



## INTEREST RATE IMPLIED VOLATILITY AND CONSUMER SENTIMENT

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**Abstract.** In this paper we examine the information content of interest rate volatility for explaining the economic agents' expectations on the business cycle as measured by consumer confidence indicators. The volatility measure is the one-year implied volatility of caps and floors. We find that implied volatility adds significantly to the yield spread and the change in the short-term interest rate in explaining consumer sentiment before and during the current financial crisis in the U.S. and Germany. Moreover, implied volatility outperforms realized volatility in all of the cases.

**Key words:** *consumer sentiment; expectations; term structure of interest rates; implied interest rate volatility*

**JEL code:** E32, E43

### Introduction

There is a lot of literature concerning the ability of financial variables to predict business cycle. Kessel (1965) showed evidence, for the first time, on the procyclical behaviour of the yield spreads between nine-to twelve-month government securities and Treasury bills in the U.S. for the period from 1942 to 1953. Since the late eighties, consistent empirical evidence on the predictive power of the yield spread can be found for different countries and time periods.<sup>2</sup> See, for instance, Estrella and Hardouvelis (1991) for evidence in the U.S. over the period 1955-1988; Davis and Fagan (1997) for the E.U. countries from various 1970s up to 1992; Estrella and Mishkin (1997) for the U.S., the U.K., Germany, France, and Italy, covering the period from 1973 to 1995; Kozicki (1997) for the G-7, Australia, Sweden, and Switzerland from 1970 up to 1996; or, more recently, Duarte *et al.* (2005) for the Euro area over the period 1970-2000.<sup>3</sup>

Harvey (1988) provides a theoretical model based on the CCAPM that establishes a positive linear relationship between expected real yield spreads and expected consumption growth. The underlying idea behind this model can be described as follows. If investors expect an economic downturn, they will tend to reduce current consumption in order to invest in long-term bonds that will provide an extra income in the bad times. This practice then will raise the price of long-term bonds and reduce the corresponding long rate, whereas the sale of short-term bonds will push short rates up. As a result, the yield curve will flatten.

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<sup>2</sup> The most commonly used spread in the literature is the one computed as the difference between the yield on a ten-year government security and the yield on a three-month security.

<sup>3</sup> See also Wheelock and Wohar (2009) for a review of the most recent research on the usefulness of the term spread for predicting changes in economic activity. According to the authors, many studies find that the spread predicts output growth and recessions up to one year in advance, although several also find that its usefulness varies across countries and over time.



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Harvey (1988) tests this model on U.S. data from 1953-1987 and finds that the short end of the real term structure of interest rates is significant for predicting consumption growth from quarter  $t+1$  to quarters  $t+3$  and  $t+4$ , mainly since 1972. Furthermore, he finds that the model outperforms both in sample and out-of-sample alternative models based on lagged consumption growth or lagged real stock returns as explanatory variables.

Results in Harvey (1988) show that the short-term expected real rate does not contribute significantly to the explanatory power of the model, thus Harvey (1989) extends the analysis in Harvey (1988) by using a simplified version of his model in which the only explanatory variable is the spread, with the expected real short-term rate contained in the intercept. In addition, some other changes are introduced into the model. In particular, the U.S. real GNP annualized growth from quarter  $t+1$  to quarter  $t+5$  is used as a proxy of expected consumption, and the real yield spread is also replaced by the nominal spread, where the long-term rates are the five- and ten-year yields instead of the yield of a bond with five quarters to maturity. He finds that the spread alone is able to explain more than 30 per cent of the variation in economic growth. The simplified version of the model is also tested for the G-7 countries over the period 1970-1989 by Harvey (1991), where the most favorable empirical evidence on the predictive power of the yield spread is reported for Canada, Germany, and Italy, in addition to the U.S.

Another branch of the literature (see Davis and Henry, 1994; Davis and Fagan, 1997; Dueker, 1997; Dotsey, 1998; and Hamilton and Kim, 2002, among others) attributes the ability of the yield spread to forecast economic activity to monetary policy actions. The argument runs as follows. A contraction of monetary policy causes short-term interest rates to rise; however, market participants will probably expect future short-term rates to be lower than current short-term rates once economic growth slows or inflation decreases. As a result, according to the expectations theory of the term structure, long-term rates will rise less than short-term rates and, hence, the slope of the yield curve will drop. Monetary policy tightening will bring about a future decline in investment and, consequently, an economic deceleration. Thus, the yield spread falls in advance of an economic slowdown and vice versa.<sup>4</sup>

The monetary policy explanation has been repeatedly tested in the literature by regressing real economic growth from time  $t$  to time  $t+N$ , on both the yield spread observed at time  $t$  and a new variable representing the current stance of monetary policy. That is,

Based on this regression equation, Estrella and Hardouvelis (1991) find that the yield spread (computed as the difference between yields on ten- and three-month Treasury securities) alone is able to explain more than 30 percent of the cumulative change in real GNP from three- to eight-quarter horizons, and that it continues to be statistically significant when the real (nominal) federal funds rate or the three-month Treasury bill rate are also significantly included into the equation as explanatory variables. That is, the spread appears to contain information for future economic growth over and above that provided by variables that reflect the stance of monetary policy.<sup>5</sup> Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Moersch (1996), Kozicki (1997), Dotsey (1998), and Hamilton and Kim (2002) confirm these results and extend the evidence to other countries.

