Revista de Economía Aplicada E A *Número 70 (vol. XXIV), 2016, págs. 111 a 145*

VOLATILITY RISK PREMIA BETAS*

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This paper analyzes the cross-sectional and time-series behavior of the volatility risk premia betas at the portfolio level. These betas show a monotonic relation with respect to the magnitude of the volatility risk premium payoffs. Moreover, portfolio conditional volatility risk premia betas increase significantly in recessions. In particular, these betas tend to increase significantly with default premium, market betas and the HML and SMB Fama-French risk factors. On the other hand, conditional betas tend to decrease when industrial production growth, consumption growth, the market excess return, and the momentum factor increase.

Key words: volatility risk premium, betas, conditional betas, macroeconomic indicators.

JEL Classification: G12, G13.

The objective of this paper is to understand the cross-sectional and time-varying behavior of volatility risk premia betas for a sample of 20 volatility risk premia-sorted portfolios. This is a first step to future research on the determinants of the cross-sectional variation of the volatility risk premia. The huge literature on the equity return betas contrasts dramatically with the lack of information regarding the behavior of volatility betas. The main contribution of this paper is to cover, at least partially, this gap.

Since the seminal paper of Bakshi and Kapadia (2003a), the market variance risk premium has been reported to be negative on average during alternative sample periods[1]. Since the payoff of a variance swap contract is the difference between the realized variance and the variance swap rate, negative returns to long positions on variance swap contracts for all time horizons mean that investors are willing to

(*) The authors acknowledge financial support from the Ministry of Economics and Competitiveness through grant ECO2012-34268**.** Ana González-Urteaga also acknowledges financial support from ECO2012-35946 and Gonzalo Rubio from Generalitat Valenciana grant PROMETEOII/2013/015. The authors thank Rafael Santamaría (the Editor), and two anonymous referees for helpful comments that substantially improved the contents of the paper. They also recognize the expertise help and advice of Francisco Sogorb.

(1) For empirical evidence about the negative variance risk premium on the market index, see Carr and Wu (2009) and the papers cited in their work.

accept negative returns for purchasing realized variance[2]. Equivalently, investors who are sellers of variance and are providing insurance to the market, require substantial positive returns. This may be rational, since the correlation between volatility shocks and market returns is known to be strongly negative and investors want protection against stock market crashes.

Along these lines, Bakshi and Madan (2006), and Chabi-Yo (2012) theoretically show that skewness and kurtosis of the underlying market index are key determinants of the market variance risk premium. Indeed, Bakshi and Madan (2006), Bollerslev, Gibson, and Zhou (2011), Bekaert, Hoerova and Lo Duca (2013) and Bekaert and Hoerova (2013) argue that the market variance risk premium is an indicator of aggregate risk aversion[3]. A related interpretation is due to Bollerslev, Tauchen, and Zhou (2009) and Drechsler and Yaron (2011) who interpret the market variance risk premium as a proxy of macroeconomic risk (consumption uncertainty). They show that time-varying economic uncertainty and a preference for early resolution of uncertainty are required to generate a negative market variance risk premium. Zhou (2010) shows that the market variance risk premium significantly predicts short-run equity returns, bond returns, and credit spreads. Consequently, he argues that risk premia in major markets comove in the short-run, and that such a comovement seems to be related to the market variance risk premia. Campbell, Giglio, Polk, and Turley (2014), using an intertemporal CAPM framework, argue that covariation with aggregate volatility news has a negative premium. Finally, Nieto, Novales, and Rubio (2014) show that the uncertainty that determines the variance risk premium –the fear by investors to deviations from Normality in returns– is also strongly related to a variety of macroeconomic and financial risks associated with default, employment growth, consumption growth, stock market and market illiquidity risks. At this point, it is fair to argue that we understand the behavior of the market variance risk premium, and its implications for financial economics.

However, it is surprising how little we know about the variance risk premium at the individual level. Bakshi and Kapadia (2003b) show that the variance risk premium is also negative in individual equity options. However, Driessen, Maenhout, and Vilkov (2009) show that the variance risk premium for stock indices is systematically larger, i.e., more negative, than for individual securities. They argue that the variance risk premium can in fact be interpreted as the price of time-varying correlation risk. They show that the market variance risk is negative only to the extent that the price of correlation risk is negative. In a related paper, Buraschi, Trojani, and Vedolin (2014) argue that the wedge between index and volatility risk premia is explained by investors disagreement. Hence, the greater the differences in beliefs among investors, the larger the market volatility risk relative to the volatility risk premium of individual options. Even these papers are particularly concerned with the behavior of the market variance risk premium despite the fact that data at the indi-

(2) A variance swap is an OTC derivative contract in which two parties agree to buy or sell the realized variance of an index or single stock on a future date.

(3) More specifically, Bekaert, Hoerova, and Lo Duca (2013) show significant interactions between monetary policy and the market variance risk premium which suggests that monetary policy may impact aggregate risk aversion.

vidual level is employed. An analysis and the understanding of the time-series and cross-sectional behavior of the variance risk premium at the individual level is missing in previous literature. We argue that the first step to understand the individual variance premium is to study the main drives of volatility risk premia betas.

This paper analyzes the volatility risk premium (*sVRP* hereafter) at the individual level[4]. We employ daily data from OptionMetrics for the S&P100 index options and for individual options on all 181 stocks included at some point in the S&P100 index during the sample period from January 1996 to February 2011. We employ options with expiration from 6 to 60 days. We calculate the *sVRP* for each stock at the 30-day horizon as the difference between the corresponding realized volatility and the model-free implied volatility described in Jiang and Tian (2005). At each month, we rank available individual *sVRP* on all stocks with at least 15 daily observations according to the *sVRP* in the last day of each month. Then, we construct 20 equally-weighted-*sVRP*-sorted portfolios to analyze the behavior of the sensitivity (betas) of the portfolio volatility risk premia to aggregate factors, including the market volatility risk premium, estimated on the S&P 100 index option.

We find a strong and significant commonality among the *sVRP* across all 20 portfolios. The *sVRP* betas with respect to the market *sVRP* are all positive and statistically significant. On top of that, we report a perfectly monotonic relation between the average *sVRP* of the 20 portfolios and their corresponding *sVRP* betas, with the more negative *sVRP* portfolios presenting the lowest beta and the more positive *sVRP* portfolio having the highest sensitivity to the market *sVRP*. Moreover, the conditional *sVRP* betas of portfolios 1 (the portfolio with the most negative *sVRP*), 5, 10, 15, and 20 (the portfolio with the most positive *sVRP*) are significantly higher in recessions than during normal times although these differences are especially large for the two extreme portfolios. Overall, the conditional *sVRP* betas of our 20 portfolios are simultaneously explained by the market return betas of the portfolios, the market excess return, industrial production growth, consumption growth, the default premium, and Fama-French HML, SMB, and momentum factors.

This paper is organized as follows. Section 1 briefly describes the variance swap contract and defines the variance and volatility risk premia, while Section 2 contains a description of the data. Section 3 discusses the model-free implied variance and the estimation of the *sVRP*. Section 4 contains the basic empirical results using unconditional *sVRP* beta estimates. In Section 5, we report the evidence about conditional *sVRP* betas. Section 6 concludes.

(4) Rather than working with realized variances and variance swap rates, we first take the square root of both measures and then we take the difference between them. As discussed by Carr and Lee (2007, 2009), due to the concavity s price impact associated with Jensen s inequality, the difference between the value of a variance swap and the value of a volatility swap depends on the volatility of volatility of the underlying. If we recognize this potential bias and adjust our estimated volatility risk premia accordingly, the dispersion between the volatility risk premia across portfolios remains. The average volatility risk premium of portfolio P1 becomes slightly less negative, and the volatility risk premium of portfolio P20 slightly more positive. See Burashi, Trojani, and Vedolin (2014) for a similar approximation.

1. Variance and volatility swap contracts

In a variance swap, the buyer of this forward contract receives at expiration a payoff equals to the difference between the annualized variance of stock returns and the fixed swap rate. The swap rate is chosen such that the contract has zero present value which implies that the variance swap rate represents the risk-neutral expected value of the realized return variance:

$$E_t^Q\left(RV_{t,t+\tau}^a\right) = SW_{t,t+\tau}^a \qquad [1]$$

where $E_t^Q(\cdot)$ is the time-t conditional expectation operator under the risk-neutral measure Q, $RV_{t,t+\tau}^a$ is the realized variance of asset (or portfolio) a between t and $t+\tau$, and $SW_{t,t+\tau}^a$ is the delivery price for the variance or the variance swap rate on the underlying asset a. The variance risk premium of asset a is defined as:

$$VRP_{t,t+\tau}^a = E_t^P\left(RV_{t,t+\tau}^a\right) - E_t^Q\left(RV_{t,t+\tau}^a\right) \qquad [2]$$

On the other hand, at expiration, a volatility swap pays the holder the difference between the annualized volatility and the volatility swap rate:

$$N_{vol}\left(sRV_{t,t+\tau}^a - sSW_{t,t+\tau}^a\right), \qquad [3]$$

where $sRV_{t,t+\tau}^a$ is the realized volatility of asset a between t and $t+\tau$, $sSW_{t,t+\tau}^a$ is the fixed volatility swap rate, and N_{vol} denotes the volatility notional[5]. This paper analyzes the behaviour of volatility risk premia betas. We therefore define the volatility risk premium of asset a as follows,

$$sVRP_{t,t+\tau}^a = E_t^P\left(sRV_{t,t+\tau}^a\right) - E_t^Q\left(sRV_{t,t+\tau}^a\right) \qquad [4]$$

2. The data

We employ daily data from OptionMetrics for the S&P100 index options and for individual options on all stocks included in the S&P100 index at some point during the sample period from January 1996 to February 2011. This gives a total of 181 stocks used in our estimations. From the OptionMetrics database, we take all put and call options on the individual stocks and on the index with time-to-maturity between 6 and 60 days. Given that the options are American-style, it is convenient to work with short-term maturity options for which the early exercise premium tends to be negligible[6]. We select the best bid and ask closing quotes to calculate the midquotes as the average of bid and ask prices, rather than actual transaction prices in order to avoid the well known bid-ask bounce problem described by Bakshi, Cao, and Chen (1997). In selecting our final option sample, we apply the usual filter requirements. We discard options with zero open interest, with zero bid prices, with missing delta

(5) Carr and Lee (2009) provide a survey of the methodologies for pricing and hedging volatility derivative products.

(6) See the evidence reported by Driessen, Maenhout, and Vilkov (2009) who employ a similar database.

or implied volatility, and with negative implied volatility. We also ignore options with extreme moneyness; puts with Black-Scholes delta above -0.05 and calls with delta below 0.05. Finally, regarding the exercise level, we employ out-of-the-money options using puts with delta above -0.5, and calls with delta below 0.5.

