in the three-month interest rate and the change in the one-year implied volatility and in the historical volatility, for both the US and Germany. Statistics are provided for the two sub-periods into which we divide the sample. The first sub-period extends from March 1995 up to July 2007 (what we call the pre-crisis period, in Panel A)[14], and the second one from August 2007 up to May 2012 (denoted as the crisis period in this study, Panel B).[15]

Table 2: USA. Descriptive statistics of the data

	CCI	BOS	PMI	Spread	ΔR	ΔIVOL	ΔHVOL
Panel A: Pre-crisis period (1995.2-2007.7)							
Mean	110.09	26.90	51.93	0.90	-0.11	-0.01	0.00
Median	106.55	24.85	52.40	0.87	0.37	-0.02	-0.03
Maximum	144.70	62.00	61.40	2.87	20.42	0.54	3.04
Minimum	61.40	-9.60	40.80	-0.75	-33.55	-0.41	-2.59
Std.Dev.	18.60	16.20	4.42	0.85	6.13	0.14	0.65
Panel B: Crisis period (2007.8-2012.2)							
Mean	58.21	29.06	51.11	1.47	-7.17	0.04	0.08
Median	55.20	31.00	52.30	1.53	-6.25	0.02	-0.10
Maximum	105.60	56.10	59.60	2.53	143.80	0.85	5.47
Minimum	25.30	-12.30	33.10	-0.19	-231.88	-0.29	-6.44
Std.Dev.	16.35	16.35	6.97	0.69	55.26	0.20	2.42

Notes: CCI is the Consumer Confidence Index, BOS is the Philadelphia Fed's Business Outlook Survey and PMI stands for the Purchasing Management Index.
Spread is the difference between the 5-year and the 3-month interest rates, ΔR is the change in the 3-month rate, ΔIVOL is the change in the implied volatility and ΔHVOL is the change in the historical volatility

[13] The market convention for caps and floors is to quote their prices in terms of the implied volatility which sets prices from the well-known Black pricing formula equal to the market prices. According to the Libor Market Model, the use of the Black formula to price cap contracts can be justified if we assume that forward rates follow a lognormal process This implied volatility can be understood as the average of future volatilities of a set of forward interest rates with consecutive terms to maturity up to the expiration date of the cap (floor). Thus it can be considered a good measure of the expectations of economic agents with respect to the uncertainty of the future behavior of interest rates.

[14] According to Christiano, Motto and Rostagno (2010), the crisis started in August 2007. Espinoza *et al* (2012) say that it started "around July 2007", and Stock and Watson (2012) say that it happened in summer 2007.

[15] Statistics reported for the second period should be interpreted with caution given the small size of the sample (48 observations) in comparison to the first period (149 observations).

Table 3: GERMANY. Descriptive statistics of the data

	ESI	IFO	ZEW	Spread	ΔR	ΔIVOL	ΔHVOL
Panel A: Pre-crisis period (1995.2-2007.7)							
Mean	99.91	100.43	38.02	0.87	-0.14	-0.01	0.00
Median	101.15	99.85	40.10	0.90	0.11	-0.01	0.00
Maximum	111.80	113.80	89.60	2.05	19.67	0.40	1.03
Minimum	82.80	91.60	-28.50	-0.30	-15.51	-0.27	-0.95
Std.Dev.	7.40	5.42	30.88	0.56	4.07	0.12	0.33
Panel B: Crisis period (2007.8-2012.2)							
Mean	100.25	103.43	-4.58	0.32	-2.52	0.04	0.01
Median	104.40	106.80	-5.80	0.49	-0.64	0.01	-0.02
Maximum	118.80	115.10	57.70	1.74	18.46	0.94	2.18
Minimum	72.50	84.60	-63.90	-1.65	-29.06	-0.32	-1.73
Std.Dev.	13.08	9.37	37.63	0.99	10.40	0.22	0.50

Notes: ESI is the Economic Sentiment Indicator, IFO is the IFO Business Climate Index and ZEW is the Centre for European Economic Research (ZEW) Indicator of Economic Sentiment
Spread is difference between the 5-year and the 3-month interest rates, ΔR is the change in the 3-month rate, ΔIVOL is the change in the implied volatility and ΔHVOl is the change in the historical volatility.

The period analyzed by this study covers, therefore, two very different environments. The first one characterized by economic steadiness and the second one from the eruption of the financial crisis up until the present.