Thus, the joint forecasting ability of the yield spread and short-term interest rates on economic growth has been consistently tested in the financial literature for different countries. Concerning interest rate volatility, we are aware of only a few studies that address the information content of interest rate volatility for predicting economic activity.

Andreou *et al.* (2000) analyze the behavior of certain financial variables and their volatilities over the business cycle in the U.S., the U.K., and Germany from 1970 up to 1998. Volatilities are calculated as the square of the first difference of the series. They find that the volatility in the term structure appears to be

<sup>4</sup> Nevertheless, according to Wheelock and Wohar (2009), this argument has been usually stated with little underlying theory.

<sup>5</sup> According to Beranke and Blinder (1992), short-term rates can be considered good indicators of monetary policy actions.



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procyclical and to lead industrial production growth in the U.K., whereas the volatility of real short- and long-term rates appears to have countercyclical and leading indicator properties in Germany.<sup>6</sup> However, interest rate volatility does not seem to lead economic activity in the U.S.

Annaert *et al.* (2001) analyze the extra information content of short-term interest rate and stock return volatility over two traditional leading indicators of the business cycle: the yield spread and stock returns. Volatility estimates of short-term interest rates as constructed as mean absolute deviations, over a one-month interval, of daily changes in three-month interest rates. Results in this study show that interest rate volatility adds significantly to the yield spread and real stock returns to forecast the probability of future recessions up to twelve months in advance in the U.S., Germany, and Japan for a sample starting at different 1960s and ending at 2000. As expected, higher interest rate volatility increases the probability of entering a recession. However, the sign and the statistical significance of stock return volatility differ between countries.

More recently, Fornari and Mele (2009) analyze the single and in blocks forecasting power on industrial production growth of a wide set of macroeconomic and financial variables and their volatilities (including the yield spread) in the U.S. 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. Volatility is defined as a moving average of past absolute returns.

As stressed, all these studies use volatility estimates based on historical data. So far, we are not aware of any study that analyzes the forecasting performance of, according to Annaert *et al.* (2001), the most forward-looking volatility estimate: the volatility implied from interest rate options. We build on this issue by analyzing the information content of interest rate volatility for explaining economic agents' expectations regarding the future state of economy.

### Data

The study is performed on U.S. and Germany data from January 1995 to July 2011. Next we describe the four variables involved in our empirical model: the consumer confidence index (CCI), the yield spread, the change in the three-month interest rate, and the one-year implied volatility. Then we analyze the statistical properties of the series.

In order to measure expectations about future economic activity, we employ the Conference Board CCI for the U.S. and the Icon CCI for Germany. Data have been obtained from Reuters.

The link between consumer confidence and spending can be found in the work by Katona (1968). The author states that consumer spending is a function both of ability to buy and willingness to buy. While the ability to buy is mainly a function of disposable income, the willingness to buy depends primarily on attitudes and expectations about personal finances and the economy as a whole. And this is specifically what questions included in these two indices cover.

In addition, according to Curtis (2007), consumer spending accounts for one-half to two-thirds of all spending in market-based economies, and hence even small changes in household spending can have a major impact on the economy. Empirical evidence in this study for an extensive group of countries shows that consumer confidence in Germany and the U.S. (based on the same questionnaires that we use in this paper) Granger causes changes in more than 50% of the economic variables included in the analysis.<sup>7</sup>

<sup>6</sup> See also Sun (2005) and Gerlach *et al.* (2006) for further evidence on the countercyclical properties of the volatility of short-term interest rates (Treasury bill rates and interbank rates) and bond returns, respectively.

<sup>7</sup> These variables are the unemployment rate, inflation rate, interest rates, personal income, GDP, total personal consumption, retail sales, expenditures for durables, and vehicle registrations.



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The Conference Board CCI is closely followed by financial markets and business community and so it is treated by financial press as an important piece of economic information. It is constructed on the basis of a monthly household survey of consumers' perceptions of current business and employment conditions, and their expectations over the next six months concerning business situation, employment, as well as their total family income.<sup>8</sup> The index is benchmarked to 1985 = 100. Thus, values greater than 100 indicate above-average consumer confidence and vice-versa.

Questionnaires used to obtain the monthly value of the index are mailed to sample households at the end of the previous month, and responses flow in throughout the survey month. Responses received up to approximately the eighteenth of the month are used for the preliminary estimates of the index, which the Conference Board releases on the last Tuesday of the survey month. Final estimates for the month based on all the responses received are released with the next month's preliminary figures and are not subject to further revision. So we use final estimates of the index in our study.

The Icon CCI is based on the German consumers' responses to the E.U. harmonized consumer survey elaborated by the European Commission.<sup>9</sup> However, we prefer this index instead of the one published by the European Commission since the former is scaled to have a long-term mean of 100. In this way, values above 100 indicate that optimistic consumer estimates outweigh the pessimistic ones, while values below 100 indicate the opposite.

Specifically, consumers are asked about their expectations of change in the financial position of their households, the general economic situation and employment, as well as their saving possibilities over the next 12 months.<sup>10</sup>

Surveys responses are normally collected in the first half of the month and transmitted to the European Commission services around one week before the end of the month. Based on the results of the surveys, the Icon CCI is then released in the first calendar week after the end of the month that is reported about.

A usual dilemma that academics have to face when working with indicators of consumer sentiment is whether to focus on index-level or monthly changes. The decision must depend basically on the time frame of the questions included into the consumer surveys. In this case, both consumer confidence indices ask about changes in the near-future, suggesting that the indices are measures of change in sentiment (see Matsusaka and Sbordone (1995)). Given this and the fact that both indices are scaled to have a long-term mean of 100, we use data in levels.