It seems reasonable to expect that aggregate macroeconomic variables and market-wide portfolios extensively used by researchers when explaining the time series and cross-sectional behavior of excess equity returns should also be the relevant factors to estimate volatility risk premia betas. This is the main criterion we follow when collecting our data. As our option data, the market return for the S&P100 index, and individual stock prices and dividends are also taken from OptionMetrics, while portfolio return data is taken from Kenneth French s web page. In particular, we collect monthly data on the value-weighted stock market portfolio return, the risk-free rate, the SMB and HML Fama-French risk factors, and the momentum factor denoted as MOM. As the measure of market-wide liquidity, we employ the Pastor-Stambaugh (2003) liquidity proposal which is based on daily regressions for individual stock excess returns over the market return in a calendar month,

$$R^{em}_{j,t+1} = a + b\ \mathrm{R}_{\mathrm{j,t}} + g \left[\ sign\left(\mathrm{R}^{\mathrm{em}}_{\mathrm{j,t}}\right)\ \right]\ DVol_{j,t} + e_{j,t+1}\,, \qquad [5]$$

where $R^{em}_{j,t+1}$ denotes the return of stock j over the market return. Pastor and Stambaugh (2003) aggregate g across stocks and scale it for growing dollar volume. They finally propose the innovations as the final measure of liquidity[7]. The intuition is that high volume moves prices away equilibrium and they rebound the following day which suggests that g is typically negative.

Additionally, yields for the 10-year Government Bond, the 1-month T-Bill, and the Moody's Baa Corporate Bond have been obtained from the Federal Reserve Statistical Release. We compute two state variables based on interest rates. Term is a term structure slope, computed as the difference between the 10-year Government Bond and 1-month T-Bill yields, and Default is the difference between Moody s yield on Baa Corporate Bonds and the 10-year Government Bond yield.

We collect three alternative series of monthly macroeconomic growth, and the price deflator rate. We obtain nominal consumption expenditures on nondurable goods and services from Table 2.8.5 of the National Income and Product Accounts (NIPA) available at the Bureau of Economic Analysis. Population data are from NIPA's Table 2.6 and the price deflator is computed using prices from NIPA's Table 2.8.4, with the year 2000 as its basis. All this information is used to construct monthly rates of growth of seasonally adjusted real per capita consumption expenditures on nondurable goods and services. Monthly data for the industrial production index are downloaded from the Federal Reserve, with series identifier G17/IP Major Industry Groups. Finally, we use aggregate per capita stockholder consumption growth rate. These three macroeconomic series are available from January 1960 to December 2011. Exploiting micro-level household consumption data, Malloy, Moskowitz, and Vissing-Jorgensen (2011) show that long-run stockholder consumption risk ex-

(7) The monthly series are available in Lubos Pastor s web site.

plains the cross-sectional variation in average stock returns better than the aggregate consumption risk obtained from nondurable goods and services. On top of that, they report plausible risk aversion estimates. They employ data from the CEX for the period March 1982 to November 2004 to extract consumption growth rates for stockholders, the wealthiest third of stockholders, and non-stockholders. In order to extend their available time period for these series, they construct factor-mimicking portfolios by projecting the stockholder consumption growth rate series from March 1982 to November 2004 on a set of instruments, and use the estimated coefficients to obtain a longer time series of instrumented stockholder consumption growth. They use a small growth portfolio (average of the two smallest size, two lowest BE/ME portfolios) from the 25 Fama-French portfolios, a large growth portfolio (average of the largest size, two lowest BE/ME portfolios), a small value portfolio (average of the two smallest size, two highest BE/ME portfolios), and a large value portfolio (average of the two largest size, two highest BE/ME portfolios) as instruments. Using the estimated coefficients of this regression, they generate a factor-mimicking portfolio for stockholder consumption growth from July 1926 to November 2004. In this paper, we employ the reported estimated coefficients by Malloy, Moskowitz, and Vissing-Jorgensen (2011) to obtain a factor-mimicking portfolio with the same set of instruments for stockholder consumption from January 1960 to September 2012.

3. Model-free implied volatility and the estimation of the volatility risk premium

Britten-Jones and Neuberger (2000) first derived the model-free implied volatility under diffusion assumptions. They obtain the risk-neutral expected integrated variance over the life of the option contract when prices are continuous and volatility is stochastic. Jiang and Tian (2005) extends their paper to show that their method is also valid in a jump-diffusion framework and, therefore, their methodology is considered to be a model-free procedure[8].

We calculate the model-free implied variance denoted as $MFIV^{a}_{t,t+\tau}$ by the following integral over a continuum of strikes:

$$MFIV^{a}_{t,t+\tau} = 2\int_{0}^{\infty} \frac{C^{a}_{t,t+\tau}(K)\big/B(t,t+\tau) - \max\left(S^{a}_{t}\big/B(t,t+\tau) - K, 0\right)}{K^{2}}\, dK, \qquad [6]$$

where $C^{a}_{t,t+\tau}(K)$ is the spot price at time t of a τ-maturity call option on either asset or index a with strike K, $B(t, t+\tau)$ is the time t price of a zero-coupon bond that pays \$1 at time $t+\tau$, and S^{a}_{t} is the spot price of asset a at time t minus the present value of all expected future dividends to be paid before the option maturity. Expression [6] can be approximated accurately by the following sum over a finite number of strikes,

$$MFIV^{a}_{t,t+\tau} \cong \sum_{j=1}^{m} \left[\, g^{a}_{t,t+\tau}\left(K_{j}\right) + g^{a}_{t,t+\tau}\left(K_{j-1}\right) \,\right] \Delta K, \qquad [7]$$

(8) See Aït-Sahalia, Karaman, and Mancini (2012) for the description of the procedure to detect the priced jump component in variance swap rates.

where

$$\Delta K = \frac{\left(K_{\max} - K_{\min}\right)}{m}, \quad K_j = K_{\min} + j\Delta K \text{ for } j = 0, 1, ..., m, \qquad [7.a]$$

and

$$g^a_{t,t+\tau}\left(K_j\right) = \frac{C^a_{t,t+\tau}\left(K_j\right)/B\left(t,t+\tau\right) - \max\left(S^a_t/B\left(t,t+\tau\right) - K_j, 0\right)}{K_j^2} \qquad [7.b]$$

For each time-to-maturity from 6 to 60 days, we calculate the model-free implied variance on each day for each underlying that has at least three available options outstanding, using all the available options at time t. For the risk-free rate, we use the T-bill rate of appropriate maturity (interpolated when necessary) from OptionMetrics, namely the zero-coupon curve. For the dividend rate for the index we employ the daily data on the index dividend yield from OptionMetrics. To infer the continuously compounded dividend rate for each individual asset, we combine the forward price with the spot rate used for the forward price calculations. We obtain the mean continuously compounded dividend rate by averaging the implied OptionMetrics dividends. Finally, we annualize the model-free implied variance using 252 trading days in a calendar day.

The specific implementation follows the approach of Jiang and Tian (2005). It is well known that options are traded only over a limited number of strikes. In principle, expression [7] requires prices of options with strikes K_j for $j = 0, 1, ..., m$. However, the corresponding option prices are not observable because these options are not listed. We apply the curve-fitting method to Black-Scholes implied volatilities instead of option prices. Prices of listed calls (and puts with different strikes) are first transformed into implied volatilities using the Black-Scholes model, and a smooth function is fitted to the implied volatilities using cubic splines[9]. Then, we extract implied volatilities at strikes K_j from the fitted function. Finally, we employ equation [7] to calculate the model-free implied variance using the extracted option prices.

It is sometimes the case that the range of available strikes is not sufficiently large. For option prices outside the range between the maximum and minimum available strikes, we also follow Jiang and Tian (2005) and use the endpoint implied volatility to extrapolate their option prices. This implies that the volatility function is assumed to be constant beyond the maximum and minimum strikes[10]. Finally, discretization errors are unlikely to have any effect on the model-free implied variance if a sufficiently large m, beyond 20, is chosen. In our case, we employ an m equals to 100.

At each time t, we focus on a $\tau = 30$-day horizon maturity, interpolated when necessary using the nearest maturities τ_1 and τ_2 following the procedure of Carr and Wu (2009). The interpolation is linear in total variance:

(9) As pointed out by Jiang and Tian (2005), the curve-fitting procedure does not assume that the Black-Scholes model holds. It is a tool to provide a one-to-one mapping between prices and implied volatilities.

(10) Jiang and Tian (2005) discuss this approximation error and the (different) truncation error that arise when we ignore the tails of the distribution across strikes. In our case, and in order to avoid the truncation error, we use 3.5 standard deviations from the spot underlying price as truncation points.

$$MFIV^a_{t,t+\tau} = \frac{1}{\tau}\left[\frac{MFIV^a_{t,t+\tau_1}\tau_1\left(\tau_2-\tau\right)+MFIV^a_{t,t+\tau_2}\tau_2\left(\tau-\tau_1\right)}{\left(\tau_2-\tau_1\right)}\right] \quad [8]$$

In this paper we work with volatilities, so that we take square root of the model-free implied variance to obtain the model-free annualized implied volatility as:

$$sMFIV^a_{t,t+\tau} = \sqrt{MFIV^a_{t,t+\tau}} \quad [9]$$

For each day in the sample period, we also calculate the realized variance over the same period τ as the one which implied variance is obtained for that day, that is, for 30 days, requiring that no more than 14 returns be missing from the sample:

$$RV^a_{t,t+\tau} = \frac{1}{\tau}\sum_{s=1}^{\tau} r^2_{t+s}\ , \quad [10]$$

where r denotes the rate of return adjusted by dividends and splits. As before, we annualized the realized variance and we take the square root to obtain the realized volatility:

$$sRV^a_{t,t+\tau} = \sqrt{RV^a_{t,t+\tau}} \quad [11]$$

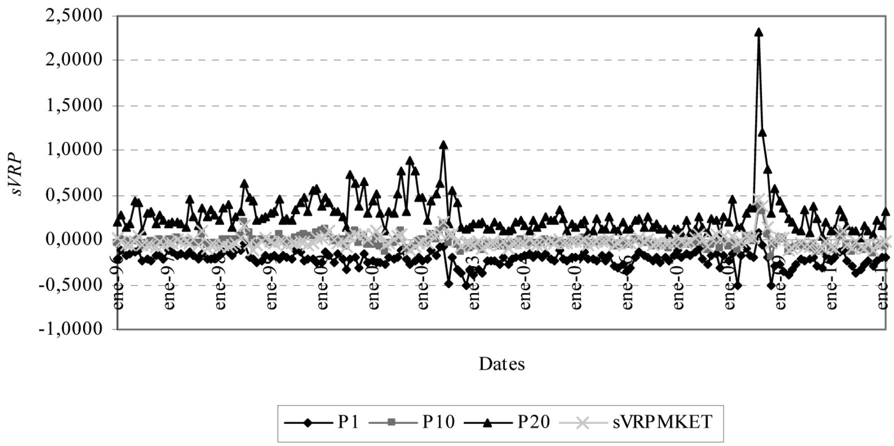
Finally, for each asset and the index, we calculate the volatility risk premium, *sVRP*, at the τ = 30-day horizon as the difference between the corresponding realized and model-free implied volatility:

$$sVRP^a_{t,t+\tau} = sRV^a_{t,t+\tau} - sMFIV^a_{t,t+\tau} \quad [12]$$

We next construct 20 equally-weighted-*sVRP*-sorted portfolios. Using the *sVRP* at the last day of each month, we rank all *sVRP* from the lowest to the highest[11]. Portfolio 1 contains the assets with the lowest *sVRP*, while Portfolio 20 includes the securities with the highest *sVRP*. All portfolios have approximately the same number of securities, and the asset must have at least 15 daily observations to be included in the portfolios. Figure 1 displays the temporal behaviour of the *sVRP* for portfolios 1, 10, 20, and also the *sVRP* for the market index. For practically all months of the sample period, Portfolio 1 has a negative *sVRP*. On the contrary, Portfolio 20 has, most of the time, a positive *sVRP*. Note that we display the *sVRP* of the market using options written on the S&P100 index, so that the series contained in Figure 1 is not the cross-sectional average of the individual *sVRP*. In all series, the positive peaks coincide with periods of high realized volatility.

