Relating Interest Rate Swaps Volatility and Macroeconomic Uncertainty in Europe

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This paper explores how the volatility of interest rate swaps (IRS) is affected by macroeconomic risks in Europe (UK, France, Germany, Spain and Portugal) using monthly data from April 1993 to December 2012. This issue has become more important since the global financial credit crunch due to the increased use of IRS to manage other financing costs. Additionally, the IRS market has been marked by economic events and institutional changes, especially in Europe. Empirical results illustrate: that interest rates are the macroeconomic risk/uncertainty variable which most influences IRS volatility; that financial market variables influence IRS more than macroeconomic variables; and that interest rate (IR) levels are more indicative than IR volatility in explaining investors' behaviors during the financial crisis period. As such, macroeconomic, financial and monetary policy risks lead to greater levels of hedging and speculative activities in financial markets through the greater use of IRS volatility. Moreover, macroeconomic uncertainty impacts depend upon the country under analysis, its development level, and the maturity of the IRS. Looking at the volatility impact of macroeconomic risks over IRS volatility allows hedgers to forecast macroeconomic fluctuations and fix swap rates of maturities which have a stronger relationship with macroeconomic risk proxies.

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1. Introduction

Interest rate swaps (IRS) are plain vanilla derivatives agreed between two parties to periodically exchange fixed-for-floating payments based on a fixed notional amount or principal. Among derivatives, swaps, whose trading began in 1981, are now one of the most recognized (Azad et al., 2012). A company typically uses IRS to limit or manage exposure to fluctuations in interest rates, or to obtain a marginally lower interest rate than it would have been able to get without the swap. In addition to risk management (Allen et al., 2013) and speculative purposes, IRSs can be used to manage interest rate borrowing costs, convert fixed borrowing costs to floating rate borrowing costs, or vice-versa.

IRS became even more common since the global financial credit crunch to manage other financing costs, as pointed out by Ashton et al. (2012). And, it is known that financial markets respond to external forces - this is known as systematic risk. Macroeconomic risk is the uncertainty or volatility associated with macroeconomic variables (Azad et al., 2011) like volatility of industrial production, volatility of CPI, volatility of interest rate, etc., measuring the size and magnitude of macroeconomic aggregates surprises over the year. Daily data for a set of European countries were used to infer if IRS volatility could be explained by macroeconomic risk, using closing mid-rates on IRS variable maturities (which ranged from 1 to 10 years). It is important to study this relationship because macroeconomic risk/volatility is considered central to market risk which influences asset pricing. Besides, the bigger the macroeconomic risk, the greater the use of derivative instruments to hedge or speculate, especially in countries facing financing restrictions during crisis periods. Looking back, the IRS market has been marked by economic events and institutional changes in

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minor ways all around the world.

Although not the same as risk, volatility can be interpreted as uncertainty; thus, it can be considered a valuable input for investment decisions and portfolio creation. Given that investors and portfolio managers have certain levels of risk which they can tolerate, having good forecasts of asset prices volatility during the investment period would be valuable to assess investment risk. Moreover, as stated by Poon and Granger (2003) "volatility is the most important variable in the pricing of derivative securities, whose trading volume has quadrupled in recent years" (p. 478).

Following Cowen (2009), exploring the empirical relationship between derivatives and macroeconomic uncertainty is doubly essential as far as financial and economic crises are concerned. Keeping this in mind, European markets were selected for this study, because in Europe, some of the countries analyzed are facing financing restrictions and fiscal and monetary policy contractions within their economies. Moreover, we need to consider that the underestimation of macroeconomic risk is one of the major sources of the current global financial and economic crisis. Therefore, placing due emphasis over macroeconomic risk is important, given that IRS is an interest rate-sensitive product.

Black (1987) suggested that macroeconomic risk (or volatility) and investment activities are positively correlated, which can also be applied for the swap rate model (Azad et al., 2011). Following their way of thinking, there is a higher or lower incentive for hedgers to use swaps if the macroeconomic volatility is higher or lower, respectively. Similar to Azad et al. (2011; 2012), the statistical and economic relationship between the volatility of macroeconomic fundamentals and that of IRS were both analyzed - this time considering European countries.

The present study is a contribution to the ongoing exploration of the effect of macroeconomic fundamentals volatility over IRS volatility, since it explored the European IRS market using IRSs for countries with different characteristics, including France, Germany, and the UK. These countries each maintain more developed financial markets, and belong to the top 10 countries list in derivatives usage. Portugal and Spain were also analyzed, which are facing high macroeconomic (both economic and financial) risks and, in comparative terms, have lower developed financial markets. In addition, the market index volatility was included as an explanatory variable in order to explain IRS volatility. This link between IRS volatility and macroeconomic uncertainty has practical implications, especially for this set of countries. Market makers, speculators and hedgers use the swap rate as a benchmark for pricing long-term interest rates, corporate bonds and various other securities available in the market, and should thus be aware of their impact when forming investment portfolios. Swaps also help in the overall risk management of financial resources. As such, they are useful tools not only for corporate treasures, but also for banks, portfolio managers, central bankers and monetary authorities. All of these entities trade such contracts to reach lower costs of funds, to obtain higher return rates, to better manage interest rate exposure or even for risk currency diversification purposes. As argued by Bhargava et al., (2012) swap rates are a proxy for credit risk, and monetary authorities should be aware of the determinants of swap rates to formulate appropriate interest rate policies. For Azad et al. (2011), swap instruments are more effective tools for hedging, as compared to futures or options, for horizons of more than two or three years. Moreover, Smith et al. (1986) highlighted that using swaps offers can act beneficially, as financial arbitrage, tax and regulatory arbitrage, management exposure and completing markets.

Results obtained in this study conclude that interest rates are the macroeconomic risk/uncertainty variable which most influences IRS volatility independently of the country and swaps maturity. Macroeconomic variables do influence IRS volatility, but those related to financial markets exert a higher influence. In Germany, UK and France, which have more liquid and developed financial markets, IRS volatility is positively influenced by the interest rate (IR) slope. Although some results may be generalized in terms of macroeconomic influence over IRS volatility, there exists instability in terms of market/country and IRS maturity. When using IR level and volatility, results revealed that investors changed their behavior from the financial crisis period onwards, suggesting that they remained concerned with IR levels, despite the fact that the

importance of IR volatility decreased. Lastly, results may offer an argument that macroeconomic, financial and monetary policy risks lead to greater levels of hedging and speculative activities in financial markets, meaning a greater use of IRS and/or derivatives.

The rest of the paper is structured as follows. Section 2 provides a brief literature review concerning the issue of IRS volatility and macroeconomic influences. Data descriptions, descriptive statistics, and the methodology used is explained in Section 3, and the results are presented in Section 4. Section 5 concludes this work with an interpretation of these results.

2. Literature Review

It is important to study the macroeconomic determinants of IRS volatility, given that IRSs are interest rate-sensitive products. As such, this volatility is expected to be a highly positive influence over IRSs, and to have a closer link to macroeconomic fundamentals than other derivative products. Pertaining to past available data, the swap market has strongly evolved and is even more liquid than other financing assets, such as bonds (ISDA, 2009). The Derivatives Usage Survey 2009 points out that 94% of the world's largest companies use derivative instruments to manage and hedge their business and financial risks, and 70% to 94% of the respondents assumed to use interest rate derivatives. In this brief report it is possible to verify that UK (34%), Germany (36%) and France (39%) are on the list of the 10 top countries that use more derivatives. In 1988, the Financial Executive argued that the continued growth of the financial swaps market was due to the degree of interest volatility and currency rates. In the Financial Executive article, it is stated that "swaps have contributed to the integration of international money, capital and foreign exchange markets," while they have also increased available options for participants.

In the literature surrounding the issue, we found different points of view with respect to the use of interest rate swaps. Fabozzi et al. (2005) employed IRS to mitigate exposure to interest rate volatility; Yu et al. (2004) used IRSs to reduce borrowing costs; and Belton and Wadhwa (2002) used IRSs to improve portfolio returns. In Fehle (2003), IRSs were used for price bonds and derivatives securities. Bhargava et al. (2012) and In (2007) both used IRSs to study volatility transmissions and swap markets integration; and Mitra et al. (2013) made use of IRSs to exploit inefficiencies in pricing and managing credit risk. Preceding authors like In et al. (2003a), Malhotra et al. (2005), Liu et al. (2006) and Cortes (2006) supported the rationale that swap pricing should reflect interest rate volatility, counterparty credit risk, liquidity premiums for government securities and other market frictions in the swap market.

Anatoli (1994) concluded that interest rate swaps expand a firm's financing choices, which allows the undertaking of investments that would otherwise not be possible. In this sense, IRS may be a leeway for countries with fairly limited access to cheap capital (like Portugal and Spain at this stage) to have precious, high-risk financing opportunities. To examine volatility spillovers of US dollar IRSs into the Indian IRS volatility, Bhargava et al. (2012) employed GARCH, EGARCH and TGARCH models. A unidirectional impact from the US market into the Indian market was found, and was revealed to be asymmetric for one-year swaps but not for five-year swaps.