As for interest rates, we collect daily data on three- and 12-month yields on U.S. Treasury securities, and three- and 12-month interbank interest rates from the Bundesbank. Given that the Conference Board CCI and the Icon CCI cover expectations over the next six and 12 months, respectively, the 12-month interest rate is selected to represent the long-term rate.<sup>11</sup>

In order to obtain the monthly data on interest rates, we proceed in two different ways depending on the collection period of the survey responses used to estimate the values of the consumer confidence indices. This way, since the final monthly data of the Conference Board CCI are based on responses received during the whole month, the monthly interest rate data for the U.S. are the average of the daily data corresponding to the month of reference. However, in regard to German interest rates, given that surveys responses used to estimate the Icon CCI are collected in the first half of the month the index is

<sup>8</sup> See technical notes on the consumer confidence survey available at the website of the Conference Board for further details.

<sup>9</sup> See "Joint Harmonised E.U. Programme of Business and Consumer Surveys (12.10.2006)" and "The Joint Harmonised E.U. Programme of Business and Consumer Surveys. User Guide 2007" for a complete description of the survey (questionnaires, timetable, use of information...). Further information about the Icon CCI can be found at <http://icon-added-value-source.com/>.

<sup>10</sup> Thus, it must be highlighted that consumers are not surveyed on the future development of any financial market variable in any case.

<sup>11</sup> This is in accordance to Plosser and Rouwenhorst (1994), who match the maturity of long-term rates to the forecast horizon of growth rates of industrial production.



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reported about, the monthly data on interest rates are the average of daily data collected from the second fortnight of the prior month up to the first fortnight of the month of reference.

The yield spreads for both countries are then just obtained as the difference between the monthly continuously compounded annualized 12- and three-month interest rates. As usual in the literature on the predictive power of the yield spread, we also use a monetary policy variable: the monthly change in the three-month interest rate.<sup>12</sup>

So, the first monthly average data on interest rates for Germany is computed from daily data corresponding to the period from the second fortnight of January 1995 up to the first fortnight of February 1995. Thus, the first data on the change in the three-month interest rate for Germany is obtained as the difference between the monthly average data corresponding to the period from the second fortnight of February 1995 up to the first fortnight of March 1995 and the monthly average data corresponding to the period from the second fortnight of January 1995 up to the first fortnight of February 1995. Thus, the first data on CCI in our study is March 1995 for both countries.

With respect to 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 with a twofold purpose. First, data can be directly obtained from the market, and second, this is a forward-looking measure of interest rate volatility.

In particular, we collect daily volatility (bid close) quotes of at-the-money (ATM) one-year caps and floors for the U.S. and the Euro area from Reuters.<sup>13</sup> It is important to point out that these implied volatilities are used to obtain the prices of caps and floors by applying the well-known Black pricing formula. According to the Libor Market Model (LMM), the use of this pricing formula can be justified under the assumption that forward interest rates follow a lognormal stochastic process. Then, volatilities implied from caps and floors can be considered some sort of average of the instantaneous volatility of the logarithm of the forward rates up to the maturity of the contracts.<sup>14</sup> So these volatilities are forward-looking. This way, the one-year implied volatility represents the market estimation of the volatility of three-month forward interest rates over the next year.<sup>15</sup>

With respect to the estimation of the monthly average data on volatility from daily data, we proceed in a similar way as for interest rates for the U.S. and Germany. Thus, we use interest rate and volatility data that are available around one month before the CCI is published in the case of the U.S., and around three months before in the case of Germany.

In the U.S., the average level of consumer confidence remained just below the neutral 100 mark over the whole period. However, as suggested by the standard deviation, it was remarkably variable not only across the entire sample but also within the two subperiods. Thus, the differences in the index level before and during the crisis are noticeable: the mean of the index values dropped from 110.16 to 58.66. It is not the case for Germany, where consumer confidence stayed on average around 92 over the two subperiods. The yield spread between the 12- and the three-month interest rates was three times higher during the crisis period than before in Germany, and nearly 50 percent higher in the U.S. Statistics also show that the monthly difference in the three-month interest rate series was more stable in both countries before the crisis burst out. The average implied volatility level and its standard deviation were greater in the U.S. than in the Eurozone throughout the sample period and in both subperiods. Moreover, as expected, interest rate volatility was noticeably higher during the crisis period than before in the U.S. and Germany: more than 3.5 and two times higher, respectively. The autocorrelations show that consumer confidence indices and implied volatilities are the most persistent series in both countries.

<sup>12</sup> Dotsey (1998) and Hamilton and Kim (2002), for instance, use the change in the Federal funds rate as a measure of changes in monetary policy.

<sup>13</sup> Quotations for countries that belong to the Euro area are just provided for the whole of the Eurozone.

<sup>14</sup> See, for instance, Brigo and Mercurio (2001) for a comprehensive overview of caps (floors) valuation within the LMM framework.

<sup>15</sup> Caps and floors with terms to maturity of one year from the U.S. and Euro area markets have a three-month tenor.