(11) We repeat the ranking procedure employing the average *sVRP* during the month. However, since market return data at the monthly frequency employs transaction prices observable during the last day of the month, this research follows the same criterion for the *sVRP* data.

Figure 1: Volatility risk premia for extreme and intermediate portfolios and the market: January 1996-February 2011



Source: Own elaboration.

4. Unconditional volatility risk premia betas

Although, we calculate expression [12] on each day during the sample period, the first column of Table 1 reports the average *sVRP* calculated at monthly frequencies for each of the 20 portfolios, and also for the market *sVRP*. All of these figures are given on annualized terms. As expected, given the well known evidence provided among others by Carr and Wu (2009), the market *sVRP* is, on average, negative and equal to 1.4%. The averages of the *sVRP* for the alternative portfolios reflect the construction criterion described in the previous section, with an average *sVRP* of -21.3% for P1, and 28.6% for P20. The magnitude of the cross-sectional differences is rather striking[12]. These averages reflect that investors have very different volatility investment vehicles depending on whether they go long or short on volatility. We tend to identify the purchase of volatility as a hedging instrument against potentially large stock market declines. However, the evidence reported in Table 1 suggests that, on average, going long on volatility can also report substantial (ex-post) gains depending on the portfolio on which investors buy volatility. The average annualized *sVRP* obtained directly from daily data present a very similar pattern although the range of averages *sVRP* is smaller, and it goes from -16.4% to 19.9%. The standard deviations of the *sVRP* of the 20 portfolios suggest that portfolios with high and positive average *sVRP* and, on the other hand, the portfolio with the lowest average *sVRP* are the

(12) These magnitudes are also relevant from an economic point of view. During the same sample period, VIX is approximately 22% on annual basis. The *sVRP* of the extreme portfolios is about the same order of magnitude or even higher. Using equation (3), and for a notional of $100,000, the monetary loss for purchasing P1 over the full sample period is as high as $1,600,000.

Table 1: THE VOLATILITY RISK PREMIA: DESCRIPTIVE STATISTICS AND BETAS, JANUARY 1996-FEBRUARY 2011

sVRP-sorted Portfolios	Average *sVRP* (monthly data)	Average *sVRP* (daily data)	Standard Deviation *sVRP* (monthly data)	Standard Deviation *sVRP* (daily data)	*sVRP* Beta (monthly data)
P1	-0.213	-0.164	0.080	0.111	0.547
P2	-0.143	-0.118	0.061	0.079	0.610
P3	-0.113	-0.099	0.060	0.071	0.636
P4	-0.094	-0.083	0.061	0.071	0.662
P5	-0.079	-0.072	0.062	0.069	0.678
P6	-0.067	-0.060	0.063	0.072	0.707
P7	-0.056	-0.052	0.065	0.075	0.731
P8	-0.045	-0.045	0.066	0.074	0.756
P9	-0.035	-0.033	0.068	0.074	0.788
P10	-0.024	-0.026	0.070	0.076	0.827
P11	-0.013	-0.016	0.072	0.075	0.853
P12	-0.002	-0.007	0.075	0.076	0.895
P13	0.010	0.004	0.078	0.080	0.935
P14	0.023	0.014	0.081	0.080	0.980
P15	0.037	0.022	0.087	0.082	1.066
P16	0.054	0.039	0.095	0.090	1.163
P17	0.074	0.052	0.106	0.101	1.303
P18	0.100	0.073	0.117	0.111	1.438
P19	0.142	0.103	0.136	0.135	1.635
P20	0.286	0.199	0.239	0.213	2.506
Market *sVRP*	-0.014	-0.014	0.069	0.069	1.000

The volatility risk premium (*sVRP*) for each portfolio is defined as the difference between the realized volatility and the model-free risk-neutral integrated return volatility over the corresponding month. The risk-neutral volatility is obtained by the set of prices of options on each underlying individual security with one month to maturity. The numbers reported are annualized volatility risk premia for both the 20 *sVRP*-sorted portfolios and the S&P 100 index. Portfolio one contains the securities with the lowest *sVRP*, and portfolio 20 includes securities with the highest *sVRP*. The portfolios are updated each month during the sample period. The *sVRP* beta is the OLS regression coefficient from linear regressions of the monthly *sVRP* of each portfolio on the *sVRP* of the S&P 100 market index. Monthly data refers to the observation of each portfolio on the last day of each month.

Source: Own elaboration.

most volatile portfolios. Figure 1 also reflects the highly volatile behavior of the *sVRP* of P20, followed by the relatively smoother behaviour of P1.

The last column of Table 1 contains the *sVRP* betas of each of the portfolios relative to the *sVRP* of the market index. Using monthly data, we estimate a market model type of OLS regression of the following form:

$$sVRP^{p}_{t,t+\tau} = a + \beta \; sVRP^{m}_{t,t+\tau} + \varepsilon_{t,t+\tau} \, , \qquad [13]$$

where $sVRP^{p}_{t,t+\tau}$ is the volatility risk premium of each of the 20 portfolios, and $sVRP^{m}_{t,t+\tau}$ is the volatility risk premium of the market index from January 1996 to February 2011. In all cases, we employ HAC robust standard errors. The portfolio *sVRP* betas follow a monotonic relation with respect to their average *sVRP*. Portfolios with high and positive *sVRP* also have high *sVRP* betas suggesting a very highly sensitive behavior relative to the market volatility risk premium. Indeed, the range of *sVRP* betas goes from 0.55 for P1 to 2.51 for P20. The cross-sectional differences in *sVRP* betas are surprisingly high given the cross-sectional differences in the average volatility risk premia.

Table 1 also reflects that portfolios P15 to P20 have, on average, a positive *sVRP*, and a volatility risk premium beta higher than one. As pointed out above, the behavior of portfolio P20 is particularly interesting. Its average *sVRP* and beta are 28.6% and 2.51 respectively. Table 2.A contains the correlation coefficients between alternative *sVRP* portfolios and the *sVRP* of the market. Panel A employs monthly data while Panel B displays the results with daily data. As expected, independently of the frequency used, the correlation between portfolios P1 and P20 is the lowest among all possible pairs and, given the evidence from Table 1, the overall pattern of the rest of correlation coefficients seems reasonable. The only exception is that the correlation between P20 and the *sVRP* of the market is lower than the correlations for the intermediate portfolios. Table 2.B reports the correlation between the *sVRP* of the market and several macroeconomic and financial indicators. The correlation between the excess market return and the market *sVRP* is negative and equals to -0.273. This is well known and implies a negative correlation between market returns and realized market volatilities. Thus, going long on the market *sVRP* provides a hedging investment vehicle for moments of extremely high market volatility. However, the compensation for this hedging strategy is, on average, negative. In this sense, the average behavior of portfolios P15 to P20, and especially the results associated with portfolio P20 are very surprising. To go long on market volatility gives a positive payoff in high marginal utility events with the corresponding negative average payoff. To go long on portfolio P20 provides a very strong hedging strategy because the volatility risk premium beta is even higher than two. When the realized market volatility is high, the realized volatility of this portfolio is much higher. This suggests that, on average, the payoff from going long on this portfolio in high marginal utility events is extraordinarily high. On top of this, the average payoff of portfolio P20 is also high and positive. Going long on this portfolio not only provides a very strong hedging instrument but positive average gains. Naturally, this contrasts with the negative and large average payoff of portfolio P1. Sellers of volatility should buy portfolios with negative average payoffs and positive volatility risk premium betas, and buyers of volatility should buy portfolios with positive average payoffs and very high and positive volatility risk premium betas.

Table 2.A: Correlation coefficients between volatility risk premia for representative portfolios, January 1996-February 2011

Panel A: Monthly Correlations	P5	P10	P15	P20	Market *sVRP*
P1	0.743	0.663	0.579	0.397	0.472
P5	1	0.971	0.906	0.643	0.760
P10		1	0.969	0.734	0.813
P15			1	0.827	0.844
P20				1	0.725

Panel B: Daily Correlations	P5	P10	P15	P20	Market *sVRP*
P1	0.685	0.679	0.550	0.364	0.560
P5	1	0.876	0.785	0.573	0.725
P10		1	0.848	0.685	0.804
P15			1	0.758	0.778
P20				1	0.684

Source: Own elaboration.

Our previous evidence may be due to the fact that other aggregate factors, over and above the market *sVRP*, may explain the behavior of the *sVRP* of our 20 portfolios over time. Table 3 contains the 20 *sVRP* betas controlling for well known aggregate risk factors. The robustness of the magnitudes of the *sVRP* betas reported in Table 3 is striking. Independently of the factor (or factors) employed in the regression, portfolio P1 has a particularly low beta while P20 has a very high volatility risk premium beta. The monotonic relation between the *sVRP* betas and the average volatility risk premium of the twenty portfolios is maintained across all aggregate factors.

Panels A and B of Table 3 considers market wealth, represented by the return on the market, and either consumption growth of non-durable goods and services or stockholder consumption growth. In Panel A, when we add either the market portfolio

Table 2.B: Correlation coefficients between state variables, January 1996-February 2011

Monthly Correlations	Excess Market Return	Cons Growth	Stock Cons Growth	Term	Default	Liquidity	SMB	HML	MOM
Market *sVRP*	-0.273	-0.189	-0.118	-0.068	0.075	-0.116	0.019	0.130	0.185
Excess Market Return	1	0.213	0.769	0.006	-0.132	0.258	0.242	-0.247	-0.296
Cons Growth		1	0.131	-0.188	-0.356	0.106	0.043	-0.125	-0.356
Stock Cons Growth			1	0.038	-0.149	0.223	0.449	0.237	-0.301
Term				1	0.502	0.052	0.140	-0.027	-0.066
Default					1	-0.174	0.058	-0.087	-0.198
Liquidity						1	0.026	0.004	-0.114
SMB							1	-0.372	0.091
HML								1	-0.156

Source: Own elaboration.