We also found in the literature several attempts to study swap spread determinants. These emphasize the importance of variables like counterparty default risk, liquidity premium, slope and level of term structure of interest rates and market microstructure as factors influencing swap spreads (Duffie & Singleton, 1997; Fehle, 2003; In et al., 2003b; Cortes, 2006; Huang & Chen, 2007). Globalization turned markets higher, allowed a higher use of debt for project financing and increased firms' interest rate exposure. Bodnar et al. (1996) pointed out that interest rate derivative usage is related to interest rate risk management, but also to the reduction in financing costs, when used together with debt-financing. A floating exchange rate regime, especially in developed countries, results in frequent shocks or unanticipated exchange rate changes. These shocks affect firms' long-term future cash flows and change firms' values. As such, looking at the volatility impact of macroeconomic risks over IRSs allows hedgers to forecast macroeconomic fluctuations and fix swap rates of maturities which have a stronger relationship with macroeconomic risk proxies.

It is possible to find studies which have focused on the determinants of IRS spreads. Toyoshima (2012) examined the determinants of US IRS spread accounting for time series nonstationary. Empirical results reveal that there exists a cointegration relationship between IRS spreads and the corporate bond spread, the slope of the yield curve, the T-Bill and Eurodollar spread, and yield volatility. Previously, Lekkos and Milas (2001) used as factor proxies the level, volatility and slope of the zero coupon government yield curve as well as the T-Bill Libor spread and the corporate bond spread to identify a pro-cyclical behavior for short-term maturity US swap spreads, and a countercyclical behavior for longer maturity US swap spreads. Later, Fehle (2003) provided both a theoretical and empirical analysis of the components of IRS spreads in seven countries (US, UK, Japan, Germany, France, Spain and the Netherlands) to conclude that expected Libor spreads, default risk and market structure are components of swap spreads. Huang and Chen (2007) analyzed the asymmetric impacts of various economic shocks on swap spreads under distinct federal monetary policy regimes. Their results indicate that during periods of aggressive interest rate reductions, the slope of the treasury term structure accounts for a sizeable share of the swap spread variance, that the liquidity premium is the only contributor to the two-year swap spread variance in monetary tightening cycles, that the impact of default risk varies across both monetary cycles and swap maturities, and that the effect of interest rate volatility is generally more evident in loosening monetary regimes. In that same year, Ito (2007) investigated the determinants of Japanese swap spreads, choosing the Eurodollar (TED) spread, corporate bond spread, interest rate, and the slope of the yield curve. Previously, Marshall and Ho (2006) examined UK swap spread determinants, considering the interest rate, the slope, the curvature of the yield curve, corporate bond spread, and TED spread, to conclude that interest rates, credit and liquidity risks are the main factors driving swap spreads.

Chung and Chan (2010) investigated the determinants of US swap spreads based on the development of the swap market and the major events that happened between 1991 and 2006. They found that changes in swap spreads are jointly determined by the liquidity premium, interest rate level, default risk premium and the business cycle. For this same market, Ito (2010) investigated the determinants of IRS spreads during a period that included the financial crisis. The study focused on the asymmetric impacts of default risk, slope of the yield curve, the T-Bill and TED spread and volatility, by dividing the whole sample period into two sub periods. Apart from Ito (2010), no other empirical study focused on interest rate swap spreads during a period that included the financial crises, besides Toyoshima (2012). However, these studies have established the importance of macroeconomic news on IRS spreads. To our knowledge, very few studies have investigated the extent of the impact of specific macroeconomic news on IRS volatility, which is still not well understood.

Both Azad et al. (2011; 2012) studies are related to the present analysis. Using the Japanese yen IRS volatility, Azad et al. (2011) used low-frequency volatility extracted from aggregate volatility shocks in the interest rate swap market to verify if it could be explained by macroeconomic risks. The authors related macroeconomic risks through a fundamental variables variance. They showed that IRS volatility has a strong and positive association with the consumer price index, industrial production, foreign exchange rate, slope of the term structure and money supply. Still, IRS volatility in Japan was found to have a negative association with the unemployment rate. Their main conclusion stated that the higher the macroeconomic risk, the higher the usage of interest rate swaps to hedge or speculate. However, the relationship between macroeconomic risks and IRS volatility varies across different swap maturities (3, 5, 7 and 10 years), while being robust to different volatility specifications. One year later, Azad et al. (2012) extended their analysis to the UK and US markets, using a different method to extract low-frequency volatility and using solely 5- and 10-year IRS maturities. Conclusions undertaken for both markets were basically the same as those for Japan. Further research on the volatility effect of different macroeconomic news arrivals therefore is warranted, especially because previous studies tend to examine each market in isolation.

3. Data, Methodology and Descriptive Statistics

Daily closing mid rates on swap maturities of 1, 3, 5 and 10 years in Germany, France, UK, Portugal and Spain were collected from Datastream to estimate volatility of IRS. The log's first difference of daily prices was used to compute daily swap rate returns for each swap maturity and country. To maintain consistency with end-of-month observations of macroeconomic fundamentals collected, we used the last available observation in a given month for IRS. In the former, we used the autoregressive model of order one, exponential generalized autoregressive conditional heteroskedasticity [AR(1)-EGARCH(1,1)] to obtain conditional volatility for both dependent and independent variables. Whenever disposable, monthly macroeconomic variables/proxies were obtained from the European Central Bank (ECB) website, for the period from April 1993 to December 2012. When not available, macro series were complemented with Datastream data. Given the data availability, it wasn't possible to have the same timespan for all series. In this case, estimation periods needed to be shortened, as is evident from the number of observations presented in the table 3 results. This was observed especially for one-year IRS data in all countries. Following Azad et al. (2011) and for a robustness check, two alternative measures of volatilities for each of the variables have been used. Results for both GARCH(1,1) and TGARCH(1,1) – Threshold – models were not presented here to save space, and because they have revealed less consistency in estimates. The following section explains the reasoning for using industrial production (IP), the consumer price index (CPI), the market index return (MI), the exchange rate (EX), the interest rate (IR), the slope of the yield curve (SIR), money supply (M2) and the unemployment growth rate (UR).

The analysis is separated as follows: 1) into financial market volatility, proxied by interest rate (both in level/return and its volatility, using the short-term bond index yield for three-months), market index return volatility and the slope of the yield curve computed as the difference between long-term and short-term Treasury Bond yield; 2) into macroeconomic risk, proxied by the volatility of industrial production, the volatility of the consumer price index (seasonally adjusted), the foreign exchange volatility - whose volatility considered was the option-implied volatility obtained from the real effective exchange rate, and the unemployment growth rate measured by changes in the seasonally-adjusted unemployment rate; and 3) into monetary policy shocks, proxied by money supply which was computed as percentage changes from the previous month in average amounts of outstanding/money stock, the interest rate and the slope of the yield curve, both already described. These variables were used due to their previously proven relevance in explaining IRS market movements, volatility and other kinds of financial markets (Azad et al., 2011; 2012; Sahu, 2012).

Hypothesis 1: Market index (MI) volatility has both a positive and negative impact over IRS volatility.

It seems rational to assume that market indices and derivatives usage have a straight relationship. Beber and Brandt (2009) indicated that macroeconomic uncertainty leads to a greater degree of hedging or speculative activities in financial markets through derivatives. Nevertheless, the empirical evidence has been inconclusive with respect to this signal relationship. According to Bessembinder and Seguin (1992), the volatility of the underlying market increases after the introduction of equity derivatives. Contrarily, and for the Indian market, Sahu (2012) and the references provided by the author, concluded that the introduction of equity derivative trading reduces spot market volatility. By introducing stock derivative instruments, speculative trading can be diverted towards derivatives. This would make it easier for investors to select the level of portfolio risk that they are able to bear, whereas any risk beyond this level may be hedged away. On the other hand, an introduction of derivatives may improve the speed and quality of the information flowing in the spot market. This introduction could enhance market depth, increase market liquidity, and reduce information asymmetries, since it should reduce spot market volatility.

A negative impact of stock market volatility over IRS volatility is expected, because when an economy is in recession, there is less economic activity, less investment and less of a preference for derivative instruments, thus lowering IRS volatility. At the same time, this should increase the

market index volatility. As such, it could also be expected to be a positive influence on the market index volatility over IRS volatility through the increased volume of IRS trading activities. Given this different reasoning, the present work introduces the market index for each country as an explanatory variable in regression estimates about IRS volatility. The final impact, in terms of expected signs, should be initially inconclusive.

Hypothesis 2: IRS volatility can be both inversely or directly associated with the volatility of Industrial Production (IP).

