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BIDIRECTIONAL RELATIONSHIP BETWEEN INVESTOR SENTIMENT AND EXCESS RETURNS: NEW EVIDENCE FROM THE WAVELET PERSPECTIVE

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Bidirectional Relationship between Investor Sentiment and Excess Returns: New Evidence from the Wavelet Perspective

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Abstract

This paper sheds new light on the mutual relationship between investor sentiment and excess returns corresponding to the bubble component of stock prices. We propose to use the wavelet concept of the phase angle to determine the lead–lag relation between these variables. The wavelet phase angle allows for decoupling short– and long–run relations and is additionally capable of identifying time–varying comovement patterns. By applying this concept to excess returns of the monthly S&P500 index and two alternative monthly US sentiment indicators we find that in the short run (until 3 months) sentiment is leading returns whereas for periods above 3 months the opposite can be observed.

JEL Classification: G11, G14, C22, C32

Keywords: wavelet phase angle, wavelet analysis, sentiment indicator, excess returns, speculative bubble, stock market

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1 Introduction

The last decade saw a huge increase in the number of studies dealing with the impact of investor sentiment on stock prices. To answer the question how these variables are related to each other, some studies simply consider a linear regression of future stock returns on an indicator of investor sentiment and (possibly) some control variables, see Bathia and Bredin (2013) and the references therein. However, such an approach implies a unidirectional causality running from sentiment to stock returns. Some studies deal with this critique by estimating a VAR model and/or performing Granger causality tests to check for a potential influence of returns on sentiment; see, for example, Brown and Cliff (2004) and Kim and Kim (2014). Dergiades (2012) analyzes investor sentiment and stock returns within a non-linear causality framework. However, so far there is scant evidence on whether the lead–lag relationship between sentiment and stock returns may change over time or exhibit specific patterns over the business cycle, the exceptions being the studies of Li (2015) and Lutz (2015).

Complementary to the existing literature, we suggest to resort to wavelet analysis, and more specifically, to the wavelet concept of the phase angle, for a more detailed picture on the lead–lag relationship between sentiment and returns. To the best of our knowledge, this is the first paper employing wavelet analysis to this research question.[1] Wavelet analysis distinguishes between different horizons at which the comovements are measured and thus allows to derive conclusions about the short–run and long–run relationship between stock returns and sentiment. Further, since wavelet analysis describes the time–varying relationship between different periodic components of two or more time series, it makes it possible to capture changes in behavior patterns or to uncover asymmetric effects of investor sentiment in different periods, like stock market expansions and contractions. From a technical point of view, wavelet analysis can deal with irregularities in the data, like outliers or breaks, and with nonstationary data.

We demonstrate the usefulness of the wavelet phase angle by applying it to the S&P500 excess returns ("bubble premium") and two measures of US investor sentiment for the period from 1970.M1 to 2014.M9. Excess returns correspond in this paper to the deviations of total returns from their fundamental part derived from the well–known static Gordon model (Gordon, 1962). Investor sentiment broadly reflects stock market expectations unrelated to fundamentals, hence it is by its very nature unobservable and difficult to measure. We extract two indicators for investor sentiment from a set of 9 "direct" sentiment proxies and technical indicators that have been suggested in, e.g., Brown and

[1] Recent applications of wavelet analysis to economic questions can be found in, e.g., Trezzi (2013) and Michis (2014).

Cliff (2004) and Baker and Wurgler (2007) using two alternative approaches, principal component analysis and a simple factor model.

2 Excess Returns and Investor Sentiment

In the following, we set out the procedures to obtain the excess return component based on the S&P500 index and two sentiment indexes. The generated data are given on a monthly frequency in the time span 1970.M1 – 2014.M9.

To calculate excess returns that are caused by deviations of stock prices from their fundamental values, the stock price index P_t must be decomposed into the fundamental price P_t^f and the bubble component P_t^b. The fundamental price is related to the future stream of dividends and is determined in this paper using the well–known static Gordon model (Gordon, 1962), according to which the fundamental price of an asset is given by:

$$P_t^f = \frac{1 + g_t^e}{r_t^e - g_t^e} Y_t, \tag{1}$$

where Y_t denotes dividends, g_t^e is the expected growth rate of dividends, and r_t^e is the expected rate of return. We compute g_t^e as the 10–year moving average of dividend growth rates. To obtain r_t^e we refer to a simple CAPM, according to which