Table 3: PANEL A: CONSUMPTION AND MARKET FACTOR BETAS FOR 20 PORTFOLIOS SORTED BY THE VOLATILITY RISK PREMIUM, JANUARY 1996-FEBRUARY 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Market *sVRP*	Cons Growth	Market *sVRP*	Stock Cons Growth
P1 Beta	0.547	0.601	0.081	0.585	1.616	0.575	0.425
(t-stat)	(8.79)	(10.43)	(2.26)	(9.33)	(2.20)	(9.32)	(2.25)
[R^2-adj]	[0.218]	[0.241]		[0.243]		[0.255]	
P2 Beta	0.610	0.648	0.057	0.643	1.430	0.625	0.237
(t-stat)	(13.92)	(15.50)	(2.12)	(14.39)	(2.85)	(14.07)	(1.83)
[R^2-adj]	[0.476]	[0.496]		[0.513]		[0.495]	
P3 Beta	0.636	0.671	0.052	0.672	1.529	0.650	0.212
(t-stat)	(15.87)	(17.16)	(2.10)	(17.39)	(3.38)	(15.52)	(1.75)
[R^2-adj]	[0.527]	[0.545]		[0.571]		[0.543]	
P4 Beta	0.662	0.693	0.046	0.698	1.538	0.674	0.189
(t-stat)	(16.68)	(17.70)	(1.88)	(17.70)	(3.89)	(16.31)	(1.58)
[R^2-adj]	[0.559]	[0.572]		[0.603]		[0.571]	
P5 Beta	0.678	0.703	0.037	0.715	1.584	0.689	0.160
(t-stat)	(17.14)	(17.91)	(1.51)	(18.72)	(4.20)	(16.83)	(1.35)
[R^2-adj]	[0.575]	[0.582]		[0.620]		[0.582]	
P6 Beta	0.707	0.728	0.032	0.742	1.516	0.716	0.140
(t-stat)	(17.67)	(18.11)	(1.33)	(19.96)	(4.21)	(17.21)	(1.19)
[R^2-adj]	[0.593]	[0.597]		[0.632]		[0.598]	
P7 Beta	0.731	0.752	0.031	0.767	1.523	0.740	0.133
(t-stat)	(18.41)	(18.92)	(1.37)	(21.01)	(4.18)	(18.07)	(1.18)
[R^2-adj]	[0.608]	[0.612]		[0.647]		[0.612]	
P8 Beta	0.756	0.774	0.027	0.792	1.531	0.763	0.115
(t-stat)	(19.62)	(19.98)	(1.27)	(21.85)	(4.02)	(19.33)	(1.10)
[R^2-adj]	[0.622]	[0.625]		[0.659]		[0.625]	
P9 Beta	0.788	0.804	0.023	0.824	1.529	0.795	0.103
(t-stat)	(20.46)	(20.56)	(1.08)	(22.74)	(4.06)	(20.26)	(0.97)
[R^2-adj]	[0.639]	[0.640]		[0.674]		[0.640]	
P10 Beta	0.827	0.842	0.021	0.861	1.435	0.834	0.096
(t-stat)	(20.88)	(20.41)	(0.98)	(21.78)	(3.80)	(20.47)	(0.92)
[R^2-adj]	[0.659]	[0.660]		[0.687]		[0.660]	

Source: Own elaboration.

Table 3: Panel A: Consumption and market factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Market *sVRP*	Cons Growth	Market *sVRP*	Stock Cons Growth
P11 Beta	0.853	0.866	0.019	0.887	1.418	0.859	0.086
(t-stat)	(21.56)	(21.00)	(0.85)	(22.99)	(3.95)	(21.19)	(0.82)
[R^2-adj]	[0.673]	[0.673]		[0.699]		[0.673]	
P12 Beta	0.895	0.908	0.020	0.930	1.449	0.902	0.095
(t-stat)	(21.69)	(20.58)	(0.83)	(22.01)	(4.16)	(21.56)	(0.88)
[R^2-adj]	[0.685]	[0.685]		[0.711]		[0.686]	
P13 Beta	0.935	0.947	0.017	0.969	1.444	0.941	0.091
(t-stat)	(21.57)	(20.32)	(0.71)	(21.55)	(4.27)	(21.44)	(0.85)
[R^2-adj]	[0.695]	[0.694]		[0.718]		[0.695]	
P14 Beta	0.980	0.990	0.015	1.012	1.385	0.985	0.073
(t-stat)	(22.22)	(21.31)	(0.67)	(22.34)	(3.40)	(22.03)	(0.69)
[R^2-adj]	[0.701]	[0.701]		[0.721]		[0.701]	
P15 Beta	1.066	1.078	0.017	1.098	1.326	1.071	0.070
(t-stat)	(17.79)	(16.62)	(0.65)	(17.12)	(3.53)	(17.46)	(0.60)
[R^2-adj]	[0.710]	[0.709]		[0.723]		[0.709]	
P16 Beta	1.163	1.170	0.011	1.193	1.262	1.167	0.057
(t-stat)	(15.14)	(13.87)	(0.38)	(14.53)	(3.09)	(14.80)	(0.46)
[R^2-adj]	[0.716]	[0.715]		[0.727]		[0.715]	
P17 Beta	1.303	1.305	0.003	1.331	1.201	1.301	0.044
(t-stat)	(13.15)	(12.03)	(0.10)	(12.65)	(2.68)	(12.85)	(0.34)
[R^2-adj]	[0.728]	[0.725]		[0.735]		[0.726]	
P18 Beta	1.438	1.436	-0.003	1.464	1.110	1.441	0.042
(t-stat)	(13.75)	(12.60)	(-0.08)	(13.16)	(1.99)	(13.50)	(0.27)
[R^2-adj]	[0.723]	[0.721]		[0.728]		[0.721]	
P19 Beta	1.635	1.629	-0.009	1.662	1.128	1.638	0.040
(t-stat)	(10.27)	(9.54)	(-0.24)	(10.10)	(1.62)	(10.13)	(0.25)
[R^2-adj]	[0.691]	[0.689]		[0.694]		[0.689]	
P20 Beta	2.506	2.502	-0.006	2.527	0.897	2.514	0.124
(t-stat)	(5.11)	(4.78)	(-0.08)	(5.23)	(0.63)	(5.04)	(0.38)
[R^2-adj]	[0.523]	[0.521]		[0.522]		[0.521]	

Source: Own elaboration.

Table 3: PANEL B: CONSUMPTION AND MARKET FACTOR BETAS FOR 20 PORTFOLIOS SORTED BY THE VOLATILITY RISK PREMIUM, JANUARY 1996-FEBRUARY 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Cons Growth	Market *sVRP*	Excess Market Return	Stock Cons Growth
P1 Beta	0.547	0.626	0.068	1.393	0.580	0.010	0.392
(t-stat)	(8.79)	(9.77)	(1.98)	(1.90)	(9.95)	(0.23)	(1.45)
[R^2-adj]	[0.218]	[0.258]			[0.251]		
P2 Beta	0.610	0.670	0.045	1.281	0.641	0.034	0.124
(t-stat)	(13.92)	(14.21)	(1.77)	(2.59)	(16.32)	(1.19)	(0.77)
[R^2-adj]	[0.476]	[0.525]			[0.496]		
P3 Beta	0.636	0.695	0.039	1.400	0.665	0.033	0.103
(t-stat)	(15.87)	(16.76)	(1.72)	(3.21)	(18.23)	(1.13)	(0.64)
[R^2-adj]	[0.527]	[0.580]			[0.544]		
P4 Beta	0.662	0.718	0.033	1.430	0.687	0.029	0.094
(t-stat)	(16.68)	(17.10)	(1.46)	(3.78)	(18.65)	(0.98)	(0.59)
[R^2-adj]	[0.559]	[0.608]			[0.571]		
P5 Beta	0.678	0.730	0.024	1.506	0.670	0.021	0.092
(t-stat)	(17.14)	(17.80)	(1.04)	(4.19)	(18.68)	(0.67)	(0.57)
[R^2-adj]	[0.575]	[0.622]			[0.581]		
P6 Beta	0.707	0.754	0.019	1.453	0.724	0.017	0.082
(t-stat)	(17.67)	(18.84)	(0.86)	(4.20)	(18.92)	(0.55)	(0.50)
[R^2-adj]	[0.593]	[0.633]			[0.596]		
P7 Beta	0.731	0.777	0.018	1.464	0.747	0.017	0.076
(t-stat)	(18.41)	(20.05)	(0.86)	(4.05)	(19.49)	(0.57)	(0.47)
[R^2-adj]	[0.608]	[0.647]			[0.611]		
P8 Beta	0.756	0.800	0.013	1.487	0.770	0.015	0.066
(t-stat)	(19.62)	(20.78)	(0.69)	(3.97)	(20.40)	(0.49)	(0.42)
[R^2-adj]	[0.622]	[0.659]			[0.623]		
P9 Beta	0.788	0.830	0.010	1.496	0.800	0.012	0.064
(t-stat)	(20.46)	(21.40)	(0.49)	(4.05)	(20.94)	(0.38)	(0.41)
[R^2-adj]	[0.639]	[0.672]			[0.639]		
P10 Beta	0.827	0.866	0.009	1.406	0.838	0.010	0.063
(t-stat)	(20.88)	(20.19)	(0.43)	(3.77)	(20.90)	(0.31)	(0.39)
[R^2-adj]	[0.659]	[0.686]			[0.658]		

Source: Own elaboration.

Table 3: Panel B: Consumption and market factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Cons Growth	Market *sVRP*	Excess Market Return	Stock Cons Growth
P11 Beta	0.853	0.890	0.006	1.397	0.863	0.008	0.060
(t-stat)	(21.56)	(21.08)	(0.30)	(3.92)	(21.49)	(0.24)	(0.37)
[R^2-adj]	[0.673]	[0.698]			[0.671]		
P12 Beta	0.895	0.934	0.007	1.426	0.904	0.006	0.075
(t-stat)	(21.69)	(19.91)	(0.30)	(4.11)	(20.78)	(0.18)	(0.47)
[R^2-adj]	[0.685]	[0.710]			[0.684]		
P13 Beta	0.935	0.972	0.004	1.430	0.942	0.002	0.086
(t-stat)	(21.57)	(19.46)	(0.18)	(4.18)	(20.51)	(0.04)	(0.53)
[R^2-adj]	[0.695]	[0.717]			[0.693]		
P14 Beta	0.980	1.014	0.003	1.376	0.987	0.005	0.057
(t-stat)	(22.22)	(20.56)	(0.12)	(3.86)	(21.50)	(0.13)	(0.34)
[R^2-adj]	[0.701]	[0.720]			[0.699]		
P15 Beta	1.066	1.101	0.006	1.308	1.076	0.012	0.031
(t-stat)	(17.79)	(15.71)	(0.21)	(3.32)	(16.70)	(0.29)	(0.18)
[R^2-adj]	[0.710]	[0.724]			[0.708]		
P16 Beta	1.163	1.193	-0.000	1.263	1.168	0.002	0.051
(t-stat)	(15.14)	(13.20)	(-0.01)	(2.93)	(13.88)	(0.04)	(0.28)
[R^2-adj]	[0.716]	[0.726]			[0.713]		
P17 Beta	1.303	1.326	-0.008	1.226	1.300	-0.012	0.083
(t-stat)	(13.15)	(11.55)	(-0.24)	(2.54)	(12.01)	(-0.25)	(0.41)
[R^2-adj]	[0.728]	[0.733]			[0.724]		
P18 Beta	1.438	1.457	-0.013	1.153	1.430	-0.025	0.122
(t-stat)	(13.75)	(12.11)	(-0.36)	(1.92)	(12.48)	(-0.48)	(0.55)
[R^2-adj]	[0.723]	[0.727]			[0.720]		
P19 Beta	1.635	1.650	-0.020	1.193	1.620	-0.041	0.174
(t-stat)	(10.27)	(9.35)	(-0.49)	(1.58)	(9.43)	(-0.67)	(0.66)
[R^2-adj]	[0.691]	[0.693]			[0.689]		
P20 Beta	2.506	2.518	-0.014	0.944	2.482	-0.070	0.354
(t-stat)	(5.11)	(4.89)	(-0.17)	(0.62)	(4.73)	(-0.66)	(0.78)
[R^2-adj]	[0.523]	[0.519]			[0.519]		

Source: Own elaboration.