It would be better to use the GDP growth rate volatility to relate the economic environment with that of IRS volatility. However, the main macroeconomic variable used to study IRS volatility is a proxy for the variability of GDP growth rate volatility, which is the volatility of the industrial production index. The rationale for examining the IP instead of the GDP is due to the fact that IP is available in monthly terms and the latter only quarterly. Looking at previous empirical findings, Diebold and Yilmaz (2008) argued that IP volatility provides a good measure of macroeconomic uncertainty, which may raise financial markets volatility. In opposition, Engle and Rangel (2008) offered results supporting a negative relationship. The authors stated that this is not necessarily bad provided that GDP is considered a measure of a country's overall economic performance. Thus, the higher the growth rate, the lower the macroeconomic uncertainty and default probability. This can be extended to that of swap counterparties, and IRS volatility should be expected to be inversely associated with IP volatility. As such, the GDP or IP variability increases the probability of default, raising default risk probability and also interest rates (Genberg and Sulstarova, 2008). However, facing a volatile macroeconomy, investors fear such volatility; in fact, IP volatility could increase that of swap markets instead of reducing it. This argument favors our initial expectation of both a positive and negative relationship between both variables.

Hypothesis 3: Unanticipated changes in CPI will be positively related with IRS volatility.

It may be argued that the consumer price index (CPI) measures overall economic activity given that when the economy is up, consumers have higher propensity to invest and consume. Fang et al. (2012) examined the effects of macroeconomic fundamentals on swap spreads under different economic states for Australian dollar IRS spreads. They examined news of money supply growth, unemployment rates, and CPI. They stated that a rise in inflation may lead to higher interest rates during expansions than during contractions. Given these conclusions, when an economy is expanding, more economic activity is expected, including more investment, a higher consumption level and also a higher preference for derivatives. Furthermore, information revealed by unemployment news appears to relate to short-term interest rates while those from CPI tend to be associated with long-term interest rates and perhaps corporate earnings (Fang et al., 2008). Therefore, the initial prediction will be that of a positive influence of CPI volatility over IRS volatility.

Hypothesis 4: An unanticipated change in money supply (M2) will have a significant and positive impact on IRS volatility.

Monetary policy shocks are transmitted to IRS volatility following several channels, including treasury interest rates (Azad et al., 2011). Both short- and long-run effects exist.

Considering the short run, money supply increases through increased M2, interest rates decrease due to excess supply, the yield curve slope is affected and so are swap markets. In the long run, interest rates increase in anticipation of future interest rate tightening due to the central bank counterpart, following the consequential inflation increase, and as such market makers' hedging costs and volatility will increase (Brown et al., 1994). If inflation rises, this will lead to increased IRS activities, thus increasing volatility. Following the ideas of Engle and Rangel (2008) and the predictions of Azad et al. (2011), a positive association between IRS volatility and monetary policy shocks are expected, as measured by M2 changes.

Hypothesis 5: Both interest rates' levels and their volatility exert a positive influence over IRS volatility.

Following the rationale provided to justify the impacts of money supply and CPI over IRS volatility, it is also important to take into account interest rate volatility. When it is higher, then

higher demand will exist for swap products in order to hedge or reduce IR exposure, as mentioned by Lekkos and Milas (2001). Given that the higher the IR, the higher the use of IRS, a positive influence of IR volatility over IRS volatility should be initially expected. But not only should volatility exert a positive influence: the level of IR is also considered. We use both measures, considering that investors are aware of IR levels even when IR volatility changes. Whereas IR volatility may decrease or increase due to a changing economic environment, the IR level and its future expectations will have a significant influence over investors' decisions to trade IRS. Considering IRS spreads, Eom et al. (2000) found that interest rate levels are negatively related to Japanese Yen swap spreads, not providing a theoretical explanation, while Fang and Muljono (2003) found that interest rate levels are positively related to changes in Australian swap spreads.

Hypothesis 6: The interest rate slope (SIR) is also positively related to IRS volatility.

As in Hypothesis 5, Hypothesis 6 tested the influence of the yield curve slope over IRS volatility. The slope is computed as the difference between long- and short-term government bond yields, as seen in the literature, especially those that applied to the determinants of IRS spreads (In et al., 2003a, b; Azad et al., 2011, 2012; among others). When considering the slope, it is possible to predict future expected interest rates and economic expansions or recessions. As a result, a positive slope indicates a future IR increase, implying more demand for hedging and speculation, which will increase IRS volatility.

Hypothesis 7: Exchange rate volatility positively impacts IRS volatility.

The exchange rate volatility is also considered an explanatory variable which represents macroeconomic uncertainty. Having an extremely volatile exchange rate implies higher demand for payer positions among cross-border counterparties, which positively impacts IRS volatility, especially if dealing with counterparties of the swap contract originating from different countries. As pointed out by Simpson et al. (2005) and Azad et al. (2011) the exchange rate can be affected by inflation, interest rate differences or even foreign exchange carry trades.

Hypothesis 8: Unexpected changes in the unemployment rate can have a positive or negative relationship with IRS volatility.

The unemployment rate can also be considered a proxy for macroeconomic fundamentals volatility. Together with industrial production, the unemployment rate may provide an overall picture of the economy. Lang et al. (1998) used the unemployment rate as a proxy for the business cycle, concluding that swap market spreads contain a pro-cyclical element. This argument is in favor of IRS volatility being positively related to the unemployment rate. So, when an economy is in recession, then less economic activity is present, along with less investment, a higher unemployment rate and lower preferences for derivatives, since investors will have a lower incentive to hedge against rising rates risk. But, a negative association between the unemployment rate and IRS volatility may also be observed. The initial prediction for the sign of this variable will in principal be unidentified.

After having presented the rationality for the selection of variables to be studied under the hypotheses presented, the study next describes the methodology used. Variances are not constant over time and many financial assets return series exhibit volatility clustering. As such, volatility should be modeled using past volatility to forecast future volatility. By analyzing financial derivatives like swaps, periods of larger or smaller unpredictable market fluctuations exist, known as heteroskedasticity (related to the fact that the size of market volatility tends to cluster in periods of high and low volatility). When using volatility instead of variables levels, both the size and magnitude of macroeconomic aggregate surprises over financial market volatility (which change over time) can be measured. Here several classes of autoregressive conditional heteroskedastic models are used, although EGARCH was revealed to be more accurate in measuring volatility.

By using standard GARCH models it is assumed that positive (good news) and negative (bad news) error terms have the same symmetric effect over volatility. Moreover, GARCH ignores the sign of the distribution and squares shocks, and forces them to be positive. However, IRS volatility may increase more with bad news than with good news (the leverage effect), which can be captured

through the exponential GARCH (EGARCH) model which allows for logarithmic leverage effects over the conditional variance specification; therefore, nonnegative forecasts of the conditional variance are ensured. Moreover, the model allows for asymmetric shocks in the sense that downward movements in the series are followed by higher volatilities than upward movements of the same magnitude.

The AR(1) - GARCH(1,1) model is specified as follows:

$$\begin{aligned} \Delta y_t &= c + \delta \Delta y_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma_t^2) \\ h_t &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{1}$$

where the first equation is the mean equation and the second the conditional variance equation; Δy_t is the first difference in the IRS return; c is the constant; Δy_{t-1} is the previous period's first difference in IRS returns; ε_t is the error term, assuming it follows a t-distribution; and h_t stands for the conditional variance. The AR stands for the autoregressive process of order 1, meaning that the first lag of the dependent variable is also used as a regressor. By changing the spillover equation we can surpass the major problems associated with the use of this standard model. In the EGARCH(1,1) setting, the spillover equation becomes:

$$\ln h_{t(spillover)} = \alpha_0 + \beta_1 \ln h_{t-1} + \alpha_1 \left| \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right| + \alpha_2 \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \tag{2}$$

where ln h_t is the natural log of variance, which automatically restricts the volatility to be positive, and $\beta_1 \ln h_{t-1}$ explains consistency, given that it is a function of volatility. The presence of leverage effects is tested by the hypothesis that $\alpha_2 = 0$, being the impact asymmetric if this parameter is different from zero. If the effect is less than zero, this implies that a negative shock will increase the predictable volatility by more than it would for a negative shock.

Having defined our volatility specification, the models seen in Engle and Rangel (2008) and Azad et al. (2011; 2012) were followed. As such, IRS volatility is modeled as a function of macroeconomic fundamentals uncertainty, as previously defined. Equation (3) presents the time series OLS regression for each of the swap maturities and market:

$$\begin{aligned} IRS_{i,t} &= \alpha_{i,0} + \beta_{i,1} CPI_t + \beta_{i,2} IP_t + \beta_{i,3} IR_t + \beta_{i,4} EX_t + \beta_{i,5} SIR_t + \beta_{i,6} UR_t + \\ &+ \beta_{i,7} M2_t + \beta_{i,8} MI_t + \varepsilon_{i,t} \end{aligned} \tag{3}$$

where IRS stands for interest rate swaps volatility of maturity i in period t; CPI is the volatility of the CPI; IP is the volatility of industrial production; IR is the interest rate in levels/returns where it is also used for a robustness check of the variable IRV, which is the volatility of the interest rate instead of IR; EX is the volatility of the exchange rate; SIR is the IR term structure slope; UR is the unemployment growth rate in the first differences, because in the levels it is revealed not to be stationary; M2 is the money supply change; and MI is the volatility of the stock market index.