In order to obtain an appropriate specification of our regression equations, that will be tested over the pre-crisis and the crisis periods, we further investigate the stationarity of the series over both subperiods by conducting the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) stationarity test (specified with and without a time trend).<sup>16</sup> The null hypothesis of stationarity is accepted at the 1% level for both specifications of the test for the four series in both countries over the first period. From the KPSS test performed over the second period, the null hypothesis is also accepted in all the cases, with the possible exception of the implied volatility for the U.S. where the evidence is mixed. Nonetheless, results from the test should again be considered with caution due to the well-known limited power of stationarity and unit root tests when conducted on small size samples.

## The information content of interest rate volatility on economic agents' expectations

Figures 1 through 6 show CCI against the yield spread (*spread*), the change in the three-month interest rate ( $\Delta R$ ), and the one-year implied volatility (*ivol*) for the U.S. and Germany, respectively, for the overall period. In addition, Table 1 shows the linear correlation coefficients between CCI and the explanatory variables the index will be regressed on, for both countries and for the two subperiods we divide the sample into. Results show that there exists a positive relationship between the German CCI and the yield spread, but this is weaker since the beginning of the crisis. Unexpectedly, we obtain the opposite sign for the U.S. before and during the crisis, where the linear fitting releases a correlation coefficient of -0.54. CCI and the change in the three-month interest rate are positively correlated in Germany. In addition, the relationship is particularly strong during the crisis period: the correlation coefficient is 0.61. In the case of the U.S., we observe that after the burst of the crisis, the relationship between these two variables has inverted. Unlike correlation coefficients between CCI and the previous two variables, linear fitting results obtained for the one-year implied volatility are robust between countries: there exists a strong negative correlation between consumer confidence and volatility during the pre-crisis and crisis periods.

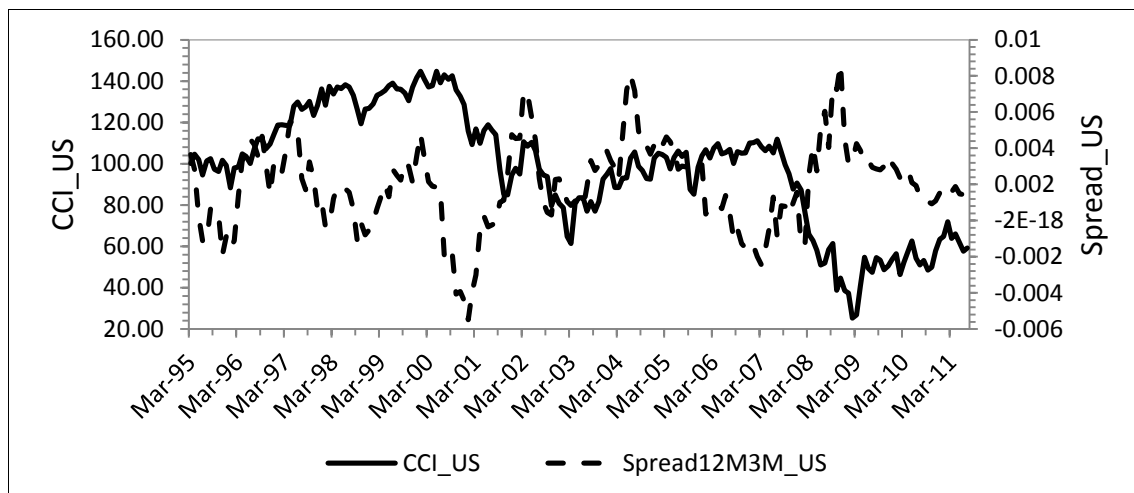


Fig. 1. The Conference Board CCI for the U.S. (line) and the yield spread between the 12- and three-month interest rates (dash)

<sup>16</sup> Results will be provided upon request.



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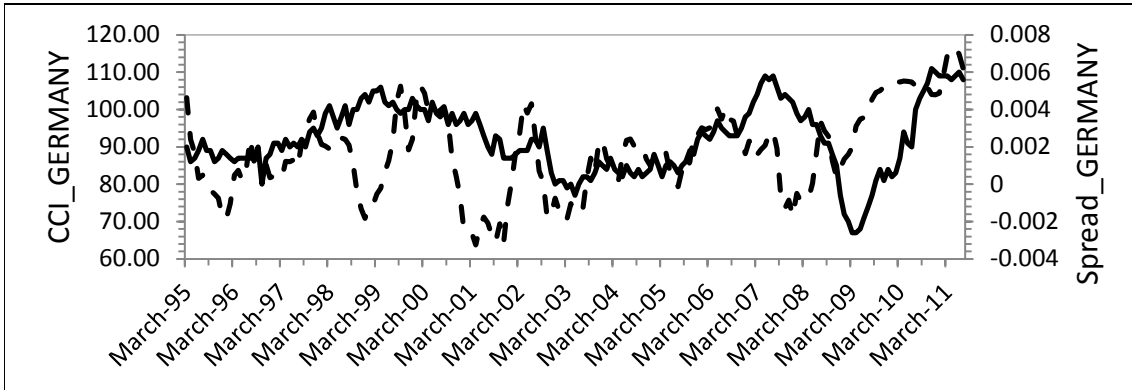


Fig. 2. The Icon CCI for Germany (line) and the yield spread between the 12- and three-month interest rates (dash)