Table 3: Panel C.1: Interest rate and liquidity factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Term	Default	Market *sVRP*	Liquidity	Default
P1 Beta	0.547	0.611	0.337	-1.509	0.600	0.028	-1.236
(t-stat)	(8.79)	(10.85)	(2.85)	(-6.84)	(9.71)	(1.26)	(-5.94)
[R^2-adj]	[0.218]	[0.473]			[0.457]		
P2 Beta	0.610	0.653	0.211	-1.033	0.643	0.011	-0.870
(t-stat)	(13.92)	(16.63)	(2.14)	(-5.70)	(14.44)	(0.80)	(-5.92)
[R^2-adj]	[0.476]	[0.688]			[0.674]		
P3 Beta	0.636	0.677	0.224	-0.946	0.665	0.006	-0.782
(t-stat)	(15.87)	(19.62)	(2.23)	(-5.17)	(16.76)	(0.42)	(-5.20)
[R^2-adj]	[0.527]	[0.704]			[0.686]		
P4 Beta	0.662	0.700	0.204	-0.873	0.687	0.002	-0.727
(t-stat)	(16.68)	(19.23)	(1.95)	(-4.69)	(16.76)	(0.18)	(-4.80)
[R^2-adj]	[0.559]	[0.705]			[0.691]		
P5 Beta	0.678	0.712	0.171	-0.813	0.701	-0.001	-0.695
(t-stat)	(17.14)	(19.72)	(1.65)	(-4.57)	(17.78)	(-0.08)	(-4.66)
[R^2-adj]	[0.575]	[0.701]			[0.691]		
P6 Beta	0.707	0.739	0.168	-0.753	0.726	-0.009	-0.642
(t-stat)	(17.67)	(20.54)	(1.56)	(-4.01)	(18.68)	(-0.63)	(-4.15)
[R^2-adj]	[0.593]	[0.694]			[0.685]		
P7 Beta	0.731	0.760	0.147	-0.705	0.748	-0.012	-0.615
(t-stat)	(18.41)	(21.49)	(1.33)	(-3.86)	(19.83)	(-0.89)	(-3.97)
[R^2-adj]	[0.608]	[0.694]			[0.688]		
P8 Beta	0.756	0.782	0.118	-0.656	0.770	-0.016	-0.590
(t-stat)	(19.62)	(21.87)	(1.04)	(-3.85)	(20.67)	(-1.18)	(-3.98)
[R^2-adj]	[0.622]	[0.694]			[0.692]		
P9 Beta	0.788	0.813	0.101	-0.622	0.800	-0.018	-0.573
(t-stat)	(20.46)	(21.95)	(0.88)	(-3.65)	(21.23)	(-1.30)	(-3.78)
[R^2-adj]	[0.639]	[0.700]			[0.701]		
P10 Beta	0.827	0.851	0.098	-0.580	0.837	-0.020	-0.536
(t-stat)	(20.88)	(20.90)	(0.83)	(-3.53)	(20.35)	(-1.39)	(-3.65)
[R^2-adj]	[0.659]	[0.708]			[0.710]		

Source: Own elaboration.

Table 3: Panel C.1: Interest rate and liquidity factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Term	Default	Market *sVRP*	Liquidity	Default
P11 Beta	0.853	0.874	0.077	-0.514	0.861	-0.022	-0.488
(t-stat)	(21.56)	(21.67)	(0.64)	(-3.26)	(21.31)	(-1.49)	(-3.39)
[R^2-adj]	[0.673]	[0.710]			[0.713]		
P12 Beta	0.895	0.912	0.041	-0.455	0.901	-0.023	-0.457
(t-stat)	(21.69)	(20.45)	(0.34)	(-2.87)	(20.57)	(-1.52)	(-3.05)
[R^2-adj]	[0.685]	[0.713]			[0.718]		
P13 Beta	0.935	0.950	0.029	-0.402	0.939	-0.026	-0.414
(t-stat)	(21.57)	(20.18)	(0.23)	(-2.71)	(20.24)	(-1.68)	(-2.85)
[R^2-adj]	[0.695]	[0.715]			[0.720]		
P14 Beta	0.980	0.991	0.015	-0.335	0.981	-0.026	-0.359
(t-stat)	(22.22)	(21.18)	(0.11)	(-2.26)	(20.95)	(-1.57)	(-2.48)
[R^2-adj]	[0.701]	[0.713]			[0.720]		
P15 Beta	1.066	1.075	-0.010	-0.267	1.066	-0.031	-0.309
(t-stat)	(17.79)	(16.53)	(-0.07)	(-1.79)	(16.51)	(-1.78)	(-2.06)
[R^2-adj]	[0.710]	[0.716]			[0.721]		
P16 Beta	1.163	1.167	-0.048	-0.170	1.158	-0.037	-0.246
(t-stat)	(15.14)	(14.10)	(-0.31)	(-1.14)	(14.29)	(-1.94)	(-1.59)
[R^2-adj]	[0.716]	[0.717]			[0.724]		
P17 Beta	1.303	1.300	-0.105	-0.052	1.293	-0.045	-0.175
(t-stat)	(13.15)	(12.31)	(-0.61)	(-0.34)	(12.77)	(-2.25)	(-1.05)
[R^2-adj]	[0.728]	[0.726]			[0.733]		
P18 Beta	1.438	1.425	-0.189	0.149	1.421	-0.050	-0.044
(t-stat)	(13.75)	(13.09)	(-1.01)	(0.89)	(13.89)	(-0.88)	(-0.24)
[R^2-adj]	[0.723]	[0.723]			[0.729]		
P19 Beta	1.635	1.610	-0.293	0.388	1.611	-0.041	0.118
(t-stat)	(10.27)	(10.02)	(-1.31)	(2.13)	(10.59)	(-0.67)	(0.55)
[R^2-adj]	[0.691]	[0.696]			[0.697]		
P20 Beta	2.506	2.455	-0.108	1.401	2.443	-0.070	1.257
(t-stat)	(5.11)	(5.31)	(-0.30)	(3.23)	(5.33)	(-0.66)	(2.52)
[R^2-adj]	[0.523]	[0.547]			[0.550]		

Source: Own elaboration.

Table 3: Panel C.2: Interest rate, consumption and market factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Default	Market *sVRP*	Cons Growth	Default
P1 Beta	0.547	0.624	0.053	-1.240	0.589	0.015	-1.272
(t-stat)	(8.79)	(10.89)	(2.20)	(-6.24)	(9.97)	(0.04)	(-5.90)
[R^2-adj]	[0.218]	[0.462]			[0.450]		
P2 Beta	0.610	0.664	0.038	-0.862	0.646	0.358	-0.851
(t-stat)	(13.92)	(15.09)	(2.38)	(-6.51)	(14.19)	(1.44)	(-5.75)
[R^2-adj]	[0.476]	[0.682]			[0.674]		
P3 Beta	0.636	0.685	0.035	-0.768	0.675	0.608	-0.731
(t-stat)	(15.87)	(17.34)	(2.34)	(-5.81)	(16.15)	(2.31)	(-4.94)
[R^2-adj]	[0.527]	[0.694]			[0.692]		
P4 Beta	0.662	0.706	0.030	-0.712	0.701	0.704	-0.662
(t-stat)	(16.68)	(17.05)	(2.00)	(-5.20)	(16.19)	(2.63)	(-4.38)
[R^2-adj]	[0.559]	[0.697]			[0.699]		
P5 Beta	0.678	0.716	0.022	-0.680	0.718	0.808	-0.616
(t-stat)	(17.14)	(17.61)	(1.40)	(-4.95)	(17.28)	(2.99)	(-4.14)
[R^2-adj]	[0.575]	[0.694]			[0.702]		
P6 Beta	0.707	0.740	0.019	-0.624	0.744	0.815	-0.557
(t-stat)	(17.67)	(18.24)	(1.13)	(-4.30)	(18.44)	(2.92)	(-3.57)
[R^2-adj]	[0.593]	[0.687]			[0.695]		
P7 Beta	0.731	0.763	0.018	-0.592	0.769	0.870	-0.519
(t-stat)	(18.41)	(19.40)	(1.17)	(-4.04)	(19.73)	(2.86)	(-3.27)
[R^2-adj]	[0.608]	[0.689]			[0.698]		
P8 Beta	0.756	0.784	0.014	-0.565	0.794	0.921	-0.485
(t-stat)	(19.62)	(20.24)	(0.95)	(-3.99)	(20.38)	(2.83)	(-3.17)
[R^2-adj]	[0.622]	[0.691]			[0.703]		
P9 Beta	0.788	0.814	0.011	-0.544	0.826	0.950	-0.459
(t-stat)	(20.46)	(20.56)	(0.70)	(-3.74)	(20.97)	(2.86)	(-2.95)
[R^2-adj]	[0.639]	[0.698]			[0.710]		
P10 Beta	0.827	0.851	0.010	-0.505	0.863	0.900	-0.425
(t-stat)	(20.88)	(19.32)	(0.61)	(-3.57)	(19.88)	(2.57)	(-2.79)
[R^2-adj]	[0.659]	[0.706]			[0.716]		

Source: Own elaboration.