$$r_t^e = \bar{r}_t + \beta RP_t,$$

where $\bar{r}_t$ is the risk–free rate of return approximated in this paper by the Moody's 30–year BAA corporate bond yield. RP_t is the market risk premium calculated here by the 10–year moving averages of the difference $(r_t^m - \bar{r}_t)$, with r_t^m being the market rate of return. Assuming that the S&P500 covers the market portfolio, β is equal to one and r_t^m corresponds to the actual return $r_t = (P_t + Y_t - P_{t-1})/P_{t-1}$. All variables are expressed in real terms by deflating nominal values with the consumer price index (CPI).[2] Once P_t^f and $P_t^b = P_t - P_t^f$ are obtained, total returns can be decomposed into two parts:

$$r_t = \frac{P_{t-1}^f}{P_{t-1}} r_t^f + \frac{P_{t-1}^b}{P_{t-1}} r_t^b$$

The second component will be referred to as excess returns and will be used in the subsequent wavelet analysis.

[2]The data for the S&P500 index and dividends are obtained from Robert Shiller's website: `http://www.econ.yale.edu/shiller/data.htm`. The source for the CPI and the Moody's 30–year BAA corporate bond yield is the FRED database: `http://research.stlouisfed.org/fred2/`.

In the literature, various approaches have been proposed to quantify investor sentiment. Some studies employ data on "direct" sentiment measures based on investor surveys like the American Association of Individual Investors (AAII) survey or the Investor Intelligence (II) survey; see, e.g., Brown and Cliff (2004). Other studies proxy investor sentiment by, among others, a consumer confidence index (e.g. Lemmon and Portniaguina, 2006), various measures reflecting investor mood (e.g. Hirshleifer and Shumway, 2003; Edmans et al., 2007; Tetlock, 2007), and stock market related measures like market liquidity (Baker and Stein, 2004) and closed–end fund discount (Neal and Wheatley, 1998).

In this paper, we exploit the information content of different sentiment measures by combining "direct" sentiment proxies based on surveys with technical indicators. As for the former, we use the bull–bear spread (BBS) computed with the data from the II survey, and the consumer confidence index (CCI) provided by the Conference Board. Technical indicators can be classified into different categories. The first one represents market breadth and the corresponding variable is the so–called Arms index (ARMS):

$$\text{ARMS} = \frac{\text{ADV/ADVVOL}}{\text{DECL/DECLVOL}},$$

where ADV and DECL give the number of advancing and declining issues on the NYSE, respectively, whereas ADVVOL and DECLVOL refer to the cumulative number of issues from the group advancing and declining issues within a given time period. The variables capturing trading activity are the percentage changes in NYSE short interest and in NYSE real margin debt. The next indicator describes market volatility and is given by the ratio of implied volatility VIX (CBOE Volatility Index for S&P500) and realized volatility (RV). The latter is computed with the extreme–value method proposed by Parkinson (1992). Finally, the remaining three indicators are mutual fund flows (MFF) provided by the Investment Company Institute, IPO number and IPO first–day returns. The final dataset consists of 9 sentiment series and is characterized by a ragged–edge structure as not all series are available in the entire time span.[3]

Based on these sentiment series we construct composite sentiment indexes using two alternative approaches: principal components analysis and a simple factor model. These

[3]Download sources and availability of original time series in the time span 1970.M1–2014.M9: 1) BBS (1970.M1–2014.M9) and CCI (1970.M1–2014.M9, until 1978 bimonthly): Thomson Reuters Datastream, 2) ADV, ADVVOL, DECL, and DECLVOL (1970.M1–2014.M9): `http://unicorn.us.com/avdec`, 3) NYSE short interest (1970.M1–2010.M4) and margin debt (1970.M1–2014.M9): `http//nyxdata.com/Data-Products/Facts-and-Figures`, 4) VIX (1990.M1–2014.M9): `http://finance.yahoo.com`, 5) MFF (1984.M1–2014.M9): Thomson Reuters Datastream, 6) IPO number and first–day returns (1970.M1–2014.M9): Jay Ritter's website `http://site.warrington.ufl.edu/ritter/ipo-data`

approaches have been commonly used in the construction of sentiment measures; see, e.g., Brown and Cliff (2004) and Baker and Wurgler (2007). Prior to index extraction all data have been standardized.