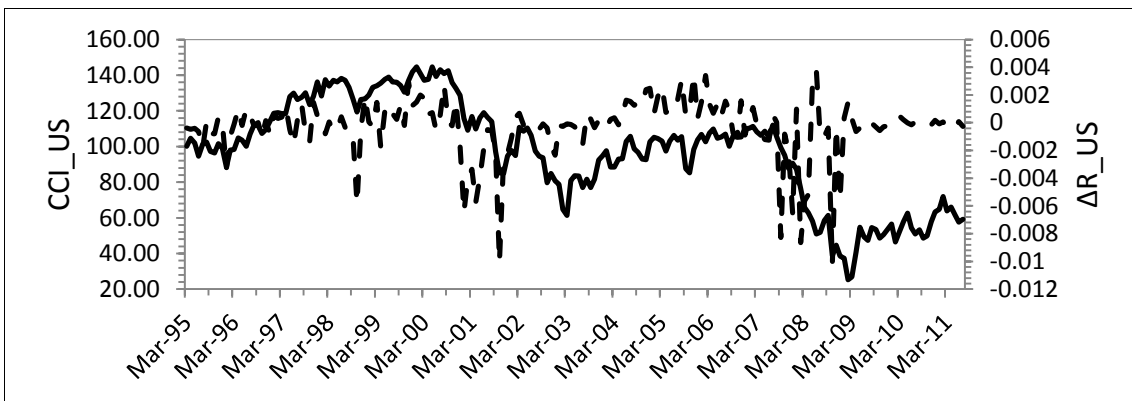


Fig. 3. The Conference Board CCI for the U.S. (line) and the change in the three-month interest rate (dash)

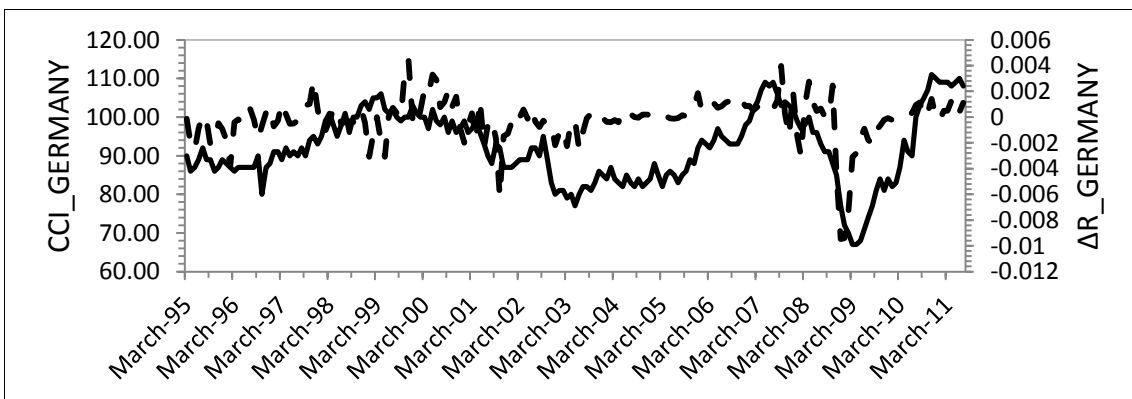


Fig. 4. The Icon CCI for Germany (line) and the change in the three-month interest rate (dash)

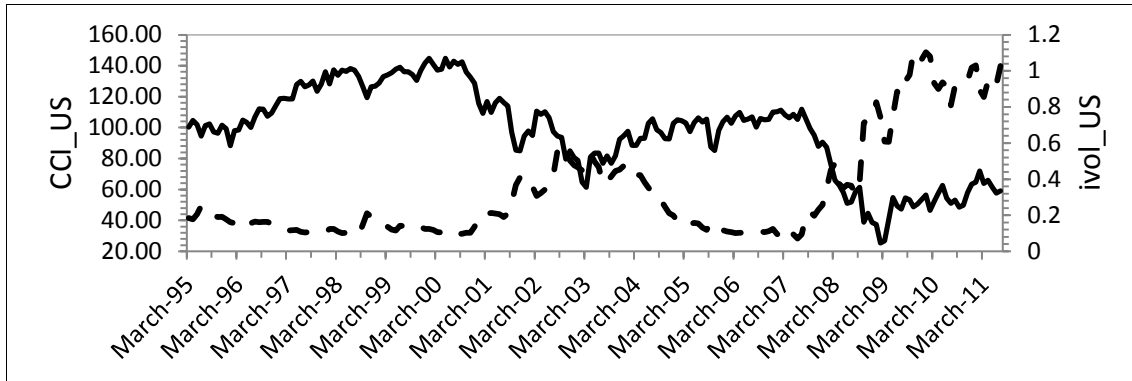


Fig. 5. The Conference Board CCI for the U.S. (line)  
and the one-year implied volatility (dash)

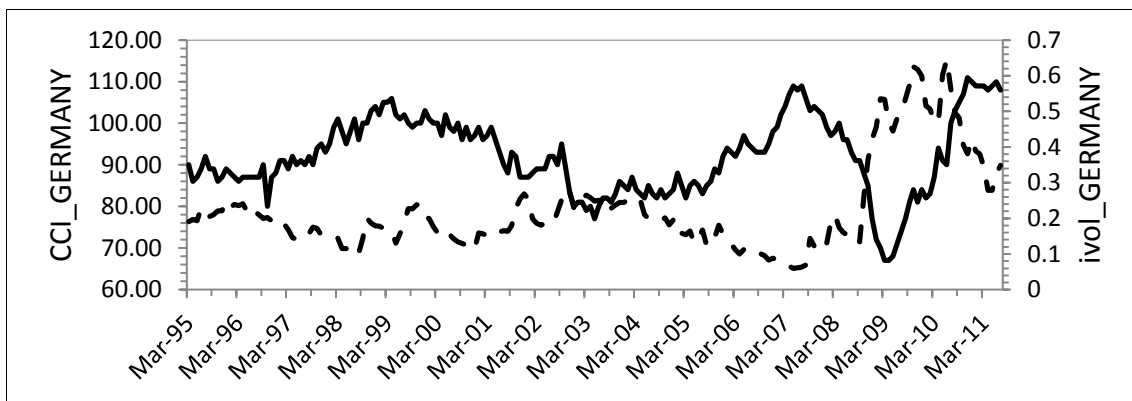


Fig. 6. The Icon CCI for Germany (line)  
and the one-year implied volatility (dash)