If we analyze Tables 2 and 3 we can see that one of the main differences between both subperiods is the extreme low values reached by all Sentiment Indicators during the second subsample capturing the depth and severity of the crisis. Another important difference between the two subperiods can be observed in the explanatory variables, particularly in the relative changes in the short-term interest rate. This fact can be related to the implementation of a monetary policy that led interest rates to historically low values during the recent financial turmoil.

Also, the two measures of interest volatility used in this paper experienced much sharper movements during the second period when volatility reached high records. This can be understood as a greater perception of risk derived from the distress that affected the whole financial system after the Lehman Brothers bankruptcy. This phenomenon affected the level of uncertainty of the expectations of economic agents and their responses to the arrival of information concerning the risks inherent in the investment decisions.

3.2 Methodology

To assess the predictive ability of implied interest rate volatility for the expectations of economic agents, we estimate the following univariate specification:

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta IVOL_t + \beta_4 I_{t-1} + \varepsilon_t \quad [1]$$

where I_t is the Expectation Index for month t; $Spread_t$ is the difference between the continuously compounded annualized 5-year and 3-month interest rates; ΔR_t represents a monetary policy variable: the monthly change in the 3-month interest rate; $\Delta IVOL_t$ is the monthly change in the one-year implied volatility and I_{t-1} is the value of the corresponding index in the previous month. We incorporate this variable to the model to prevent from spurious regressions (Granger, Hyung and Jeon, 2001) and to be able to test whether the financial variables included in the model contain additional information to the past value of the index.

Hence, this model intends to examine the marginal information content of implied volatility conditional on the slope of the yield curve and the change in the short term rate, which according to literature can be considered an indicator of the stance of monetary policy, and of the previous value of the index.

Additionally, in order to compare the information content of implied volatility with that of realized volatility, we also estimate

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta HVOL_t + \beta_4 I_{t-1} + \varepsilon_t \quad [2]$$

where $HVOL_t$ stands for the historical volatility constructed as mean absolute deviations, over the interval of the first fortnight of each month, of daily logarithmic changes in the three-month interest rate, and the rest of the variables are defined as in equation [1].

We estimate these two equations for the six confidence indicators described above. Regressions are estimated by OLS. Standard errors are corrected by using the Newey and West (1987) adjustment method, with the lag length of each specification determined by the Akaike Information Criterion (AIC).

Tables 4 and 5 show the correlation coefficients between the explanatory variables, for the US and Germany, respectively. All correlations are smaller than 0.50 in absolute values.

Table 4: USA. Correlation coefficients between explanatory variables.

Panel A: Pre-crisis period (1995.2-2007.7)				
	Spread	ΔR	ΔIVOL	ΔHVOL
Spread	1			
ΔR	0.04 (0.49)	1		
ΔIVOL	-0.08 (-1.00)	-0.36[a] (-4.76)	1	
ΔHVOL	-0.05 (-0.64)	0.03 (0.36)	0.24[a] (3.01)	1
Panel B: Crisis period (2007.8-2012.2)				
	Spread	ΔR	ΔIVOL	ΔHVOL
Spread	1			
ΔR	-0.11 (-0.78)	1		
ΔIVOL	-0.16 (-1.21)	-0.20 (-1.53)	1	
ΔHVOL	0.03 (-0.22)	-0.11 (-0.85)	0.39[a] (3.11)	1

Notes: Spread is the difference between the 5-year and the 3-month interest rates, ΔR is the change in the 3-month rate, Δivol is the change in the implied volatility and Δhvol is the change in the historical volatility.
t-Student in parenthesis
(a) Significant at the 1% level

Table 5: GERMANY. Correlation coefficients between explanatory variables.

Panel A: Pre-crisis period (1995.2-2007.7)				
	Spread	ΔR	ΔIVOL	ΔHVOL
Spread	1			
ΔR	0.09 (1.14)	1		
ΔIVOL	-0.10 (-1.20)	-0.13 (-1.54)	1	
ΔHVOL	-0.05 (-0.67)	-0.036 (-0.43)	0.31[a] (3.91)	1
Panel B: Crisis period (2007.8-2012.2)				
	Spread	ΔR	ΔIVOL	ΔHVOL
Spread	1			
ΔR	0.02 (0.15)	1		
ΔIVOL	-0.27[b] (-2.09)	-0.00 (-0.01)	1	
ΔHVOL	-0.02 (-0.15)	0.01 (0.05)	0.23[c] (1.71)	1

Notes: Spread is the difference between the 5-year and the 3-month interest rates, ΔR is the change in the 3-month rate, ΔIVOL is the change in the implied volatility and ΔHVOL is the change in the historical volatility.
t-Student in parenthesis
(a) Significant at the 1% level; (b) Significant at the 5% level; (c) Significant at the 10% level.