Table 3: Panel C.2: Interest rate, consumption and market factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	Default	Market *sVRP*	Cons Growth	Default
P11 Beta	0.853	0.874	0.009	-0.455	0.888	0.954	-0.368
(t-stat)	(21.56)	(20.02)	(0.50)	(-3.26)	(21.17)	(2.72)	(-2.46)
[R^2-adj]	[0.673]	[0.709]			[0.720]		
P12 Beta	0.895	0.916	0.010	-0.421	0.931	1.038	-0.327
(t-stat)	(21.69)	(19.17)	(0.55)	(-2.91)	(20.45)	(2.97)	(-2.10)
[R^2-adj]	[0.685]	[0.713]			[0.725]		
P13 Beta	0.935	0.954	0.009	-0.377	0.970	1.096	-0.276
(t-stat)	(21.57)	(18.94)	(0.43)	(-2.67)	(20.28)	(3.01)	(-1.83)
[R^2-adj]	[0.695]	[0.715]			[0.727]		
P14 Beta	0.980	0.996	0.008	-0.319	1.013	1.112	-0.216
(t-stat)	(22.22)	(20.14)	(0.38)	(-2.24)	(21.34)	(2.98)	(-1.43)
[R^2-adj]	[0.701]	[0.714]			[0.726]		
P15 Beta	1.066	1.083	0.011	-0.267	1.098	1.117	-0.166
(t-stat)	(17.79)	(15.71)	(0.46)	(-1.82)	(16.60)	(2.75)	(-1.07)
[R^2-adj]	[0.710]	[0.717]			[0.727]		
P16 Beta	1.163	1.174	0.007	-0.200	1.193	1.145	-0.093
(t-stat)	(15.14)	(13.34)	(0.24)	(-1.31)	(14.31)	(2.60)	(-0.58)
[R^2-adj]	[0.716]	[0.717]			[0.726]		
P17 Beta	1.303	1.307	0.000	-0.125	1.331	1.188	-0.010
(t-stat)	(13.15)	(11.78)	(0.02)	(-0.76)	(12.63)	(2.49)	(-0.06)
[R^2-adj]	[0.728]	[0.725]			[0.733]		
P18 Beta	1.438	1.436	-0.002	0.015	1.464	1.288	0.141
(t-stat)	(13.75)	(12.63)	(-0.07)	(0.08)	(13.44)	(2.38)	(0.73)
[R^2-adj]	[0.723]	[0.720]			[0.728]		
P19 Beta	1.635	1.626	-0.005	0.180	1.661	1.547	0.332
(t-stat)	(10.27)	(9.77)	(-0.13)	(0.84)	(10.43)	(2.38)	(1.51)
[R^2-adj]	[0.691]	[0.689]			[0.698]		
P20 Beta	2.506	2.477	0.023	1.340	2.521	2.922	1.609
(t-stat)	(5.11)	(5.05)	(0.27)	(2.86)	(5.52)	(2.08)	(3.09)
[R^2-adj]	[0.523]	[0.547]			[0.557]		

Source: Own elaboration.

Table 3: Panel D.1: FAMA-FRENCH-CARHART FACTOR BETAS FOR 20 PORTFOLIOS SORTED BY THE VOLATILITY RISK PREMIUM, JANUARY 1996-FEBRUARY 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	SMB	HML	MOM
P1 Beta	0.547	0.564	0.119	0.010	0.116	0.064
(t-stat)	(8.79)	(10.12)	(3.10)	(0.25)	(1.79)	(2.02)
[R^2-adj]	[0.218]	[0.269]				
P2 Beta	0.610	0.626	0.076	0.009	0.047	0.042
(t-stat)	(13.92)	(15.33)	(2.70)	(0.31)	(1.24)	(3.21)
[R^2-adj]	[0.476]	[0.509]				
P3 Beta	0.636	0.651	0.067	0.016	0.037	0.037
(t-stat)	(15.87)	(17.70)	(2.51)	(0.53)	(0.99)	(2.95)
[R^2-adj]	[0.527]	[0.554]				
P4 Beta	0.662	0.673	0.060	0.016	0.033	0.038
(t-stat)	(16.68)	(17.57)	(2.35)	(0.53)	(0.94)	(2.84)
[R^2-adj]	[0.559]	[0.580]				
P5 Beta	0.678	0.682	0.052	0.018	0.032	0.042
(t-stat)	(17.14)	(17.69)	(2.04)	(0.58)	(0.89)	(3.10)
[R^2-adj]	[0.575]	[0.594]				
P6 Beta	0.707	0.707	0.045	0.022	0.028	0.040
(t-stat)	(17.67)	(18.22)	(1.79)	(0.69)	(0.77)	(2.87)
[R^2-adj]	[0.593]	[0.608]				
P7 Beta	0.731	0.730	0.044	0.022	0.024	0.043
(t-stat)	(18.41)	(18.89)	(1.85)	(0.69)	(0.70)	(3.00)
[R^2-adj]	[0.608]	[0.624]				
P8 Beta	0.756	0.753	0.039	0.022	0.020	0.043
(t-stat)	(19.62)	(19.59)	(1.77)	(0.70)	(0.59)	(2.97)
[R^2-adj]	[0.622]	[0.636]				
P9 Beta	0.788	0.783	0.037	0.019	0.020	0.044
(t-stat)	(20.46)	(20.02)	(1.62)	(0.62)	(0.61)	(2.99)
[R^2-adj]	[0.639]	[0.651]				
P10 Beta	0.827	0.822	0.034	0.020	0.018	0.042
(t-stat)	(20.88)	(19.10)	(1.50)	(0.64)	(0.56)	(2.92)
[R^2-adj]	[0.659]	[0.669]				

Source: Own elaboration.

Table 3: Panel D.1: Fama-french-Carhart factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Excess Market Return	SMB	HML	MOM
P11 Beta	0.853	0.848	0.030	0.017	0.016	0.038
(t-stat)	(21.56)	(19.94)	(1.34)	(0.55)	(0.48)	(2.73)
[R^2-adj]	[0.673]	[0.679]				
P12 Beta	0.895	0.890	0.031	0.019	0.017	0.038
(t-stat)	(21.69)	(18.85)	(1.29)	(0.64)	(0.52)	(2.47)
[R^2-adj]	[0.685]	[0.691]				
P13 Beta	0.935	0.929	0.027	0.022	0.017	0.036
(t-stat)	(21.57)	(18.56)	(1.13)	(0.73)	(0.51)	(2.32)
[R^2-adj]	[0.695]	[0.699]				
P14 Beta	0.980	0.972	0.024	0.022	0.009	0.037
(t-stat)	(22.22)	(19.38)	(1.01)	(0.72)	(0.27)	(2.22)
[R^2-adj]	[0.701]	[0.705]				
P15 Beta	1.066	1.063	0.025	0.018	0.002	0.034
(t-stat)	(17.79)	(14.99)	(0.93)	(0.59)	(0.05)	(1.90)
[R^2-adj]	[0.710]	[0.712]				
P16 Beta	1.163	1.156	0.017	0.022	0.002	0.032
(t-stat)	(15.14)	(12.66)	(0.59)	(0.70)	(0.05)	(1.64)
[R^2-adj]	[0.716]	[0.716]				
P17 Beta	1.303	1.292	0.007	0.024	0.006	0.025
(t-stat)	(13.15)	(11.25)	(0.25)	(0.72)	(0.14)	(1.13)
[R^2-adj]	[0.728]	[0.724]				
P18 Beta	1.438	1.424	0.003	0.019	0.016	0.022
(t-stat)	(13.75)	(11.84)	(0.09)	(0.53)	(0.32)	(0.78)
[R^2-adj]	[0.723]	[0.718]				
P19 Beta	1.635	1.616	-0.008	0.031	0.015	0.017
(t-stat)	(10.27)	(9.08)	(-0.22)	(0.75)	(0.25)	(0.49)
[R^2-adj]	[0.691]	[0.686]				
P20 Beta	2.506	2.506	-0.072	0.154	-0.061	-0.072
(t-stat)	(5.11)	(4.91)	(-1.02)	(1.74)	(-0.54)	(-0.94)
[R^2-adj]	[0.523]	[0.523]				

Source: Own elaboration.

Table 3: Panel D.2: FAMA-FRENCH-CARHART AND CONSUMPTION FACTOR BETAS FOR 20 PORTFOLIOS SORTED BY THE VOLATILITY RISK PREMIUM, JANUARY 1996-FEBRUARY 2011

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Cons Growth	SMB	HML	MOM
P1 Beta	0.547	0.549	1.638	0.040	0.093	0.024
(t-stat)	(8.79)	(8.62)	(2.56)	(0.89)	(1.38)	(0.89)
[R^2-adj]	[0.218]	[0.250]				
P2 Beta	0.610	0.626	1.409	0.028	0.034	0.014
(t-stat)	(13.92)	(13.53)	(2.62)	(0.87)	(0.86)	(0.93)
[R^2-adj]	[0.476]	[0.512]				
P3 Beta	0.636	0.656	1.502	0.032	0.027	0.014
(t-stat)	(15.87)	(16.29)	(3.01)	(0.99)	(0.71)	(0.78)
[R^2-adj]	[0.527]	[0.571]				
P4 Beta	0.662	0.683	1.504	0.030	0.025	0.013
(t-stat)	(16.68)	(16.21)	(3.46)	(0.95)	(0.72)	(0.88)
[R^2-adj]	[0.559]	[0.602]				
P5 Beta	0.678	0.696	1.527	0.031	0.026	0.019
(t-stat)	(17.14)	(16.80)	(3.74)	(0.92)	(0.76)	(1.30)
[R^2-adj]	[0.575]	[0.622]				
P6 Beta	0.707	0.723	1.451	0.033	0.023	0.020
(t-stat)	(17.67)	(17.93)	(3.68)	(0.97)	(0.70)	(1.31)
[R^2-adj]	[0.593]	[0.634]				
P7 Beta	0.731	0.746	1.442	0.033	0.020	0.023
(t-stat)	(18.41)	(18.60)	(3.56)	(0.98)	(0.63)	(1.46)
[R^2-adj]	[0.608]	[0.650]				
P8 Beta	0.756	0.771	1.442	0.032	0.016	0.024
(t-stat)	(19.62)	(19.01)	(3.50)	(0.96)	(0.55)	(1.56)
[R^2-adj]	[0.622]	[0.663]				
P9 Beta	0.788	0.803	1.438	0.028	0.018	0.026
(t-stat)	(20.46)	(19.75)	(3.55)	(0.86)	(0.60)	(1.63)
[R^2-adj]	[0.639]	[0.677]				
P10 Beta	0.827	0.840	1.343	0.028	0.016	0.025
(t-stat)	(20.88)	(18.85)	(3.32)	(0.86)	(0.54)	(1.62)
[R^2-adj]	[0.659]	[0.690]				

Source: Own elaboration.