Table 1

Linear correlation coefficients between CCI and the explanatory variables<sup>a</sup>

	<i>spread</i>	$\Delta R$	<i>ivol</i>
United States			
Pre-crisis period (1995:03-2007:07)	-0.15	0.14	-0.69
Crisis period (2007:08-2011:07)	-0.54	-0.26	-0.53
Germany			
Pre-crisis period (1995:03-2007:07)	0.26	0.25	-0.59
Crisis period (2007:08-2011:07)	0.11	0.61	-0.48

<sup>a</sup> *Spread* is the difference between the 12-and three-month interest rates;  $\Delta R$  represents the change in the three-month interest rate; and *ivol* stands for the one-year implied volatility.





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Next, we estimate the first basic regression equation:

$$CCI_t / 100 = \beta_0 + \beta_1(R_t^{(12)} - R_t^{(3)}) + \beta_2\Delta R_t^{(3)} + \varepsilon_t, \quad (1)$$

where  $CCI_t$  is the Consumer Confidence Index for month  $t$ ;  $R_t^{(12)}$  and  $R_t^{(3)}$  are the monthly average data on the 12- and three-month interest rates, respectively, obtained as described in the previous section; and  $\Delta R_t^{(3)}$  represents the monthly change in the three-month interest rate.

Table 2

**OLS regression results based on Equation [3]<sup>a</sup>**

$CCI_t / 100 = \beta_0 + \beta_1(R_t^{(12)} - R_t^{(3)}) + \beta_2\Delta R_t^{(3)} + \varepsilon_t$				
	$\beta_0$	$\beta_1$	$\beta_2$	$\overline{R^2}$
United States				
Pre-crisis period (1995:03-2007:07)	1.11** (0.12)	-9.93 (10.78)	22.64 (14.34)	0.04
Crisis period (2007:08-2011:07)	0.71** (0.02)	-51.25** (7.29)	-20.35** (6.66)	0.45
Germany				
Pre-crisis period (1995:03-2007:07)	0.90** (0.05)	9.77 (6.25)	8.32 (5.38)	0.07
Crisis period (2007:08-2011:07)	0.90** (0.05)	6.04** (0.48)	31.49** (0.11)	0.34

<sup>a</sup> Inside the parentheses are standard errors computed using the Newey and West (1987) correction for autocorrelation and heteroskedasticity. One asterisk denotes statistical significance at the 5% significance level. Two asterisks denote statistical significance at the 1% significance level.  $\overline{R^2}$  is the adjusted coefficient of determination.

OLS regressions results based on Equation [3] for the U.S. and Germany over the pre-crisis and crisis periods are depicted in Table 2. Given the possible correlation between the explanatory variables, the change in the short-term interest rate is orthogonalized. In addition, since the Conference Board CCI measures expectations over the next six months and the Icon CCI does over the next 12 months, we consider that there exists overlap in the dependent variables of five and 11 months, respectively. Overlapping does not affect the consistency of the OLS regressions coefficients but does affect the consistency of the OLS standard errors. Thus, standard errors are corrected by using the Newey and West (1987) method of adjustment, including five lags in regressions for the U.S. and 11 lags in the case of Germany.

We find that the coefficients on the yield spread and the monetary policy variable are not different from zero at usual levels of significance during the pre-crisis period in both countries. Thus, the explanatory power of these regressions is low. However, the yield spread and the change in the three-month interest rate significantly help explain CCI during the crisis period. Particularly, both variables jointly are able to explain a striking 45 percent of the variation in CCI in the U.S., and more than 30 percent in Germany. In addition, as expected from the linear correlation analysis, we obtain that the coefficients on the yield spread and the short-term interest rate have opposite signs in these two countries: negative in the U.S. and positive in Germany.

Thus, two conclusions can be drawn from this analysis. On the one hand, we find that the yield spread coefficient remains significant for explaining consumer confidence when a monetary policy measure is also included in the regression. This suggests that information contained in the spread is not only a consequence of its link with monetary policy, but that it also reflects general economic conditions independent of monetary policy actions. This is in line with previous empirical evidence provided in different papers in which the dependent variable is some measure of output growth. On the other hand,



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results in this study suggest that these two variables significantly help capture consumer expectations only during the crisis period, although the sign of the coefficients is not robust between countries.

In the second basic regression equation we regress CCI for month  $t$ ,  $CCI_t$ , on the monthly average data of one-year implied volatility,  $ivol_t$ :

$$CCI_t / 100 = \gamma_0 + \gamma_1 ivol_t + \varepsilon_t, \quad (2)$$

Regression results on the information content of implied volatility for explaining consumer confidence are provided in Table 3.