Table 1 presents the summary statistics for all the variables considered in the analysis, by country. The Pearson correlation values among variables, by country, are presented in Table 2.

In each of the countries, all variables were revealed to have positive means, except the unemployment rates in Germany and UK. A decreasing standard deviation with IRS maturity in Portugal was observed, and if we measure volatility by standard deviation values, it may be argued that volatility is more important than the IRS maturity contract. The IRS standard deviation is higher for 1-year IRSs in Portugal and UK, for 3- and 5-year IRSs in Spain, for 1- and 10-year IRS volatility in Germany, and for 1- and 5-year IRS volatility in France. The values for skewness and kurtosis - independent of the variable considered, or the country - reveal that the variables under study do not follow a normal distribution. This is also confirmed by Jarque-Bera test values. From the variables representing macroeconomic volatility or uncertainty, those with higher means in Portugal, Spain and UK include: the exchange rate, the slope of the yield curve, and the market index risk measure;

Table 1
Descriptive Statistics by Country and Variable

PORTUGAL	IRS_1Y	IRS_3Y	IRS_5Y	IRS_10Y	CPI	IP	IR	EX	SIR	UR	M2	MI
Mean	0.22	0.24	0.23	0.17	0.38	1.52	0.00	2.92	2.32	0.05	1.22	5.28
Maximum	2.30	1.35	1.09	0.51	0.58	2.70	0.01	4.67	15.02	0.57	2.11	12.33
Minimum	0.12	0.18	0.17	0.12	0.23	0.79	0.00	2.35	-0.57	-0.40	0.59	2.90
Std. Dev.	0.18	0.10	0.08	0.04	0.07	0.32	0.00	0.38	2.84	0.15	0.28	1.65
Skewness	7.94	8.29	7.66	3.60	0.16	1.29	2.54	1.14	2.13	0.42	0.03	1.35
Kurtosis	84.34	87.11	75.72	25.80	2.86	4.75	9.19	5.19	7.19	3.87	3.43	5.35
Jarque-Bera	58992.80	66173.10	49733.30	5151.60	1.10	88.30	580.70	90.30	323.00	13.20	1.70	115.90
SPAIN												
Mean	0.22	0.32	0.24	0.21	0.42	1.67	0.00	2.32	1.40	0.03	1.38	5.97
Maximum	2.67	5.50	0.53	0.46	0.98	2.73	0.01	3.02	6.40	1.00	2.30	10.15
Minimum	0.12	0.17	0.10	0.09	0.19	0.83	0.00	1.83	-3.75	-0.40	0.99	4.11
Std. Dev.	0.21	0.41	0.09	0.08	0.14	0.32	0.00	0.22	1.75	0.23	0.18	1.31
Skewness	8.97	10.10	1.20	1.30	1.62	1.19	2.38	0.59	-0.01	1.31	1.16	0.90
Kurtosis	98.90	119.40	3.69	3.75	6.11	4.51	9.17	3.30	4.18	5.61	5.97	3.43
Jarque-Bera	85702.30	137287.50	61.70	72.60	199.60	78.80	600.10	14.90	13.70	135.10	140.60	34.10
GERMANY												
Mean	0.19	0.22	0.20	0.18	0.29	2.49	0.00	2.34	0.18	-0.01	0.78	6.53
Maximum	0.91	0.50	0.56	1.68	0.50	4.64	0.01	2.73	2.63	1.50	3.61	14.44
Minimum	0.11	0.16	0.15	0.14	0.21	0.88	0.00	1.88	-7.65	-0.80	0.61	3.96
Std. Dev.	0.09	0.04	0.04	0.10	0.05	0.48	0.00	0.17	2.06	0.36	0.26	1.85
Skewness	4.11	2.54	4.19	14.04	1.08	2.47	8.02	-0.17	-1.63	1.16	5.99	1.13
Kurtosis	28.44	14.65	32.57	210.93	4.19	13.26	92.33	2.69	5.43	4.89	59.22	4.51
Jarque-Bera	6439.80	1592.80	9297.80	432992.00	60.00	1278.50	81034.80	2.10	164.50	88.30	32511.10	73.10

Table 1 (continued)

FRANCE	IRS_1Y	IRS_3Y	IRS_5Y	IRS_10Y	CPI	IP	IR	EX	SIR	UR	M2	MI
Mean	0.22	0.23	0.21	0.17	0.16	2.02	0.00	2.32	0.65	0.00	1.66	4.42
Maximum	1.81	0.91	0.84	0.23	0.23	3.12	0.00	2.80	3.14	0.36	3.41	10.08
Minimum	0.10	0.17	0.16	0.11	0.12	0.95	0.00	1.87	-7.01	-0.23	1.48	2.58
Std. Dev.	0.16	0.07	0.07	0.02	0.02	0.29	0.00	0.17	2.06	0.10	0.26	1.23
Skewness	5.76	5.54	5.99	-0.31	0.71	2.59	0.57	0.09	-1.58	0.38	3.28	1.38
Kurtosis	49.11	43.12	50.02	3.47	3.17	13.33	2.63	2.82	5.41	3.98	16.54	5.74
Jarque-Bera	20440.80	17046.50	23165.00	5.90	20.50	1315.70	14.00	0.60	157.00	15.20	2229.00	149.60
UK												
Mean	0.85	0.23	0.23	0.20	0.37	1.60	0.00	1.93	1.03	-0.02	0.40	4.05
Maximum	35.59	0.71	0.97	0.97	0.43	2.48	0.00	3.93	3.94	0.40	0.63	9.77
Minimum	0.00	0.14	0.15	0.14	0.24	0.68	0.00	1.41	-6.01	-0.40	0.34	2.26
Std. Dev.	3.70	0.07	0.08	0.07	0.04	0.18	0.00	0.36	1.89	0.09	0.05	1.35
Skewness	7.00	2.82	5.04	6.39	-0.74	4.02	1.96	2.05	-1.36	0.07	1.66	1.15
Kurtosis	58.93	15.30	41.03	57.86	2.90	30.45	6.16	9.45	4.97	7.89	7.07	4.57
Jarque-Bera	22187.50	1797.30	151686.00	31083.70	22.00	8017.70	250.40	575.00	111.10	234.50	270.90	76.70

Notes: This table provides summary statistics for both dependent (IRS_1Y; IRS_3Y; IRS_5Y and IRS_10Y) and independent variables by country. Volatility of the IRS (interest rate swap), IP (industrial production), MI (market index), CPI (consumer price index) and IR (interest rate) is measured by an EGARCH(1,1) model, assuming a t-distribution. EX (exchange rate) is the option implied volatility, SIR is the difference between long- and short-term Treasury bond yield, M2 (money supply) is computed as the percentage change from the previous month in average amounts of outstanding/money stock, and UR (unemployment rate) is the change in the seasonally adjusted unemployment rate. The analysis covers the period from April 1993 to December 2012.