Table 3: Panel D.2: Fama-french-Carhart and consumption factor betas for 20 portfolios sorted by the volatility risk premium, January 1996-February 2011 (continuation)

sVRP-sorted Portfolios	Market *sVRP*	Market *sVRP*	Cons Growth	SMB	HML	MOM
P11 Beta	0.853	0.868	1.338	0.024	0.015	0.022
(t-stat)	(21.56)	(20.21)	(3.48)	(0.74)	(0.49)	(1.47)
[R^2-adj]	[0.673]	[0.700]				
P12 Beta	0.895	0.911	1.371	0.027	0.016	0.022
(t-stat)	(21.69)	(19.05)	(3.76)	(0.84)	(0.55)	(1.31)
[R^2-adj]	[0.685]	[0.712]				
P13 Beta	0.935	0.951	1.370	0.028	0.017	0.021
(t-stat)	(21.57)	(18.81)	(3.96)	(0.89)	(0.57)	(1.26)
[R^2-adj]	[0.695]	[0.719]				
P14 Beta	0.980	0.994	1.293	0.028	0.010	0.023
(t-stat)	(22.22)	(19.58)	(3.74)	(0.86)	(0.31)	(1.31)
[R^2-adj]	[0.701]	[0.722]				
P15 Beta	1.066	1.083	1.234	0.024	0.002	0.020
(t-stat)	(17.79)	(15.17)	(3.38)	(0.73)	(0.05)	(1.06)
[R^2-adj]	[0.710]	[0.724]				
P16 Beta	1.163	1.178	1.171	0.026	0.004	0.020
(t-stat)	(15.14)	(12.97)	(3.01)	(0.77)	(0.10)	(0.99)
[R^2-adj]	[0.716]	[0.726]				
P17 Beta	1.303	1.317	1.136	0.025	0.010	0.016
(t-stat)	(13.15)	(11.51)	(2.69)	(0.71)	(0.25)	(0.72)
[R^2-adj]	[0.728]	[0.732]				
P18 Beta	1.438	1.450	1.069	0.020	0.020	0.015
(t-stat)	(13.75)	(12.04)	(2.09)	(0.50)	(0.45)	(0.54)
[R^2-adj]	[0.723]	[0.724]				
P19 Beta	1.635	1.648	1.093	0.029	0.022	0.013
(t-stat)	(10.27)	(9.32)	(1.69)	(0.65)	(0.40)	(0.39)
[R^2-adj]	[0.691]	[0.690]				
P20 Beta	2.506	2.565	0.965	0.135	-0.037	-0.059
(t-stat)	(5.11)	(5.26)	(0.74)	(1.54)	(-0.33)	(-0.81)
[R^2-adj]	[0.523]	[0.522]				

Source: Own elaboration.

or stockholder consumption to explain the behavior of portfolio P1, we find that both betas are significantly different from zero with slight increases in the adjusted R^2 and with a larger impact on the *sVRP* beta when we add the market portfolio instead of stockholder consumption. The *sVRP* beta of portfolio P1 rises from 0.55 to 0.60 when we employ the market return as an additional explanatory variable. However, its beta with respect to the market *sVRP* remains the lowest among all 20 portfolios. The *sVRP* betas of portfolios P2 and P3 with respect to the market return are also statistically significant, but this is not the case for stockholder consumption. However, for the rest of portfolios, neither stockholder consumption nor the market portfolio return has a significantly different from zero betas. Once we control for the market *sVRP*, either market return or stockholder consumption growth does not explain the variability of the *sVRP* for portfolios P4 to P20. On the other hand, even after controlling for the *sVRP* market betas, aggregate consumption growth has a positive and significant beta for portfolios P1 to P18. The only exceptions are portfolios P19 and P20 which are very sensitive to fluctuations in the market *sVRP*. Aggregate consumption growth seems to be an important state variable to explain the variability of volatility risk premia across portfolios. Overall, it seems to be more relevant than the market portfolio return itself. Volatility risk premia are sensitive to macroeconomic conditions represented by aggregate consumption growth. In Panel B of Table 3 we run regressions using the three explanatory variables at the same time. The main conclusions remain the same. Together with the market *sVRP*, aggregate consumption is a key factor to explain the behavior of volatility risk premia across our 20 portfolios. As before, only extreme sensitivity market *sVRP* portfolios are not statistically related to consumption growth. We conclude that neither the excess market portfolio return, nor stockholder consumption seem to be relevant factors from a global perspective when explaining the variability of volatility risk premia at the portfolio level.

In Panels C.1 and C.2 of Table 3, we employ interest rate-based factors to explain the variability of volatility risk premia. Panel C.1 also considers market-wide equity liquidity as an explanatory variable, but it does not seem to be a significant factor. Although the term premium has a significant *sVRP* beta with respect to the first four portfolios, the general conclusion of these panels is that default premium is a second key state variable explaining the volatility risk premia across portfolios. In most cases, the default beta is negative and statistically significant even controlling for the market *sVRP*. Surprisingly, however, the default volatility risk premium beta becomes positive for portfolios P19 and P20. Once again, the time-series behavior of extreme *sVRP* portfolios is very different. The same results hold when we control for both consumption and market *sVRP* simultaneously. In the last column of Panel C.2, we observe that, for most portfolios, the three explanatory variables, that is to say, market *sVRP*, aggregate consumption growth and default premium are statistically significant state variables in explaining the variability of volatility risk premia across our portfolios. The adjusted R^2 goes from 0.45 for portfolio P1 to more than 0.70 for portfolios P5 to P18.

Finally, Panels D.1 and D.2 of Table 3 employ the Fama-French risk factors and the momentum factor together with aggregate consumption growth. Panel D.1 reports statistically significant volatility risk premia betas with respect to the momentum factor, even controlling for the market *sVRP*. None of the other Fama-French factors seem to be relevant in explaining the variability of volatility risk premia. However, when we add consumption growth in Panel D.2, the statistical significance of the momentum factor completely disappears. Once again, consumption growth is a key macroeconomic variable related to the behavior of the portfolio volatility risk premia[13].

Overall, we conclude that portfolio volatility risk premia are explained by the market *sVRP*, consumption growth, and default premium. The unconditional betas of these state variables are, in most cases, statistically different from zero even when we employ all three explanatory variables simultaneously. This is an important result, not previously reported in literature, where most research has analyzed the market volatility risk premium ignoring the potential cross-sectional differences among individual or portfolios volatility risk premia.

5. Conditional volatility risk premia betas

5.1. The time-varying behavior of volatility risk premia betas

We now estimate conditional (rolling) betas of our 20 *sVRP*-sorted portfolios using daily data of the previous 60 trading days for both the portfolios and the market volatility risk premium. At each day *d* from April 1, 1996 to February 28, 2011, we estimate the following rolling regression with daily data:

$$sVRP_d^p = a^p + \beta^p \ sVRP_d^m + \varepsilon_d \qquad [14]$$

The daily estimates of betas of each portfolio, $\hat{\beta}^p$, are averaged across all days for a given month and a given portfolio, to obtain conditional monthly betas of each of the 20 portfolios. Figure 2 displays the time-series behavior of the monthly conditional beta estimates for 5 representative portfolios namely P1, P5, P10, P15, and P20. As in the case of the volatility risk premia, the conditional betas of extreme portfolios P1 and P20 are very volatile. This is especially the case for the conditional betas of portfolio P20. Panel A of Table 4 reports the conditional betas for all 5 portfolios over the sample period using both averages from monthly betas and averages directly taken from daily data. The averages of the estimates of conditional betas tend to be lower than the unconditional betas reported in Table 1. A surprising exception is portfolio P1 whose unconditional beta is 0.55 while the average of its conditional beta is 0.81. The volatility of conditional betas over the sample period is consistent with the visual impression of Figure 2. The standard deviation of portfolios P1 and P20 are higher than the standard deviation of the remaining portfolios, with portfolio P20 having the highest volatility of conditional betas. The results are very similar using either monthly or daily data.

Given that we know every month the companies entering into each of the *sVRP*-sorted portfolios, we can calculate their portfolio returns in order to estimate the conditional market betas of the 5 portfolios. We employ a similar procedure as the one

(13) It is well known that equity return betas with respect to aggregate consumption growth tend to be very low and estimated with little precision. Equity returns are much more volatile than consumption growth. This is of course the source of the equity premium puzzle. However, volatility risk premia are much less volatile than the corresponding equity return portfolios but, at the same time, they closely follow a business cycle pattern. This may explain the significance results reported in Table 3 regarding consumption growth.

Table 4: Panel A: Rolling volatility risk premia betas estimated with 60 days of past data for representative portfolios, April 1996-February 2011

sVRP-sorted Portfolios	Average *sVRP* Market Beta (monthly data)	Average *sVRP* Market Beta (daily data)	Standard Dev *sVRP* Market Beta (monthly data)	Standard Dev *sVRP* Market Beta (daily data)	Average Market Beta of the *sVRP* Portfolios	Average Percentage Systematic Risk *sVRP* Portfolios
P1	0.806	0.813	0.821	0.882	0.921	49.8
P5	0.588	0.589	0.497	0.530	0.848	58.6
P10	0.857	0.858	0.490	0.516	0.935	64.4
P15	0.857	0.856	0.492	0.553	1.028	65.2
P20	1.654	1.644	1.448	1.528	1.305	58.4

The monthly betas are average daily betas using 60 days of past betas up to the last day of the corresponding month. The average percentage systematic risk is the average over time percentage of the rolling systematic part of the total variance of the returns for the *sVRP*-sorted portfolios.

Source: Own elaboration.

Panel B.1: Correlations coefficients between conditional *sVRP* betas and state variables (including recession states, NBER), April 1996-February 2011

Panel B.1	CBP5	CBP10	CBP15	CBP20	CON	Excess Market Return	Default	NBER
CBP1	0.412	0.434	0.340	0.216	-0.082	-0.074	0.246	0.244
CBP5	1	0.599	0.503	0.374	-0.176	-0.079	0.391	0.225
CBP10		1	0.557	0.424	-0.100	-0.062	0.191	0.193
CBP15			1	0.511	-0.059	-0.114	0.132	0.172
CBP20				1	-0.143	-0.158	0.163	0.248
CON					1	0.215	-0.355	-0.384
Excess Market Return						1	-0.130	-0.184
Default							1	0.628

Source: Own elaboration.

Panel B.2: Correlations coefficients between conditional *sVRP* betas, market betas and systematic risk, April 1996-February 2011

Panel B.2	Beta 1	Beta 5	Beta 10	Beta 15	Beta 20	SRP1	SRP5	SRP10	SRP15	SRP20
CBP1	**0.342**	-0.018	0.026	-0.004	0.073	**0.216**	0.248	0.235	0.150	0.251
CBP5	0.134	**-0.066**	-0.104	-0.024	0.325	0.299	**0.309**	0.256	0.230	0.396
CBP10	0.018	-0.189	**-0.018**	0.054	0.228	-0.043	0.020	**-0.042**	-0.049	0.048
CBP15	0.048	-0.202	-0.034	**0.081**	0.170	0.001	-0.008	-0.001	**0.054**	0.035
CBP20	0.277	-0.091	0.127	0.009	**0.106**	-0.028	-0.060	-0.043	-0.064	**0.027**

Source: Own elaboration.