Table 3

OLS regression results based on Equation [4]<sup>a</sup>

$CCI_t / 100 = \gamma_0 + \gamma_1 ivol_t + \varepsilon_t$			
	$\gamma_0$	$\gamma_1$	$\overline{R^2}$
United States			
Pre-crisis period (1995:03-2007:07)	1.31** (0.20)	-0.99* (0.49)	0.48
Crisis period (2007:08-2011:07)	0.81** (0.06)	-0.31** (0.06)	0.26
Germany			
Pre-crisis period (1995:03-2007:07)	1.06** (0.03)	-0.83** (0.15)	0.35
Crisis period (2007:08-2011:07)	1.07** (0.01)	-0.39** (0.05)	0.22

<sup>a</sup> Inside the parentheses are standard errors computed using the Newey and West (1987) correction for autocorrelation and heteroskedasticity. One asterisk denotes statistical significance at the 5% significance level. Two asterisks denote statistical significance at the 1% significance level.  $\overline{R^2}$  is the adjusted coefficient of determination.

In this case, we find that the coefficients on the implied interest rate volatility are negative and significant before and during the crisis in the two countries. That is, results suggest that volatility is a robust variable in explaining economic agents' expectations on the future state of the economy. In particular, implied volatility alone helps explain 35 percent of the variation in CCI before the crisis, and 22 percent during the crisis period in Germany. Results are more favorable for the U.S., especially before the crisis, where implied volatility alone is able to explain nearly an outstanding 50 percent of the variation in CCI.

At this point, we have obtained that the yield spread and the change in the three-month interest rate are useful for explaining consumer confidence after July 2007, and that implied volatility contains significant information on consumers' expectations during the two subperiods considered. Thus, we expect that volatility adds significantly to the yield spread and the change in the three-month interest rate for explaining consumer sentiment before the crisis. The most interest point that we want to check is whether uncertainty on the future development of interest rates also provides significant additional information beyond that contained in the previous two variables during the crisis periods. In addition, we want to investigate further whether implied volatility significantly outperforms a volatility measure based on historical data of interest rates.

Thus, the basic regression model depicted in Equation [3] is augmented by including the one-year implied volatility. That is, we estimate the following equation:

$$CCI_t / 100 = \beta_0 + \beta_1 (R_t^{(12)} - R_t^{(3)}) + \beta_2 \Delta R_t^{(3)} + \beta_3 ivol_t + \varepsilon_t, \quad (3)$$

where  $CCI_t$ ,  $R_t^{(12)}$ ,  $R_t^{(3)}$ ,  $\Delta R_t^{(3)}$ , and  $ivol_t$  are defined as before. In this case, in addition to the three-month interest rate, the implied volatility variable is also orthogonalized.



Results for the augmented regression equation in [5] are depicted in Table 4. As expected, implied volatility noticeably increases the in-sample forecasting accuracy obtained from Equation [3] before the crisis in both countries, but the adjusted  $R^2$ s are the same obtained when CCI is regressed only on implied volatility. The second part of the sample offers the most appealing results. They show that implied interest rate volatility lets enhance the explanatory power of the model including only the spread and the change in the short-term interest rate as explanatory variables in a 42 percent and a 58 percent for the U.S. and Germany, respectively. Particularly, the augmented model is able to explain a remarkable 64 percent of the variation in CCI for the U.S., and a 54 percent in the case of Germany.

Table 4

**OLS regression results based on Equation [5].<sup>a</sup>**

$CCI_t / 100 = \beta_0 + \beta_1(R_t^{(12)} - R_t^{(3)}) + \beta_2\Delta R_t^{(3)} + \beta_3ivol_t + \varepsilon_t$						
	$\beta_0$	$\beta_1$	$\beta_2$	$\beta_3$	$\overline{R^2}$	$\overline{R^2}^{[5]} / \overline{R^2}^{[3]}$
United States						
Pre-crisis period (1995:03-2007:07)	1.11** (0.09)	-9.93 (9.83)	22.64 (24.45)	-1.01** (0.34)	0.47	11.75
Crisis period (2007:08-2011:07)	0.71** (0.02)	-51.25** (3.67)	-20.35** (4.55)	-0.26** (0.03)	0.64	1.42
Germany						
Pre-crisis period (1995:03-2007:07)	0.90** (0.02)	9.77** (2.91)	8.32** (2.67)	-0.80** (0.18)	0.34	4.85
Crisis period (2007:08-2011:07)	0.90** (0.02)	6.04* (8.47)	31.49** (7.90)	-0.52* (0.20)	0.54	1.58

<sup>a</sup> Inside the parentheses are standard errors computed using the Newey and West (1987) correction for autocorrelation and heteroskedasticity. One asterisk denotes statistical significance at the 5% significance level. Two asterisks denote statistical significance at the 1% significance level.  $\overline{R^2}$  is the adjusted coefficient of determination; and  $\overline{R^2}^{[5]} / \overline{R^2}^{[3]}$  stands for the quotient between the adjusted coefficients of determination obtained from regressions based on Equation [5] and the adjusted coefficients of determination obtained from regressions based on Equation [3].