Table 2
Pearson Correlation Matrix by Country and Variable

	IRS_1Y	IRS_3Y	IRS_5Y	IRS_10Y	CPI	IP	IR	EX	SIR	UR	M2	MI
PORTUGAL												
IRS_1Y	1.000	0.461	0.450	0.526	0.071	0.180	0.009	0.127	-0.090	0.050	-0.262	-0.002
IRS_3Y	0.461	1.000	0.952	0.116	0.204	0.333	0.068	0.350	0.026	0.211	-0.429	0.140
IRS_5Y	0.450	0.952	1.000	0.200	0.156	0.300	0.106	0.308	0.035	0.119	-0.509	0.081
IRS_10Y	0.526	0.116	0.200	1.000	-0.134	0.166	-0.283	-0.152	-0.397	-0.282	-0.411	0.005
CPI	0.071	0.204	0.156	-0.134	1.000	0.045	0.037	0.174	0.024	0.061	0.021	0.083
IP	0.180	0.333	0.300	0.166	0.045	1.000	-0.010	0.249	-0.132	-0.108	-0.217	0.172
IR	0.009	0.068	0.106	-0.283	0.037	-0.010	1.000	0.275	0.890	0.365	0.209	-0.069
EX	0.127	0.350	0.308	-0.152	0.174	0.249	0.275	1.000	0.290	0.181	-0.140	0.175
SIR	-0.090	0.026	0.035	-0.397	0.024	-0.132	0.890	0.290	1.000	0.441	0.290	-0.110
UR	0.050	0.211	0.119	-0.282	0.061	-0.108	0.365	0.181	0.441	1.000	0.135	-0.047
M2	-0.262	-0.429	-0.509	-0.411	0.021	-0.217	0.209	-0.140	0.290	0.135	1.000	-0.014
MI	-0.002	0.140	0.081	0.005	0.083	0.172	-0.069	0.175	-0.110	-0.047	-0.014	1.000
SPAIN												
IRS_1Y	1.000	0.550	0.454	0.469	0.057	0.100	0.528	0.034	-0.063	-0.033	-0.019	0.029
IRS_3Y	0.550	1.000	0.551	0.534	-0.066	0.229	0.470	0.091	-0.249	0.113	-0.064	-0.113
IRS_5Y	0.454	0.551	1.000	0.987	-0.104	0.147	0.662	-0.121	-0.463	-0.233	-0.088	-0.240
IRS_10Y	0.469	0.534	0.987	1.000	-0.106	0.117	0.691	-0.106	-0.390	-0.280	-0.092	-0.249
CPI	0.057	-0.066	-0.104	-0.106	1.000	-0.021	-0.021	-0.122	0.142	0.100	-0.094	-0.040
IP	0.100	0.229	0.147	0.117	-0.021	1.000	0.093	0.190	-0.133	0.257	-0.042	0.098
IR	0.528	0.470	0.662	0.691	-0.021	0.093	1.000	0.070	0.239	-0.116	-0.003	-0,032
EX	0.034	0.091	-0.121	-0.106	-0.122	0.190	0.070	1.000	0.101	0.129	0.028	0,183
SIR	-0.063	-0.249	-0.463	-0.390	0.142	-0.133	0.239	0.101	1.000	0.247	0.077	0,297
UR	-0.033	0.113	-0.233	-0.280	0.100	0.257	-0.116	0.129	0.247	1.000	0.046	0,399
M2	-0.019	-0.064	-0.088	-0.092	-0.094	-0.042	-0.003	0.028	0.077	0.046	1.000	0,077
MI	0.029	-0.113	-0.240	-0.249	-0.040	0.098	-0.032	0.183	0.297	0.399	0.077	1.000
GERMANY												
IRS_1Y	1.000	0.641	0.507	0.035	0.098	0.554	0.181	-0.121	-0.347	0.067	0.276	0.334
IRS_3Y	0.641	1.000	0.863	0.269	0.068	0.411	0.392	-0.044	-0.130	0.121	0.096	0.435
IRS_5Y	0.507	0.863	1.000	0.551	0.028	0.241	0.499	-0.029	-0.065	0.048	0.118	0.316
IRS_10Y	0.035	0.269	0.551	1.000	0.041	-0.032	0.473	0.036	0.138	-0.067	0.098	0.011
CPI	0.098	0.068	0.028	0.041	1.000	0.188	-0.019	-0.090	0.094	0.230	-0.001	0.130
IP	0.554	0.411	0.241	-0.032	0.188	1.000	0.084	0.103	-0.126	-0.030	0.053	0.276
IR	0.181	0.392	0.499	0.473	-0.019	0.084	1.000	0.077	0.062	-0.024	-0.022	0.273
EX	-0.121	-0.044	-0.029	0.036	-0.090	0.103	0.077	1.000	-0.011	-0.084	-0.041	-0.144
SIR	-0.347	-0.130	-0.065	0.138	0.094	-0.126	0.062	-0.011	1.000	-0.021	0.088	0.212
UR	0.067	0.121	0.048	-0.067	0.230	-0.030	-0.024	-0.084	-0.021	1.000	0.088	0.058
M2	0.276	0.096	0.118	0.098	-0.001	0.053	-0.022	-0.041	0.088	0.088	1.000	0.068
MI	0.334	0.435	0.316	0.011	0.130	0.276	0.273	-0.144	0.212	0.058	0.068	1.000

Table 2 (continued)

FRANCE												
IRS_1Y	1.000	0.501	0.433	0.343	-0.003	-0.004	0.420	-0.021	-0.450	0.117	0.261	0.152
IRS_3Y	0.501	1.000	0.850	0.178	0.238	0.139	0.236	0.021	-0.129	0.363	0.038	0.228
IRS_5Y	0.433	0.850	1.000	0.210	0.137	0.106	0.225	-0.002	-0.150	0.108	0.054	0.074
IRS_10Y	0.343	0.178	0.210	1.000	0.024	-0.137	0.501	-0.101	-0.688	-0.194	0.151	0.046
CPI	-0.003	0.238	0.137	0.024	1.000	0.207	-0.175	-0.159	-0.008	0.281	-0.055	0.270
IP	-0.004	0.139	0.106	-0.137	0.207	1.000	-0.166	0.091	0.005	0.330	-0.090	0.175
IR	0.420	0.236	0.225	0.501	-0.175	-0.166	1.000	0.260	-0.437	-0.067	0.091	-0.073
EX	-0.021	0.021	-0.002	-0.101	-0.159	0.091	0.260	1.000	0.006	-0.005	-0.010	-0.059
SIR	-0.450	-0.129	-0.150	-0.688	-0.008	0.005	-0.437	0.006	1.000	0.112	-0.143	-0.019
UR	0.117	0.363	0.108	-0.194	0.281	0.330	-0.067	-0.005	0.112	1.000	-0.083	0.298
M2	0.261	0.038	0.054	0.151	-0.055	-0.090	0.091	-0.010	-0.143	-0.083	1.000	-0.059
MI	0.152	0.228	0.074	0.046	0.270	0.175	-0.073	-0.059	-0.019	0.298	-0.059	1.000
UK												
IRS_1Y	1.000	0.151	0.130	0.086	-0.285	-0.027	-0.086	-0.037	-0.261	0.210	0.033	0.113
IRS_3Y	0.151	1.000	0.948	0.797	-0.199	0.081	0.169	0.463	0.004	0.562	0.010	0.481
IRS_5Y	0.130	0.948	1.000	0.900	-0.202	0.054	0.181	0.386	0.013	0.494	-0.011	0.399
IRS_10Y	0.086	0.797	0.900	1.000	-0.179	0.039	0.395	0.278	-0.049	0.362	0.021	0.323
CPI	-0.285	-0.199	-0.202	-0.179	1.000	-0.041	0.085	-0.094	0.164	-0.269	-0.041	-0.221
IP	-0.027	0.081	0.054	0.039	-0.041	1.000	0.073	0.115	0.063	0.230	0.036	0.214
IR	-0.086	0.169	0.181	0.395	0.085	0.073	1.000	-0.033	-0.022	-0.188	0.156	0.288
EX	-0.037	0.463	0.386	0.278	-0.094	0.115	-0.033	1.000	0.276	0.440	-0.090	0.342
SIR	-0.261	0.004	0.013	-0.049	0.164	0.063	-0.022	0.276	1.000	0.032	-0.262	-0.082
UR	0.210	0.562	0.494	0.362	-0.269	0.230	-0.188	0.440	0.032	1.000	-0.157	0.402
M2	0.033	0.010	-0.011	0.021	-0.041	0.036	0.156	-0.090	-0.262	-0.157	1.000	0.092
MI	0.113	0.481	0.399	0.323	-0.221	0.214	0.288	0.342	-0.082	0.402	0.092	1.000

Notes: This table presents correlation values between IRS (IRS_1Y; IRS_3Y; IRS_5Y and IRS_10Y) volatility and macroeconomic uncertainty variables. Volatility of the IRS, IP, MI, CPI and IR is measured by an EGARCH(1,1) model, assuming a t-distribution. EX is the option implied volatility, SIR is the difference between long- and short-term Treasury bond yield, M2 is computed as the percentage change from the previous month in average amounts of outstanding/money stock, and UR is the change in the seasonally adjusted unemployment rate. The analysis covers the period from April 1993 to December 2012.

whereas in Germany and France, M2 also has a high mean. Both slope and market index present the highest standard deviation for all countries. Consistent with financial theory, the market index is the variable which shows the highest association between the mean and standard deviation.

A higher correlation is observable among IRS volatilities in all countries between 1- and 3-year IRSs (except for Portugal, which has an elevated correlation between 1- and 10-year IRSs), 5 and 3 years, and 1- and 5-year maturity. Again, for all countries, the correlation values between 3- and 5-year IRS volatility and those of 5 and 10 years are superior. Moreover, the correlation is positive for 1-year IRS volatility and CPI, IR, IP and EX in Portugal and Spain. In Germany, 1-year IRS volatility has a negative Pearson correlation with the exchange rate and slope, whereas the 5-year has a positive correlation with all macroeconomic uncertainty proxies.

In all countries except Germany, a negative correlation is observed between 1 year and 10 year maturities and slope. Also, a negative correlation exists only between 10 year IRS volatilities

and IR for Portugal. For this same country, CPI is positively correlated with all other macroeconomic fundamentals. Besides UK, in all other countries the CPI is positively correlated with the unemployment rate. This result is somehow unexpected because when the unemployment rate increases we should expect a lower CPI and vice-versa. This may be attributed to the entire period under analysis and for the specificities of the countries examined. With the financial crisis, European interest rates have remained at lower values, although unemployment rates have increased due to the arrival of the economic crisis, its installation and spread all over Europe.