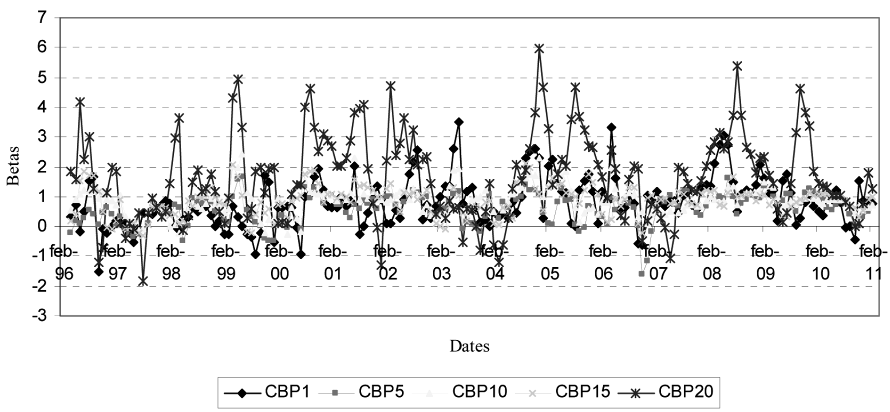
Table 5: Volatility risk premia and conditional *sVRP* betas for representative portfolios during recessions and normal economic cycles, April 1996-February 2011

Portfolios	*sVRP* Recessions	*sVRP* Normal Economic Periods	Difference *sVRP*	Conditional *sVRP* Beta Recessions	Conditional *sVRP* Beta Normal Economic Periods	Differences Conditional Betas
P1	-0.230	-0.210	-0.020	1.269	0.720	0.549
	(-8.64)	(-23.55)	(-0.71)	(5.78)	(7.56)	(2.28)
P5	-0.086	-0.079	-0.008	0.847	0.540	0.307
	(-3.65)	(-12.54)	(-0.32)	(11.35)	(8.47)	(3.09)
P10	-0.019	-0.025	0.006	1.076	0.817	0.259
	(-0.69)	(-3.93)	(0.20)	(18.69)	(11.98)	(2.91)
P15	0.062	0.033	0.029	1.053	0.821	0.232
	(1.67)	(3.58)	(0.76)	(15.74)	(12.45)	(2.52)
P20	0.471	0.253	0.217	2.485	1.500	0.985
	(4.34)	(12.00)	(1.97)	(8.08)	(7.78)	(2.72)
sVRP Market	0.021	-0.021	0.041	NA	NA	NA
	(0.62)	(-3.50)	(1.23)			

OLS regressions with HAC standard errors on dummy variables representing the official NBER recession dates.

Source: Own elaboration.

Figure 2: CONDITIONAL VOLATILITY RISK PREMIA BETAS FOR REPRESENTATIVE PORTFOLIOS: APRIL 1996-FEBRUARY 2011



Source: Own elaboration.

described above for the estimation of conditional volatility risk premium betas. In the last two columns of Panel A of Table 4, we report the average market beta of these portfolios, as well as the average systematic risk of the portfolios calculated as the ratio of the product of the squared market beta times the variance of the market portfolio to the variance of each portfolio. The pattern of the average market betas across all 5 portfolios follows exactly the pattern of the volatility risk premia betas. In both cases, the lowest beta is for portfolio P5, while the highest beta is for portfolio P20. Both the volatility risk premia betas and the market betas have an asymmetric U-shaped pattern across all 5 portfolios. However, this is not the case for the percentage of systematic risk over total risk that present an inverted U-shaped pattern.

Panel B.1 of Table 4 contains the correlation coefficients between the conditional betas of the 5 representative portfolios and key macroeconomic variables given by the excess market return, aggregate consumption growth, default premium and the National Bureau Economic Research (NBER) recession indicator. The correlation coefficients between conditional betas are always positive and they become lower when we move from portfolio P1 to portfolio P20. Moreover, the correlation coefficients of conditional betas of all 5 portfolios are negative with respect to the market and consumption growth, and they become positive for default and the recession indicator. Therefore, we may conclude that, on average, conditional volatility risk premia betas tend to increase in bad economic times.

Finally, Panel B.2 of Table 4 displays the correlation coefficients between conditional volatility risk premia betas, market betas and systematic risk. These correlation coefficients tend to be relatively low, except for portfolio P1 in the case of the market beta, and for portfolios P1 and P5 for systematic risk. In particular, the correlation coefficient between the conditional *sVRP* beta and the market beta of portfolio P1 is 0.34.

5.2. Volatility risk premia betas over recessions and expansions

We next investigate the behavior of conditional volatility risk premium betas over recessions and normal/expansion periods using the NBER recession periods. We employ the following OLS regression with HAC robust standard errors:

$$CB_{pt} = a + b\ EXPANSION_t + \varepsilon_t \qquad [15]$$

where CB_{pt} is the conditional *sVRP* beta of portfolio *p* in month *t*, and *EXPANSION* is a dummy variable that takes the value of 1 whenever month *t* does not belong to the NBER recession dates, and zero otherwise. This implies that the intercept is the average conditional beta of portfolio *p* during recessions, and the slope indicates how conditional betas change in normal/expansion times relative to recession periods. We also run similar regressions with the volatility risk premia of our 5 portfolios and the market. Table 5 contains the empirical results. On average, the market *sVRP* during recession times is positive but statistically not different from zero. The buyers of volatility get positive returns during recessions that compensate the average negative market returns although the average market volatility risk premium is estimated with little statistical precision. On the other hand, during normal/expansion periods, the buyers of market volatility get a large and negative average payoff.

Once again, the average *sVRP* of the 5 portfolios are surprising. For portfolios P1 and P5, an average negative and statistically significant volatility risk premia is obtained even during recession periods. In fact, the difference between the volatility risk premia during normal/expansion times and recession is not statistically different from zero except for portfolio P20. The average payoff of this portfolio is large, positive and statistically significant even during normal/expansion periods. Buyers of volatility of this type of companies not only are able to hedge realized return volatility, but they also get a positive payoffs in both sub-periods.

Conditional *sVRP* betas of the 5 portfolios maintain the asymmetric U-shaped patterns during both normal/expansion and recession periods. Volatility risk premia betas are always positive in both sub-periods. More importantly, in all five cases, the conditional betas increase significantly during recessions. The percentage increments of conditional *sVRP* betas are especially important for portfolios P1 and P20. Both portfolios become extremely sensitive to fluctuations in the market volatility risk premium during recessions.

5.3. The overall determinants of the conditional volatility risk premia betas

Given the sensitive behavior of conditional *sVRP* betas over the economic cycle, this section investigates the overall determinants of the volatility risk premia betas simultaneously across all 20 portfolios and over time. We perform a standard panel data analysis with fixed effects in order to understand the main drives of conditional volatility risk premia betas[14]:

$$CB_{pt} = X_{pt}\beta + \varepsilon_{pt} \qquad [16]$$

(14) The Hausman test rejects the null hypothesis of no correlation between individual effects and regressors.

where CB_{pt} denotes the conditional betas of all 20 portfolios during each month t, and X_{pt} are explanatory variables given by aggregate consumption growth, excess market return, industrial production growth, conditional market portfolio betas, default premium, size factor, value factor and momentum, respectively. Given that we have 179 months from April 1996 to February 2011, and 20 conditional beta portfolios at each month t, we have a total of 3580 observations in the panel regression (16). The macroeconomic explanatory variables are chosen following the evidence found in previous sections of this paper, with the exception of industrial production growth that is now included as an additional economic cycle variable. The analysis employs cluster-robust standard errors.

Table 6: DETERMINANTS OF CONDITIONAL VOLATILITY RISK PREMIA BETAS OF 20 VOLATILITY RISK PREMIA-SORTED PORTFOLIOS, APRIL 1996-FEBRUARY 2011

Conditional Volatility Risk Premia Betas	Coefficient	Robust Standard Error	t-statistic
Constant	0.281	0.100	2.82
IPI Growth	-5.750	1.586	-3.63
Consumption Growth	-3.856	2.191	-1.76
Excess Market Return	-1.632	0.126	-12.92
Default	10.046	1.180	8.51
HML	0.635	0.291	2.18
SMB	0.992	0.170	5.82
MOM	-0.589	0.182	-3.24
Market Betas	0.356	0.100	3.54
Number of Observations	3580		
R-squared: within	0.070		
F(8, 19) Statistic (*p*-value)	87.18 (0.00)		
Hausman Test (*p*-value)	36.36 (0.00)		

Panel data regression with fixed effects and robust standard errors of conditional *sVRP* betas of the representative *sVRP*-sorted portfolios on market return betas, macroeconomic, and financial aggregate risk factors.

Source: Own elaboration.

Table 6 contains the results. The estimated coefficients are statistically significant with the expected sign[15]. The slope coefficients associated with aggregate con-

(15) The coefficient associated with aggregate consumption is estimated with relatively low precision when compared to other macroeconomic variables.

sumption, excess market return, and industrial production growth, have a negative sign, while signals of increasing risk in the economy like market betas, default or even the HML, and the SMB aggregate factors have a positive relation with conditional betas. Increases in any of these two Fama-French factors suggest higher risks in the economy. Note that value stocks are more pro-cyclical than growth stocks. The market conditional betas of value stocks tend to rise in economic crisis like the recent great recession. This may explain the positive relation between the HML factor and conditional betas even after controlling for the excess market return. A similar argument applies to small relative to big stocks. This evidence is consistent with the behavior of conditional *sVRP* betas during recessions previously reported. On the other hand, the sign of the coefficient associated with momentum is positive and statistically different from zero. This suggests that momentum presents a relatively more similar time-series behavior with the excess market return than with HML or SMB. Indeed, this is a well known result in asset allocation. The momentum factor tends to be negatively correlated with the HML factor especially during recession periods. This explains why asset management companies employ dynamic portfolio strategies combining momentum and HML factors.

6. Conclusions

It is disturbing how little we know about the behavior of the volatility risk premium at the individual or portfolio level. Most previous research has been concerned with the behavior of the market volatility risk premium, but little research is available either at the time-series or cross-sectional dimensions with respect to the volatility risk premium of individual securities. This paper fills this gap with special emphasis on the cross-sectional and time-series behavior of volatility risk premia betas.

The average differences between the *sVRP* across our 20 portfolios are large. Especially important is the difference between extreme portfolios. Thus, portfolio P20 not only hedges volatility of the corresponding portfolio return, but it provides a positive average payoff during the sample period. This contrasts with the large and negative average payoff of portfolio P1. We first show that portfolio volatility risk premia are explained primarily by the market *sVRP*, consumption growth, and default premium. Then, we show that the cross-sectional variation in either unconditional or average conditional betas is large and economically relevant. Volatility risk premia betas show a monotonic relation with respect to the magnitude of the volatility risk premium payoffs, and the portfolio conditional volatility risk premia betas increase significantly in recessions, although the betas of portfolios P1 and P20 raise the most. In particular, conditional volatility risk premia betas increase with market betas of the same portfolios, default premium, and the HML and SMB factors. Overall, this implies that conditional volatility risk premia betas increase with the aggregate risk of the economy. On the other hand, conditional volatility risk premia betas tend to decrease with the excess market return, momentum, industrial production and consumption growth. The conclusion seems to be clear and important: volatility risk premia betas are sensitive to the economic cycle showing a clear counter-cyclical pattern.

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Fecha de recepción del original: diciembre, 2013
Versión final: julio, 2014

RESUMEN

Este trabajo analiza el comportamiento de las betas de las primas de riesgo de volatilidad tanto en sección cruzada como en serie temporal para un conjunto de carteras. Las betas muestran una relación monótona con respecto a la magnitud media de la prima de riesgo de volatilidad de dichas carteras. Además, las betas condicionales de las primas de riesgo de volatilidad de las carteras aumentan significativamente en recesiones. En particular, aumentan significativamente con la prima de riesgo de insolvencia, las betas de mercado de esas mismas carteras y los factores HML y SMB de Fama-French. Por otra parte, tienden a disminuir cuando la producción industrial, el consumo agregado, el exceso de rendimiento del mercado y el factor de inercia tienden a aumentar.

Palabras clave: prima de riesgo en volatilidad, betas, betas condicionales, indicadores macroeconómicos.

Clasificación JEL: G12, G13.