From the principal component analysis we obtain a sentiment indicator, denoted SENTPC, as the first principal component of a restricted dataset including BBS, CCI, ARMS, percentage change in NYSE real margin debt, IPO number and IPO first–day returns. The remaining 3 sentiment proxies not observable in the entire time span are excluded in the construction of SENTPC.

An alternative sentiment indicator, denoted SENTFM, is derived as the common factor component, z_t, in the following factor model framework:

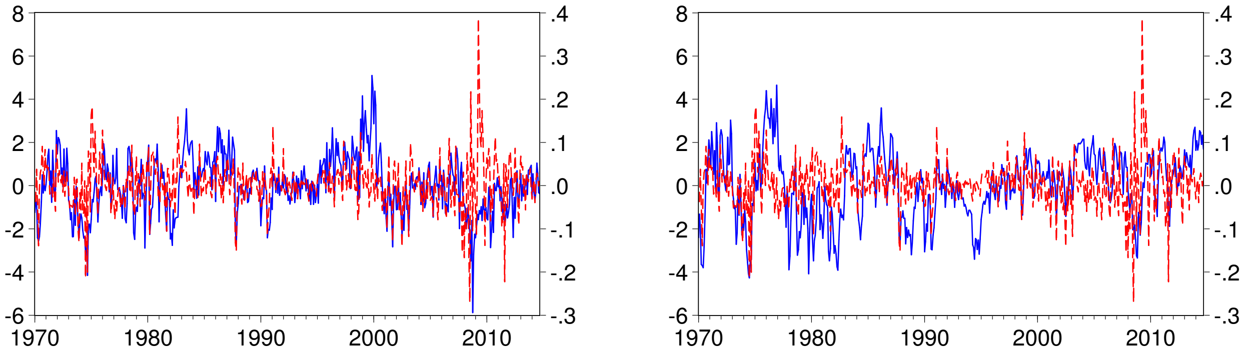
$$\begin{aligned} \mathbf{y}_t &= \boldsymbol{\mu} + \boldsymbol{\theta} z_t + \mathbf{u}_t, & \mathbf{u}_t &\sim NID(\mathbf{0}, \boldsymbol{\Sigma}_\mathbf{u}) \\ z_{t+1} &= \phi z_t + \varepsilon_t, & \varepsilon_t &\sim NID(0, \sigma^2) \end{aligned}$$

where $\mathbf{y}_t$ denotes the vector of 9 sentiment proxies, $\boldsymbol{\mu}$ is the vector of intercepts and $\mathbf{u}_t$ is the vector of idiosyncratic components with diagonal covariance matrix $\boldsymbol{\Sigma}_\mathbf{u}$. The common factor component follows an AR(1) process, and its contribution to the observed series is expressed by the vector of factor loadings $\boldsymbol{\theta}$. It is assumed that ε_t and $\mathbf{u}_t$ are mutually uncorrelated. The model parameters are estimated by maximum likelihood, and z_t is extracted by the application of the Kalman filter and smoother. These algorithms are capable of handling missing values and ragged–edge data, and thus allow for using the complete set of 9 sentiment proxies.

It can be argued that sentiment is to some extent also driven by rational factors and can thus incorporate a fundamental part. To remove this part, we regress SENTPC and SENTFM, respectively, on three monthly macroeconomic variables capturing business cycle effects: growth rate of the industrial production index (IPI), the unemployment rate and the Purchasing Managers Index (PMI).[4] The adjusted versions of SENTPC and SENTFM are nearly coincident with the original ones.

Figure 1 depicts both sentiment indexes along with excess returns. It is evident that both SENTPC and SENTFM quite reasonably reproduce bullish and bearish phases on the stock market. However, they differ from each other with regard to the extent of the oscillations.

[4]Data on the IPI, the unemployment rate and the PMI are downloadable at `http://research.stlouisfed.org/fred2/`.



(a) SENTPC (solid line, left axis) and excess returns (dashed line, right axis)

(b) SENTFM (solid line, left axis) and excess returns (dashed line, right axis)

Figure 1: Sentiment indexes obtained with principal component analysis (SENTPC) and a factor model (SENTFM), respectively depicted with excess returns