4. Empirical Findings and Policy Implications

This section presents the OLS IRS volatility regression results for all IRS maturities considered, and for all countries. Results obtained through Equation (3) are presented in Table 3. The first panel presents the German results, considering both the IR variable in levels and the IR volatility. On the left (panel a), the estimation results are presented using the volatility of the interest rate (IRV); and on the right (panel b), the IR in levels (IR) is used. From the coefficient estimates obtained in the first panel for Germany, by using IR volatility we have no statistically significant result, which doesn't happen when IR in levels (returns) is used.

The results expressed in this table show that IRS volatility for all countries, independently of IRS maturity, are statistically, positively and significantly affected by the IR level, thus confirming Hypothesis 5. So, the higher the IR, the higher the use of IRS by investors for hedging or speculative purposes. Considering Germany, and results presented on panel b on the right, IRS volatility is positively related to industrial production (1- and 3-year swaps), with slope (for 3-, 5- and 10-year swaps) and with the market index volatility (for 1- and 3-year swaps). However, 10-year swaps are negatively correlated to the exchange rate volatility, contradicting our initial prediction as stated in Hypothesis 7. Given that the coefficient of IP volatility is statistically significant, this allows us to conclude that macro-risk helps to resolve uncertainty in the German swap market.

From the results, it is apparent that there exist higher impacts of financial market and monetary policy volatility proxies. Since there is a higher statistical significance when using IR returns instead of volatility, for the rest of the countries, we only present the results that consider the former. This finding contradicts the results obtained by Azad et al. (2011; 2012). This is discussed further in subsequent sections, and presented as additional rationale for this evidence.

Considering the Portuguese market results in the second panel of Table 3, the coefficient estimates when statistical significant are in accordance with our initial testable hypotheses. In this case, IP volatility and exchange rate volatility have a positive relationship, with 1-, 3- and 5-year swaps, CPI volatility with a positive impact over the 5-year swap contract, a positive impact of the slope (SIR) over a 10-year swap maturity, the same positive impact of IR over all swap maturities, and a positive influence of the market index volatility over the 1-year swap maturity volatility. Positive coefficient values for CPI and IP volatility indicate that an increase in the volatility of the consumer price index and that of industrial production at least for 5-year swaps increases IRS volatility in Portugal and France. Diebold and Yilmaz (2008) reported similar results in different financial markets, while Azad et al. (2012) reported these results for IR swap volatilities in UK and US. Considering that the consumer price index, the unemployment rate, and industrial production are good measures of the overall level of economic activity, and of macroeconomic uncertainty (Diebold & Yilmaz, 2008; Genberg & Sulstarova, 2008), it is evident that IRS volatilities are affected by macroeconomic uncertainty for all countries despite the fact that this influence changes considering different IRS maturities.

The results attained, especially for Portugal, require a deeper understanding, considering the current volatile economic environment. It is known that in the last decade the use of interest rate swaps has increased greatly by both public and private companies. These companies have used IRSs to cover the risks of a Euribor increase expectation, especially between 2003 and 2009.

Table 3
Estimation Results for Different IRS Maturities in Germany, Portugal, UK, Spain and France

	GERMANY - Panel a)				GERMANY - Panel b)			
	1 - YS	3 - YS	5 - YS	10 - YS	1 - YS	3 - YS	5 - YS	10 - YS
Constant	0.020	0.176 ***	0.197 ***	0.177 ***	-0.049	0.099 **	0.156 ***	0.156 ***
CPI	2.311	-2.152	-0.909	-2.164	6.135	3.044	1.883	-0.700
IP	1.346 **	0.909	-0.660	-0.790	1.611 **	1.087 **	-0.566	-0.716
IR					1.314 ***	1.237 ***	0.666 ***	0.332 ***
IRV	0.143	0.031	0.016	0.023				
EX	2.095	-0.683	-0.458	-0.245	2.634	-0.352	-0.283	-0.118 ***
SIR	-0.523	0.487	0.290	0.182	0.194	1.361 ***	0.760 ***	0.532 **
UR	0.008	-0.001	-0.008	-0.007	0.008	-0.003	-0.009	-0.008
M2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MI	0.689 ***	0.288 **	0.057	-0.024	0.749 ***	0.346 **	0.088	-0.005
Observations	217	236	236	236	217	236	236	236
Adjusted R^2	0.241	0.052	0.018	0.073	0.387	0.354	0.190	0.145
	PORTUGAL				**UK**			
	1 - YS	3 - YS	5 - YS	10 - YS	1 - YS	3 - YS	5 - YS	10 - YS
Constant	-0.069	0.051 **	0.074 ***	0.076 ***	-0.408	0.030	0.079 ***	0.095 ***
CPI	3.411	4.384	4.412 *	4.352	63.397 ***	-3.233	0.358	-5.348
IP	5.313 ***	3.376 ***	1.907 ***	0.585	4.261	0.668	0.119	0.731
IR	1.143 ***	1.113 ***	1.070 ***	1.190 ***	9.088 ***	1.891 ***	1.354 ***	1.174 ***
EX	3.073 ***	1.322 *	1.167 **	0.835	6.885	1.301 *	0.070	0.575
SIR	-0.193	-0.029	0.050	0.284 ***	5.296	1.866 ***	1.362 ***	1.092 ***
UR	0.023	0.015	0.005	-0.001	0.115	0.110 ***	0.077 **	0.068 **
M2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MI	0.374 **	0.012	-0.099	-0.167	-4.769	1.198 ***	0.977 ***	0.687 ***
Observations	207	217	217	217	161	236	236	236
Adjusted R^2	0.436	0.437	0.472	0.436	0.244	0.491	0.321	0.292

Table 3 (continued)

	SPAIN				FRANCE			
	1 - YS	3 - YS	5 - YS	10 - YS	1 - YS	3 - YS	5 - YS	10 - YS
Constant	-0.117	0.043	0.080 ***	0.084 ***	-0.096	0.006	0.071 ***	0.118 ***
CPI	1.504	1.471	-1.264	-2.880	-13.766	21.900 **	14.410 **	-2.338
IP	3.396 *	2.338 **	1.960 **	1.124 *	2.501 *	2.106 ***	1.788 ***	1.291 ***
IR	4.039 ***	3.138 ***	3.149 ***	2.735 ***	5.632 ***	1.933 ***	1.237 ***	0.692 ***
EX	2.070	0.727	-0.163	0.218	-0.275	0.647	-0.075	-0.315
SIR	2.111 ***	1.931 ***	2.241 ***	2.107 ***	4.271 ***	2.044 ***	1.315 ***	0.792 ***
UR	0.034	0.035 **	-0.001	-0.007	0.214 ***	0.067 ***	0.002	-0.036
M2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MI	0.346	-0.564	-0.712	-0.686	0.527	0.319 **	0.120	0.011
Observations	217	236	236	236	218	236	236	236
Adjusted R^2	0.610	0.765	0.861	0.896	0.603	0.504	0.422	0.183

Notes: This table presents results from the OLS regression. The first panel presents Germany's results with IR volatility (panel a on the left) and IR in levels (panel b on the right). The second presents the OLS results for Portugal (left) and UK (right) and the third panel is for Spain (left) and France (right). The sample period goes from April 1993 until December 2012, in a total of 237 monthly observations for Germany, 207 monthly observations for Portugal, and 236 observations for UK, Spain and France. The dependent variable is the conditional volatility of swaps. IRS stands for interest rate swaps volatility of maturity i in period t; CPI is the volatility of the consumer price index; IP is the volatility of industrial production; IRV is the volatility of the interest rate (in panel a)); IR is the interest rate in returns (in panel b for Germany); EX is the volatility of the exchange rate; SIR is the term structure slope; UR is the unemployment rate; M2 is the money supply; and MI is the volatility of the stock market index. Conditional variable (IRS and risk factors) volatility has been obtained through an AR(1)-EGARCH(1,1), using a t-distribution for the error term. Standard errors of the estimated coefficients have been corrected for autocorrelation and heteroskedasticity by using the Newey-West method. *, ** and *** indicate level of significance at 10%, 5% and 1%, respectively. YS stands for year swap.

These instruments have been adopted around the world to protect loans from the risk of interest rate increases in a time when Euribor increased to 4%. Nonetheless, today swaps have accumulated billions of Euros in potential loss for the companies that bought these contracts. This wasn't only a Portuguese problem but for many other European countries as well. These contracts have been revealed to be high risk because they generate minimum gains for companies in a scenario of interest rate increases and a significant loss when rates decrease.

Companies do have benefits by entering into IRS contracts, because they hire these products from banks to protect themselves from their loans' interest rate increases. By entering into this type of contract, companies are exchanging, in general terms, a changing rate by a fixed one, when an interest rate increase is expected. In the Monetary European Union the contracts rate is indexed to Euribor. Managers may also choose to use an IRS to gain liquidity and short-run financial results, thus compensating for operational losses. In this case it is enough to perform the change for a higher interest rate; these operations allow for a reduction of losses in a given year.