4. Results

Tables 6 and 7 show the OLS regressions results for the US and Germany, respectively, based on Equation [1], that is, the model incorporating the implied volatility. Tables 8 and 9 present the estimation results of Model [2], where the historical volatility is used instead.

In each table, Panel A shows the results for the pre-crisis period (February 1995- July 2007) and Panel B reports the results for the crisis period (August 2007-February 2012). Each panel shows in rows the estimated coefficients of the three financial variables (the yield spread, the change in the short rate and the change in the implied or the historical volatility). The last row of each panel shows the adjusted R^2 of the model, which also includes the past value of the

corresponding index, although the estimated coefficient of this variable is not reported (it is significant in all cases).

In the case of the US, Panel A of Table 6, corresponding to the pre-crisis period, shows that both the spread and the short rate interest rate have significant explanatory power (except the spread in the case of the CCI). What is new in this paper is that we provide significant evidence of interest rate volatility containing additional power to explain the three indexes. Moreover the estimated coefficient of implied volatility is negative and significant in all cases.

That is to say, not only the interest rates but also the level of uncertainty about them can explain the evolution of confidence indicators, a result that is robust when different indexes are considered.

As for the US results in the second sub-period, after the eruption of the crisis, Panel B of Table 6 shows that the estimated coefficients of implied volatility are higher than in the previous period, that is, the impact of volatility on the three indexes is larger, although in the case of the PMI it is not significant. The goodness of fit is somewhat lower than in the previous period in the case of the model with the CCI and the BOS but higher in the case of the PMI.

The results show that the three interest rates variables contain information additional to that of the past value of the corresponding index.

Table 6: USA. Estimation results of the model with Implied Volatility.

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta IVOL_t + \beta_4 I_{t-1} + \varepsilon_t$$

Panel A: Pre-crisis period (1995:2-2007:7)

	Conference Board CCI	Philadelphia Business Outlook Survey	Purchasing Management Index
Spread	0.028	4.362[a]	0.517[b]
	(0.233)	(0.267)	(0.216)
ΔR	0.223[a]	-0.108[a]	0.072[a]
	(0.022)	(0.022)	(0.019)
ΔIVOL	-5.072[a]	-4.705[a]	-1.317[a]
	(0.499)	(0.491)	(0.504)
Adjusted R^2	90.97%	74.50%	85.67%

Panel B: Crisis period (2007:8-2012:2)

	Conference Board CCI	Philadelphia Business Outlook Survey	Purchasing Management Index
Spread	-1.673[a]	0.694[c]	0.520
	(0.448)	(0.395)	(0.601)
ΔR	0.003	0.007[a]	0.015[b]
	(0.002)	(0.002)	(0.007)
ΔIVOL	-9.277[a]	-18.678[a]	-2.131
	(0.710)	<(0.633)	(1.511)
Adjusted R^2	83.09%	62.14%	92.33%

Notes: In addition to the specified financial indicators in month t, each specification also includes a constant and one lag of I_t (not reported); t-statistics reported in brackets are computed according to Newey-West (1987) (see text for details)
(a) Significant at the 1% level; (b) Significant at the 5% level; (c) Significant at the 10% level.

As for the results for Germany, Table 7 presents the estimation of Model 1. In this country the model performs somewhat better in the crisis period than in the pre-crisis one for all the confidence indicators considered.

In the first sub-period, as reported in Panel A, the term spread coefficient is significant only to explain the ZEW. For the IFO, only the short rate contains additional information to that

contained in the past value of the indexes. As for the implied volatility, this contains useful information to explain the ESI and the ZEW.

Table 7: GERMANY. Model with Implied Volatility.