3 Wavelet Phase Angle

To establish the lead–lag relationship between sentiment and returns, we propose to use the concept of the wavelet phase angle. An advantage of this concept compared to its frequency–domain counterpart is that it carries information about the relationship of considered variables both in time and frequency. This is because wavelet functions are local in the time and frequency domain so that the resulting wavelet transform of a time series gives its two–dimensional representation. In contrast, sine and cosine functions used in the Fourier transform provide a one–dimensional representation of a series only. The wavelet phase angle between two series y_t and x_t is defined as:

$$\phi_{xy}(\tau, s) = \arctan\left[\frac{\Im(W_{xy}(\tau, s))}{\Re(W_{xy}(\tau, s))}\right], \tag{2}$$

where τ and s are time and scale parameter, respectively. Scale s is inversely related to the angular frequency ω and their functional relation depends on the type of wavelet function. In the case of the Morlet wavelet chosen in this paper it holds that $s = 2\pi/\omega$. In eq. (2), $W_{xy}(\tau, s)$ denotes the wavelet cross–spectrum given by $W_x(\tau, s)\ W_y^*(\tau, s)$, where $W_j(\cdot)$, $j = x, y$, is the continuous wavelet transform of j, and "*" labels the complex conjugate. $\Im(\cdot)$ and $\Re(\cdot)$ denote the imaginary and real part, respectively. For details concerning properties of wavelet functions as well as computational aspects the reader is referred to, e.g., Aguiar-Conraria and Soares (2014) and Marczak and Gómez (2015).[5]

[5]The computation of $\phi_{xy}(\tau, s)$ is carried out in Matlab using the ASToolbox by Aguiar-Conraria and Soares (2011).

The phase angle $\phi_{xy,\psi}(\tau, s)$ is due to the properties of arctangent a multivalued function whose values are given by the respective principal value $\pm n\pi$, where $n = 0, 1, 2...$, and the principal value lies in $(-\pi/2, \pi/2)$. For interpretation purposes, it is though useful to limit values of the phase angle to the interval $[-\pi, \pi]$. A rationale for this restriction and an interpretation of the values of the phase angle is provided by Marczak and Beissinger (2013). Note that $\phi_{xy,\psi}(\tau, s) \equiv \pm\pi/2$ for $\Re(W_{xy,\psi}(\tau, s)) = 0$ and $\Im(W_{xy,\psi}(\tau, s)) \gtrless 0$. If, for given τ and s, it holds that $0 < \phi_{xy,\psi}(\tau, s) < \pi$, y_t is said to lag x_t at (τ, s). Values satisfying $-\pi < \phi_{xy,\psi}(\tau, s) < 0$ imply leading behavior of y_t over x_t at (τ, s). If $\phi_{xy,\psi}(\tau, s) = 0$, both series are said to be in phase for given (τ, s). Values of the phase angle can be also source of information about the in–phase or anti–phase relation between the components of x_t and y_t. If $\phi_{xy,\psi}(\tau, s) \in (-\pi/2, \pi/2)$, the respective components are positively related to each other (in–phase movement), whereas in the case of $\phi_{xy,\psi}(\tau, s) \in [-\pi, -\pi/2) \vee (\pi/2, \pi]$ a negative relationship (anti–phase movement) between them is established.

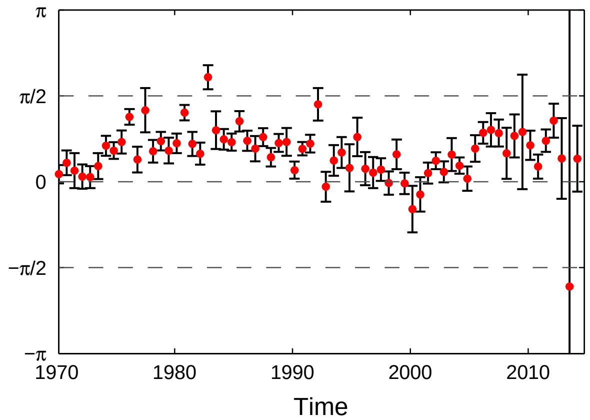
To reduce the complexity in the interpretation of phase angle values, it is useful to derive the tendency in the relationship between two series in the time and scale dimension. For that purpose, we average phase angle values separately over time and scale by employing the concept of a mean suited for data measured on a circular scale; see, e.g., Zar (1999).