These types of considerations also explain why such a high significance between interest rate changes and swaps volatility was observed. Also, the analysis period includes a highly volatile macroeconomic period, and investors' fear of volatility justifies the fact why industrial production volatility increases that of the swaps markets. So, macroeconomic risk in European markets incentivizes market participants to use IRS as a hedging and/or speculative instrument.

In the UK market IP is not statistically significant, although for all IRS maturities, the coefficient estimates were revealed to be positive. From macroeconomic variables, only CPI volatility (for a 1-year swap), exchange rate volatility (for a 3-year swap) and the unemployment growth rate seem to exert a positive influence over IRS volatility. These results contradict those obtained by Azad et al. (2012) for this same market in terms of indicators for unemployment and CPI, but not for the exchange rate (Azad et al., 2011) which was also found to be positive in Japan. Azad et al. (2011; 2012) argued that the positive impact of exchange rate volatility may be due to the fact that international banks offer IRSs to companies concerned about foreign exchange rate risk, which may explain the UK maintaining the Pound, rather than switching to the Euro. In Portugal it may be companies' internationalization or the higher foreign capital demand which could explain this fact. Banks usually charge lower costs for these types of arrangements, but these may translate into higher swap rates due to the increased volatility of the exchange rate.

In both Spain and France, IP volatility, IR and SIR each influences IRS volatilities, when it is positively and statistically significant, independent of their maturity. Azad et al. (2011) and Azad et al. (2012) also found a positive slope impact throughout all swap maturities for US but not significant for UK (Azad et al., 2012). Given that a positive slope is also a proxy for economic expansion, this indicates that hedgers try to hedge their interest rate risk exposure more intensively. Azad et al. (2011) stated that the slope and IRS volatility relationship can be positive due to liquidity, rather than economic expansion (contraction), given that a tight liquidity is related to a flat and/or inverse slope of the yield curve. Fang and Muljono (2003) used the slope as a proxy for anticipated future interest rates, which can explain why in European countries we have seen a higher demand for IRS at the beginning of the twenty-first century. Therefore, if the slope allows for the prediction of future interest rates and economic expansions or recessions, a positive value would indicate a future IR increase, implying more demand for hedging and speculation, thus turning IRS more volatile. According to Hypothesis 6 and empirical estimates, the sign of this slope when significant is always positive. This fact is somehow expected, given the historical level of IRs in Europe as fixed by the European Central Bank, and the previous expectation of these higher values remaining in the future (when contracts were realized in countries like Portugal). However, IRs have decreased recently, and companies now face huge losses given their earlier use and demand for IRS.

With respect to the money supply proxy, M2, its coefficient value was revealed to be insignificant for all countries and IRS volatility maturities, since it was low in magnitude but still positive. At first glance, it could be argued that M2 has no influence over IRS volatility, but as it

will be evident afterward, this impact is dependent over the period under analysis. Considering the unemployment rate results, when statistically significant (UK, France and Spain) its coefficient is positive, provided Hypothesis 8, which argued in favor of an initial unpredictable sign. Azad et al. (2011, 2012) found a negative effect of unemployment over IRS volatility. Bearing in mind that the higher the macroeconomic risk, the higher the use of swaps or other derivatives, in volatile economies, investors require hedging and managing risks while market makers demand a higher risk premium when macroeconomic risk is high. Similar to Lang et al. (1998), who used the unemployment rate as a proxy for the business cycle, it can be argued that swap market volatility contains pro-cyclical elements, justifying this positive relationship. Facing a higher unemployment rate, a country faces lower economic activity and investments; therefore, a higher preference for derivatives may exist. This would, in turn, increase their volatility due to hedging needs; in other words, they would protect themselves from higher expected interest rates in the future, which in turn would justify the higher demand for IRSs. This has occurred in several European economies, especially in Portugal.

Finally, the market index volatility impact over IRS volatility deserves a discussion. Hypothesis 1 initially predicted undefined results in terms of sign, but it a positive influence on the market index volatility over IRS trading activities would be expected due to the increased volume of IRS trading activities when facing higher macroeconomic risk. Although not for all markets and IRS maturities, when statistically significant, the obtained coefficient is revealed to be positive (3-year swap in Spain, France and UK; 1-year swap in France; and 5- and 10-year swaps in UK). As stated previously, when interest rates go up, inflation can also increase, leading to amplified IRS activities, which can be related to market index volatility increases (Bessembinder & Seguin, 1992; Beber & Brandt, 2009). In Portugal, the foreign exchange rate volatility was revealed to be a macro variable which significantly influenced IRS swaps. This is not the case in other European countries—investors need to take this into account when forming their international portfolios.

With minor exceptions due to market specificities, such as intrinsic and macroeconomic differences, results are consistent with those of previous authors (Beber & Brandt, 2009; Azad et al., 2011; 2012). Therefore, we can say with certainty that macroeconomic, financial and monetary policy risks lead to greater levels of hedging and speculative activities in financial markets, resulting in a greater use of derivatives. Moreover, R^2 values obtained for Spain, Portugal and France, present, in general, higher values than those obtained for Germany and UK. In Azad et al. (2012), R^2 values were lower, which may be due to the fact that the realized volatility of IRSs is computed using a GARCH two component specification. As such, differences are not due to volatility specification; rather, they are due to the macroeconomic environment of the countries under analysis. Still, and similar to Engle and Rangel (2008) and Azad et al. (2011; 2012), it can be argued that market participants should be aware of IRS volatility responses to macroeconomic variables to extract trading signals. This awareness allows hedgers to decide with respect to the increase or decrease of IRS usage, to be able to hedge risk originating from macroeconomic increases or decreases, respectively. However, results differ considering different market economic stability and financial market size. Therefore, they should not be generalized at the European level and investors should be aware of this fact when they try to diversify their portfolios, and/or hedge or speculate using IRS derivative instruments in international terms.

Turning back to the rationale of using IR levels instead of its volatility, and trying to explain macroeconomic risks and its effects over IRS volatility evolution through time, Figure I shows all nine beta coefficient estimates and their confidence interval at the 90% level, through time. This was obtained by applying the moving windows estimation technique for periods of 60-month windows for each of the macroeconomic risk proxies used. This figure only presents results for the 5-year IRS contract in Germany, although results can be generalized in terms of countries and IRS maturities, and will be made available upon request.

Using moving windows estimates, the OLS regressions for each IRS volatility contract were

performed considering the same endogenous and exogenous variables, and using small samples of 60 months each. This allowed us to obtain beta coefficient estimates for each macroeconomic variable considered through time, given that the last 60 monthly observations were used to compute these same coefficient evolutions through time. Thus, the question of whether or not results are statistically insignificant is always verified through time interval samples of 60 months.

In Figure I, the first plot confirms the finding that CPI volatility isn't significant through the entire sample period, given that its confidence band has always been around zero. Changes of significance through time for macroeconomic risk proxies like IP, UR and MI can also be observed. The money supply proxy, for example, only seems to impact IRS volatility for a short period of time (from 2000 until 2002), thus indicating that although significant in that period, this impact over IRS volatility has been absorbed in other periods of time, justifying the insignificant values obtained in Table 3. The same happens for all other countries and contracts, and confidence band values around zero justify the null coefficient estimate for M2 changes that were previously obtained.

It seems that UR, IP, EX and IR coefficients tend to follow a common pattern from the year 2008 onwards, given that their betas and confidence intervals have converged towards zero. With respect to the interest rate, it is observed that while IR returns seem to point toward positive statistical significance for the entire sample, the same does not occur with IR volatility, whose coefficient estimates are lower along with its significance.