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta IVOL_t + \beta_4 I_{t-1} + \varepsilon_t$$

Panel A: Pre-crisis period (1995.2-2007.7)			
	Economic Sentiment Indicator	IFO Business Climate	ZEW Economic Sentiment
Spread	0.335 (0.323)	0.307 (0.325)	5.733[c] (3.400)
ΔR	0.159[a] (0.030)	0.059[b] (0.028)	-0.059 (0.287)
ΔIVOL	-1.545[b] (0.677)	-0.842 (0.668)	-23.688[b] (9.522)
Adjusted R^2	96.73%	95.43%	89.11%
Panel B: Crisis period (2007.8-2012.2)			
	Economic Sentiment Indicator	IFO Business Climate	ZEW Economic Sentiment
Spread	1.389[a] (0.284)	1.087[a] (0.285)	8.193[a] (0.619)
ΔR	0.050[b] (0.024)	0.002 (0.024)	-0.563[a] (0.023)
ΔIVOL	-2.142[a] (0.622)	-1.292[b] (0.620)	-8.672[a] (0.718)
Adjusted R^2	97.58%	97.30%	94.41%

Notes: In addition to the specified financial indicators in month t, each specification also includes a constant and one lag of I_t (not reported); t-statistics reported in brackets are computed according to Newey-West (1987) (see text for details)
(a) Significant at the 1% level; (b) Significant at the 5% level; (c) Significant at the 10% level.

As for the crisis period, as can be seen in Panel B of Table 7, during this period, the term spread coefficient is significant for the three indices as is the change of the short rate, with the exception of the IFO. As for implied volatility, it contains significant marginal information for explaining all indices, the coefficient being negative in all cases. The adjusted R^2 is somewhat higher than in the pre-crisis period.

Another outcome that is worth commenting upon is that the sensitivity of sentiment indicators to the implied volatility has increased after the crisis in both countries (except in the case of ZEW), a result that may reflect a greater response of expectations to changes in financial markets in periods of turbulences.

Tables 8 and 9 show the results of estimating Model 2, that is, the model containing historical volatility. The structure of both tables is the same as that of Tables 6 and 7.

Table 8: USA. Model with Realized Volatility.

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta HVol_t + \beta_4 I_{t-1} + \varepsilon_t$$

	Conference Board CCI	Philadelphia Business Outlook Survey	Purchasing Management Index
Panel A: Pre-crisis period (1995.2-2007.7)			
Spread	0.032 (0.233)	4.293[a] (0.268)	0.533[b] (0.216)
ΔR	0.269[a] (0.022)	-0.065[a] (0.022)	0.083[a] (0.019)
ΔHVOL	-0.853[a] (0.065)	-0.876[a] (0.066)	-0.009 (0.065)
Adjusted R^2	90.93%	74.47%	85.51%
Panel B: Crisis period (2007.8-2012.2)			
	Conference Board CCI	Philadelphia Business Outlook Survey	Purchasing Management Index
Spread	-1.360[a] (0.449)	2.006[a] (0.390)	0.651 (0.493)
ΔR	0.006[b] (0.002)	0.019[a] (0.003)	0.016[b] (0.006)
ΔHVOL	-0.933[a] (0.039)	-0.862[a] (0.039)	-0.145 (0.114)
Adjusted R^2	83.94%	58.73%	92.22%

Notes: In addition to the specified financial indicators in month t, each specification also includes a constant and one lag of I_t (not reported); t-statistics reported in brackets are computed according to Newey-West (1987) (see text for details)
(a) Significant at the 1% level; (b) Significant at the 5% level.

Table 8 presents the results for the US. In this case, realized volatility results are not very different from the model with the implied volatility. Nevertheless, whereas implied volatility is able to explain the PMI in the pre-crisis, the realized volatility is not.

Table 9: GERMANY. Model with Realized Volatility.

$$I_t = \beta_0 + \beta_1 Spread_t + \beta_2 \Delta R_t + \beta_3 \Delta HVol_t + \beta_4 I_{t-1} + \varepsilon_t$$

Panel A: Pre-crisis period (1995.2-2007.7)

	Economic Sentiment Indicator	IFO Business Climate	ZEW Economic Sentiment
Spread	0.369 (0.322)	0.327 (0.324)	6.596 (3.493)
ΔR	0.164[a] (0.030)	0.060[b] (0.028)	0.024 (0.293)
ΔHVOL	0.147 (0.126)	-0.039 (0.126)	-1.048 (2.131)
Adjusted R^2	96.68%	95.41%	88.35%

Panel B: Crisis period (2007.8-2012.2)

	Economic Sentiment Indicator	IFO Business Climate	ZEW Economic Sentiment
Spread	1.528[a] (0.277)	1.173[a] (0.278)	10.087[a] (0.544)
ΔR	0.045[c] (0.024)	-0.001 (0.024)	-0.547[a] (0.024)
ΔHVOL	-0.218 (0.134)	-0.014 (0.134)	-3.765[a] (0.134)
Adjusted R^2	97.46%	97.20%	94.45%

Notes: In addition to the specified financial indicators in month t, each specification also includes a constant and one lag of I_t (not reported); t-statistics reported in brackets are computed according to Newey-West (1987) (see text for details).