Finally, in order to compare the explanatory ability of implied interest rate volatility to that of the realized volatility, we also estimate the following model:

$$CCI_t / 100 = \beta_0 + \beta_1(R_t^{(12)} - R_t^{(3)}) + \beta_2\Delta R_t^{(3)} + \beta_3hvol_t + \varepsilon_t, \quad (4)$$

where  $CCI_t$ ,  $R_t^{(12)}$ ,  $R_t^{(3)}$ ,  $\Delta R_t^{(3)}$  are defined as in Equations [3] and [4]; and  $hvol_t$  stands for the historical volatility constructed as mean absolute deviations, over a one month interval, of daily logarithmic changes in the one-year interest rate<sup>17</sup>. Similar to Equation [5], the change in the three-month interest rate and the historical volatility are orthogonalized.

Table 5 reports the results. We find that historical volatility is negative and significant at usual levels of significance, except for the crisis period in Germany. Favorable to our expectations, we obtain that the in-sample forecasting ability of the model including the implied volatility outperforms the model including the historical volatility measure in all the cases. The explanatory power of the model including the implied volatility within the pre-crisis period is 42 percent higher than that of the model including the

<sup>17</sup> This is also the volatility measure employed in the work by Annaert et al. (2001). Poon and Granger (2003) provide an extensive review on the forecasting performance of various volatility measures and find that after implied volatility, the historical volatility provides the second best forecasting.



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historical volatility for the U.S., and 36 percent higher in the case of Germany. For the crisis period, adjusted  $R^2$ s from regressions based on Equation [5] for Germany and the U.S. are 63 and 33 percent, respectively, greater than those based on Equation [6].

Table 5

OLS regression results based on Equation [6]<sup>a</sup>

$CCI_t / 100 = \beta_0 + \beta_1(R_t^{(12)} - R_t^{(3)}) + \beta_2\Delta R_t^{(3)} + \beta_3 hvol_t + \varepsilon_t$						
	$\beta_0$	$\beta_1$	$\beta_2$	$\beta_3$	$\bar{R}^2$	$\bar{R}^{2[5]} / \bar{R}^{2[6]}$
United States						
Pre-crisis period (1995:03-2007:07)	1.11** (0.10)	-9.93 (10.48)	22.64 (18.16)	-14.33** (4.93)	0.33	1.42
Crisis period (2007:08-2011:07)	0.71** (0.03)	-51.25** (6.81)	-20.35** (3.28)	-2.74* (1.09)	0.48	1.33
Germany						
Pre-crisis period (1995:03-2007:07)	0.90** (0.00)	9.77** (2.60)	8.32 (4.79)	-11.83** (1.92)	0.25	1.36
Crisis period (2007:08-2011:07)	0.90** (0.03)	6.04 (30.50)	31.49** (9.37)	2.06 (9.63)	0.33	1.63

<sup>a</sup> Inside the parentheses are standard errors computed using the Newey and West (1987) correction for autocorrelation and heteroskedasticity. One asterisk denotes statistical significance at the 5% significance level. Two asterisks denote statistical significance at the 1% significance level.  $\bar{R}^2$  is the adjusted coefficient of determination; and  $\bar{R}^{2[5]} / \bar{R}^{2[6]}$  stands for the quotient between the adjusted coefficients of determination obtained from regressions based on Equation [5] and the adjusted coefficients of determination obtained from regressions based on Equation [6].

Thus, overall, results from this study suggest that implied volatility contains extra information for capturing consumer sentiment not already embodied in two traditional leading economic indicators of the business cycle: the yield spread and a variable that reflects the stance of monetary policy. In addition, these results are robust to the inclusion of the period associated to the current financial crisis. Given that we use interest rate and volatility data that are available at least three months before the consumer confidence indices are published, we are able to explain in advance an important percentage of the variability of the indices. Concerning the most suitable volatility measure for capturing uncertainty on interest rates, the results we obtain are quite concluding. As expected, a forward-looking measure of volatility is able to explain a greater percentage of the variation in CCI than a volatility measure based on historical data of interest rates.

## Conclusions

Since the late eighties, many papers have shown consistent empirical evidence on the usefulness of the slope of the term structure of interest rates (the yield spread) for predicting economic growth. Moreover, expectations are the foundation of the most widespread explanations on this forecasting ability. In this paper we want to implicitly check the hypothesis on the information content of financial variables for explaining economic agents' expectations by using another variable in addition to the yield spread: the interest rate variable. In particular, we analyze the ability of interest rate volatility to capture economic agents' expectations regarding future economic activity, and whether it provides extra information content over the yield spread.



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For this purpose we must decide how to measure expectations and volatility. For the first issue we employ consumer confidence indicators which contain consumers' expectations over the near-future (six or twelve months) concerning micro- and macro-economic aspects over which they have no control. Concerning the second non-observable variable, we suggest using a forward-looking measure of volatility not based on historical data of interest rates. This is the volatility implied from the market prices of caps and floors according to the Black-pricing formula. Thus, it can be understood as an estimation of the average future volatilities of a set of forward interest rates with consecutive terms to maturity up to the expiration date of the contracts. That is, it reflects the market consensus on the uncertainty regarding the future development of one of the most important financial variables: interest rates.

Outcomes from this study suggest that implied volatility is a robust variable for explaining consumer sentiment before and during the crisis both in Germany and the U.S. As expected, there exists a significant negative relationship between consumer sentiment and interest rate volatility. In addition, we find that implied volatility can add significant explanatory power to the yield spread in order to explain economic agents' expectations of future economic growth. Moreover, the in-sample forecasting accuracy of the model including the implied volatility as the volatility measure is always greater than that obtained when a realized volatility measure is used instead. Thus, it seems to support the extra information content of a forward-looking measure of volatility on economic agents' expectations.

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