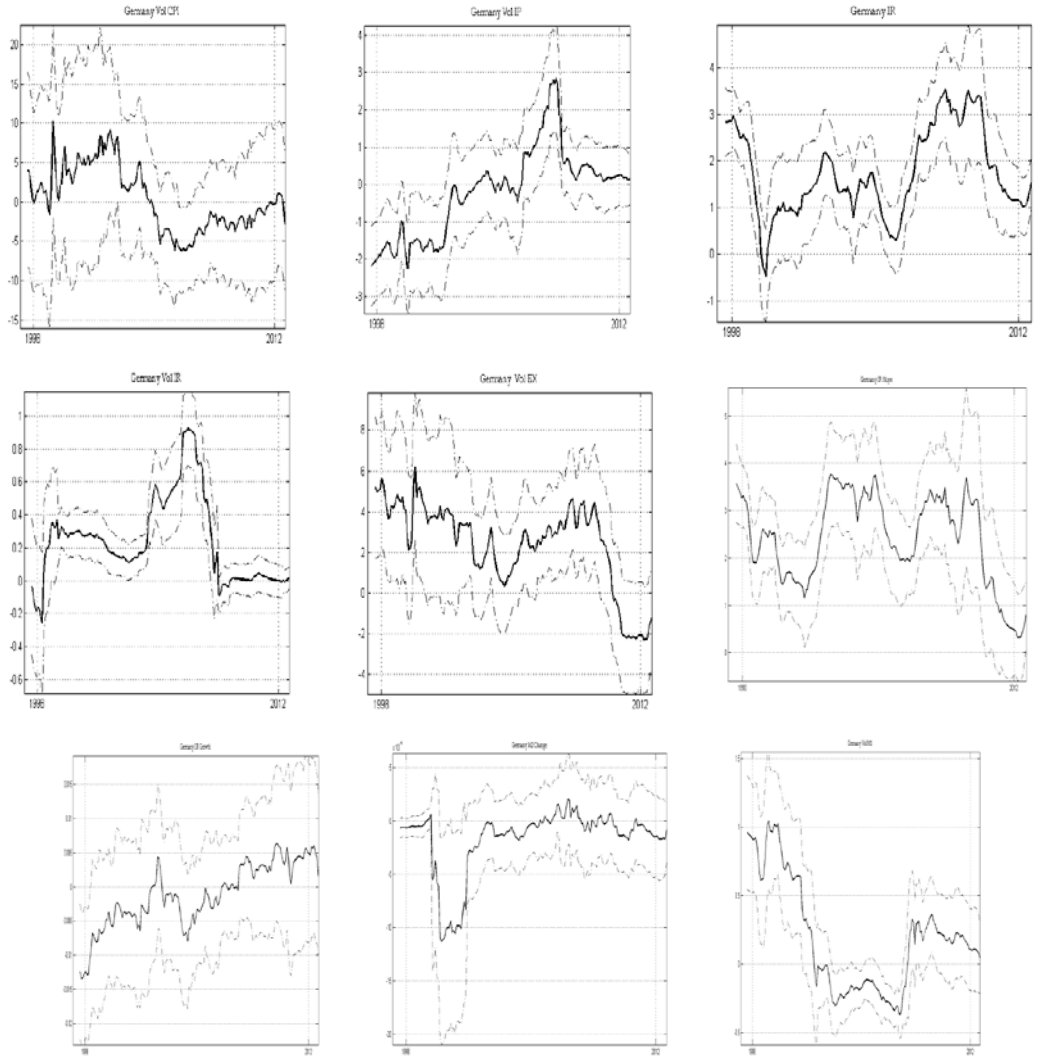
Regarding the IR results, previous literature concluded that the true relative importance of the slope explains IRS volatility (In et al., 2003; Azad et al., 2011; 2012). From 1998 to 2010 it is evident that the relative, positive and increased importance of this variable explains IRS volatility. A positive slope indicates a future IR increase, implying more demand for hedging and speculation, which will end up reflected in higher IRS volatility. From 2010 onwards, the financial crisis and the pattern followed by interest rates, which turned out to decrease instead of increase as previously expected, also justify why slope coefficient estimates turned out to decrease and converge towards zero. Considering both IR and IR volatility coefficient estimates, we can see that both variables behave well, as well as all other macroeconomic risk variables (see Figure I) in the entire sample period. Despite this fact, an evident regularity break from the financial crisis is ahead, not just because of the crisis emergence but because interest rates started to decrease and remained at low values in this period.

From the end of the 1990s, the volatility or uncertainty of interest rates is a clear determinant of swaps volatility, but from the financial crisis until recently it has lost its significance. A clear interest rate level decrease was clearly observed in this time period, which has forced the volatility of interest rates to lose significance, while the IR level remained significant. Similar to Azad et al. (2012), our empirical results confirm that the coefficient of IR volatility was positive during the 1990s, meaning that markets answered in a positive manner towards the threat of higher interest rate volatility. The authors of this study point to the change of the coefficient sign from the 1990s onward (due to structural factors and economic environment) as the culprit for this change of behavior for the entire sample period. The authors also argue that this sign change may be attributed to investors' revisions of expectations, because before the 1990s, investors sought protection against IR volatility, which caused an increase in swap trading. From the 1990s onward, investors had substituted IRS for IR. The authors conclude that investors include policy changes into their revised investment decisions; therefore, the change of sign is due to swap users' perceptions.

By using both IR volatility and levels, it is possible to make different conclusions. Results obtained seem to indicate that interest rates in levels continue to be significant even in the face of the financial crisis, but not the IR volatility. The justification is that IR was still a concern to investors but not so much its volatility. The verified decrease in IR volatility beta estimates may be driven by a lower concern from investors, which is aligned with the difference of beta signs

obtained by Azad et al. (2012).

Figure I
Moving windows estimates for 60-month time interval regressions: macroeconomic risk impacts over volatility of 5-year swap maturity IRSs in the German market



Source: Own produced results. Notes: These figures present beta coefficient estimates obtained for IRS volatility using macroeconomic risk proxies in the German market, by using small moving window regression estimates based on the last 60 months of observations. The x axis shows the betas' evolution through time for the time period analyzed, and also takes into account, in each month estimate, the previous 60 months of values. The y axis represents the beta coefficients' estimated values, which goes from 0 (no sensibility of IRS volatility to that macroeconomic variable) until 20 (high sensibility of IRS volatility to that macroeconomic variable – positive or negative). The black line represents the betas estimates' trough time, while gray lines represent the 90% confidence band. CPI is the volatility of the consumer price index; IP is the volatility of industrial production; Vol IR is the volatility of the interest rate; IR is the interest rate in returns; EX is the volatility of the exchange rate; Slope is the term structure slope; UR is the unemployment rate; M2 is the money supply change; and MI is the volatility of the stock market index. Conditional variables (IRS and risk factors) volatility has been obtained through an AR(1)-EGARCH(1,1) using a t-distribution for the error term.

In sum, it seems reasonable to conclude that investors changed their behavior in the market during the financial crisis associated with the economic contraction. Even if IR continued to be a concern during these contractions, its volatility appears to still decrease in importance. Investors increased their use of IRS due to the fact that the future fears of IR increases turned out to be unrealistic. In fact, IRs started to decrease due to the financial crisis impact.

Results can even be extended in the future to include other macroeconomic fundamentals or even different European countries. A world comparison could also be relevant in terms of international portfolios diversification using derivatives, namely interest rate swaps.

5. Conclusions

This work explores the impact of macroeconomic risks over the volatility of interest rate swaps (IRS) in Europe (UK, France, Germany, Spain and Portugal). Different IRS volatility maturities of 1, 3, 5 and 10 years are considered in monthly terms from April 1993 to December 2012. Considering that market risk influences asset pricing, and that the higher the risk, the greater the use of derivative instruments to hedge or speculate, more research over this topic is still needed, especially in terms of IRS volatility.

Empirical results indicate that the higher the interest rate (IR) return, the higher the use of IRS by investors for hedging or speculative purposes, independently of the country or IRS maturity, because IR is the macroeconomic variable most likely to positively and strongly influence and explain IRS volatility, even if we take the financial variables uncertainty out of the analysis.

Macro-risk, as measured by industrial production, helps to solve uncertainty in swap markets of Spain and France for all IRS maturities, for 1-, 3- and 5-year IRS maturities in Portugal, and 1- and 3-year IRS maturities in Germany. So, macroeconomic uncertainty helps to explain IRS volatilities for all countries, but results differ in terms of swap maturities. As such, hedgers can use swaps in all countries to forecast macroeconomic fluctuations and fix swap rates of those maturities which have a stronger relationship with macroeconomic risk proxies. Moreover, macroeconomic uncertainty faced by European markets have encouraged market participants like investors, market makers and managers to demand for the use of IRS for hedging or speculative purposes, at least for the sample period considered. Results are even more accurate for countries whose financial market development is superior at turning results that are also dependent of the country-intrinsic characteristics or its development stage. The differences of results concerning previous authors' findings are also attributed to these differences and not to different volatility specifications.

Moreover, the term "structure slope" shows a positive influence over IRS volatility, even if not for all maturities, and monetary policy, as measured by M2, influences IRS volatility depending on the period under analysis, as revealed by moving average estimates. Market participants should thus be aware of IRS volatility responses to macroeconomic variables to extract trading signals, allowing hedgers to realize if they need to increase or decrease IRS usage in order to hedge risk originating from macroeconomic increases or decreases, respectively.

Finally, IR volatility was a clear determinant of swaps volatility, up until the financial crisis period. This is consistent with the prediction that investors demanded more IRS for hedging or speculative purposes, thus increasing IRS volatility. With interest rate decreases in Europe from 2008 onwards, IR volatility lost significance, while IR in levels remained significant to explain IRS volatility. IR was still a concern for investors but not so much its volatility, which is also in line with the difference of beta signs obtained by Azad et al. (2012). This brings to light the investors' change in behavior before and after the crisis period. Investors increased their use of IRS, due to their fears of IR increases in the future, which turned out not to be realistic. In fact, they started to decrease during the financial crisis period, revealing some fragilities in the fulfillment of previously realized contracts in countries like Portugal. In sum, this study's results justify the statement that macroeconomic, financial and monetary policy risks lead to greater levels of

hedging and speculative activities in financial markets, thus leading to a greater use of derivatives, in this case IRSs.

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