(a) Significant at the 1% level; (b) Significant at the 5% level; (c) Significant at the 10% level.

With regard to Germany, we can say that the realized volatility model performs significantly worse than the model including implied volatility. Actually, as reported in Panel A of Table 9, the realised volatility estimated coefficient is not significant for explaining any indicator in the pre-crisis period. Moreover, it has the opposite sign to the expected one according to the theory in the regression of the Economic Sentiment Indicator.

As for the crisis period, Panel B of Table 9 reports that realized volatility does not contain marginal information about the ESI and the IFO, whereas in that period, implied volatility coefficient is significant for the three indices, as was shown above in Table 6.

5. Conclusions

In this paper we have found evidence of the relationship between the expectations of economic agents about the business cycle and interest rate volatility. As expected, this relationship is found to be negative in the sense that greater interest rate volatility accounts for negative expectations about the future behavior of the economy.

Needless to say interest rates are of key importance in the decision-taking process of all the agents involved in any economy including households, firms, government, financial intermediaries, etc . . . In as much as increments in interest rate volatility capture the level of uncertainty with respect to the future evolution of interest rates they can affect the level of uncertainty of economic agents with respect to the upcoming behavior of the business cycle. In this sense this paper provides significant evidence of interest rate volatility as a gauge of the concerns of all economic agents.

It should be noted that the measure of interest rate volatility employed in this article is an implied volatility directly obtained from one of the most liquid interest rate derivative contracts. It clearly improves upon the explanatory power of realized volatilities that have been commonly used in former research. This result can be explained by the fact that implied volatilities are forward-looking measures of the uncertainty about the future behavior of interest rates. On the contrary, realized volatilities only account for the past behavior of interest rates.

Also, we have obtained significant evidence of the additional power that this variable has with respect to others such as yield spreads or short term interest rates that have been already used to explain the business cycle.

The robustness of the results has been confirmed by using data from two different countries (the US and Germany), different periods (before and after the beginning of the current crisis) and different sentiment indexes as direct measures of the expectations of economic agent.

And finally the model in this paper has the advantage of providing a tool for now-casting these Sentiment Indicators, which are broadly followed by financial press, practitioners and policy makers.

6. References

Andreou E, Osborn D, Sensier M. 2000. A comparison of the statistical properties of financial variables in the USA, UK and Germany over the business cycle. *Manchester School* **68**(4): 396-418.

Ang A, Piazzesi M, Wei M. 2006. What does the yield curve tell us about GDP growth?. *Journal of Econometrics* **131**: 359-403.

Annaert J, De Ceuster MJK, Valckx N. 2001. Financial market volatility: informative in predicting recessions. Bank of Finland discussion papers 14.

Bernanke BS, Blinder AS. 1992. The Federal funds rate and the channels of monetary transmission. *American Economic Review* **82**(4): 901-921.

Bittlingmayer G. 1998. Output, stock volatility, and political uncertainty in a natural experiment: Germany, 1880-1940. *The Journal of Finance* **53** (6): 2243-2257.

Bleaney M, Mizen P, Veleanu V. 2013. Bond Spreads and Economic Activity in Eight European Economies. University of Nottingham, Centre for Finance and Credit Markets Discussion Paper Series, Working Paper 13/09.

Bram J, Ludvigson S. 1998. Does consumer confidence forecast household expenditure? A sentiment index horse race. *Economic Policy Review* June: 59-78.

Campbell JY, Lettau M, Malkiel BG, Xu Y. 2001. Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk. *The Journal of Finance* **56**(1): 1–43.

Carroll CD, Fuhrer JC, Wilcox DW. 1994. Does consumer sentiment forecast household spending? If so, why? *The American Economic Review* **84**(5): 1397-1408.

Chauvet M, Senyuz Z, Yoldas E. 2012. What does financial volatility tell us about macroeconomic fluctuations?. Finance and Economics Discussion Series 2012-09, Board of Governors of the Federal Reserve System.

Christiano LJ, Motto R, Rostagno M. 2010. Financial Factors in Economic Fluctuations, Working Paper 1192. European Central Bank.

Díaz A, Meneu V, Navarro E. 2009. International evidence on alternative models of the term structure of volatilities. *Journal of Futures Markets* **29**(7): 653-683.

Dotsey M. 1998. The predictive content of the interest rate term spread for future economic growth. *Federal Reserve Bank of Richmond Economic Quarterly* **84**(3): 31-51.

Espinoza R, Fornari F, Lombardi MJ. 2012. The Role of Financial Variables in Predicting Economic Activity. *Journal of Forecasting* **31**: 15–46.

Estrella A, Hardouvelis GA. 1991. The term structure as a predictor of real economic activity. *The Journal of Finance* **46**(2): 555-576.

Estrella A, Mishkin FS. 1997. The predictive power of the term structure of interest rates in Europe and the United States: implications for the European Central Bank. *European Economic Review* **41**: 1375-1401.

European Commission Directorate-General for Economic and Financial Affairs. 2007. The Joint Harmonised EU Programme of Business and Consumer Surveys. User Guide.

Ferreira E, Martínez MI, Navarro E, Rubio G. 2008. Economic sentiment and yield spreads in Europe. *European Financial Management* **14**(2): 206-221.

Fornari F, Mele A. 2009. Financial volatility and economic activity. Discussion paper, 642. Financial Markets Group Discussion Paper 642. London School of Economics and Political Science, London, UK.

Fuhrer, JC. 1993. What role does consumer sentiment play in the U.S. macro-economy?. *New England Economic Review* January/February: 32 -44.

Gelper S, Croux C. 2010. On the construction of the European Economic Sentiment Indicator. *Oxford Bulletin of Economics and Statistics* **72**(1): 47-62.

Gerlach S, Ramaswamy S, Scatigna M. 2006. 150 years of financial market volatility. *BIS Quarterly Review* September: 77-91.

Giannone D, Reichlin L, Small D. 2008. Nowcasting: The real-time informational content of macroeconomic data. *Journal of Monetary Economics* **55**(4): 665–676.

Gilchrist S, Zakrajsek E. 2012. Credit Spreads and Business Cycle Fluctuations. *American Economic Review* **102**(4): 1692-1720.

Granger, CWJ, Hyung N, Jeon Y. 2001. Spurious regressions with stationary series. *Applied Economics* **33**(7): 899-904.

Hamilton JD, Lin G. 1996. Stock market volatility and the business cycle. *Journal of Applied Econometrics* **11**: 573-93.

Harvey CR. 1988. The real term structure and consumption growth. *Journal of Financial Economics* **22**(2): 305-333.

Harvey CR. 1989. Forecasts of economic growth from the bond and stock markets. *Financial Analysts Journal* **45**(5): 38-45.

Henry ÓT, Olekalns N, Thong J. 2004. Do stock market returns predict changes to output? Evidence from a nonlinear panel data model. *Empirical Economics* **29**: 527–540.

Kozicki S. 1997. Predicting real growth and inflation with the yield spread. *Federal Reserve Bank of Kansas City, Economic Review* 4th quarter: 39-57.

Kuosmanen P, Vataja J. 2011. The role of stock markets vs. the term spread in forecasting macrovariables in Finland. *Quarterly Review of Economics and Finance* **51:** 124–132.

Lemmon M, Portniaguina E. 2006. Consumer Confidence and Asset Prices: Some Empirical Evidence. *The Review of Financial Studies* **19**(4): 1499-1529.

Ludvigson SC. 2004. Consumer Confidence and Consumer Spending. *Journal of Economic Perspectives* **18**(2): 29-50.

Matsusaka JG, Sbordone AM. 1995. Consumer confidence and economic fluctuations. *Economic Inquiry* **33**(2): 296-318.

Newey WK, West KD. 1987. A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica* **55**(3): 703-708.

Plosser CI, Rouwenhorst KG. 1994. International term structures and real economic growth. *Journal of Monetary Economics* **33**: 133-155.

Stock JH, Watson MW. 2012. Disentangling the Channels of the 2007-2009 Recession. NBER Working Papers 18094. National Bureau of Economic Research, Inc.

Sun L. 2005. Regime shifts in interest rate volatility. *Journal of Empirical Finance* **12**(3): 418-434.

Vuchelen J. 2004. Consumer sentiment and macroeconomic forecasts. *Journal of Economic Psychology* **25**: 493-506.

Wheelock DC, Wohar ME. 2009. Can the term spread predict output growth and recessions? A Survey of the literature. *Federal Reserve Bank of St. Louis Review* **91**: 419-440.