4 Results

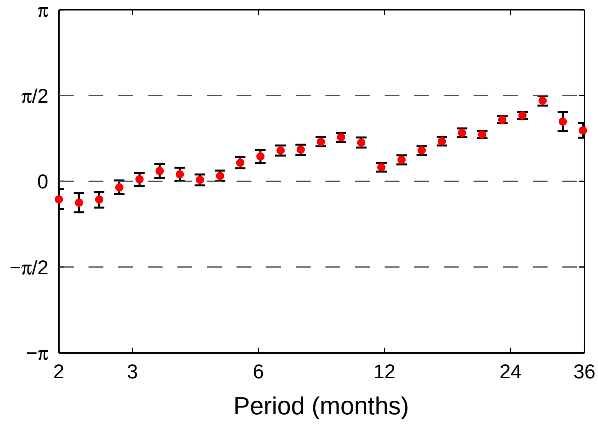
Figure 2 depicts the estimated mean phase angle values with their corresponding 95% confidence bounds in the case of SENTPC and SENTFM, respectively. In the right panels of Figure 2, the horizontal axis represents periods computed according to the formula $p = 2\pi/\omega$ which in the case of the chosen Morlet wavelet reduces to $p = s$. The depicted range of periods between 2 and 36 months is also used to obtain the mean phase angle values in 2a and 2c. The lower bound is restricted by the Nyquist frequency whereas the upper bound is set to 3 years so as to capture the long–run relationship between returns and sentiment.[6]

It can be seen that the results are similar for both sentiment indexes. In the entire time interval the mean phase angle takes on values between 0 and $\pi/2$ suggesting that sentiment is positively related with returns and is lagging behind. Even though this pattern seems to be stable over time, until the mid–1970's and around 2000 the mean phase angle tends

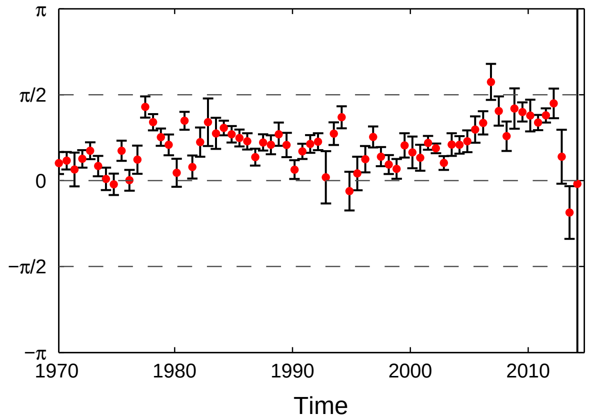
[6]The boundary at 3 years represents a compromise between interpretability and accuracy of results. Increasing the boundary could contaminate findings with information of long–run lead–lag relation which can hardly exist. On the contrary, too low upper bound reduces the number of phase angle values involved in calculation of the mean values.



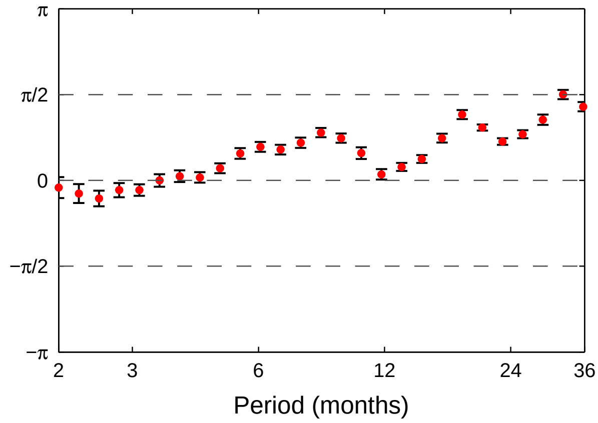
(a) Mean phase angle over scales: SENTPC



(b) Mean phase angle over time: SENTPC



(c) Mean phase angle over scales: SENTFM



(d) Mean phase angle over time: SENTFM

Figure 2: Mean phase angle between excess returns and two sentiment indicators, SENTPC and SENTFM, respectively; red dots: point estimates, black lines: corresponding 95% confidence bounds

towards zero, meaning that the lagging behavior of sentiment is less pronounced in these time intervals. The overall picture can, however, mask effects attributed to different horizons at which the comovements are measured. Phase angle values averaged over time allow for disentangling the information about the short– and long–run relationship between sentiment and excess returns. In the short run – up to 3 months – sentiment is leading returns, as indicated by values between $-\pi/2$ and 0. Positive values observed for periods above 4 months suggest that in the longer run returns are leading sentiment. Since this pattern dominates across all periods between 2 and 36 months, sentiment is lagging behind in Figures 2a and 2c.

5 Conclusions

In this paper we reassess the relationship between returns and investor sentiment. Even though this research question has been examined in a large number of studies using time–domain methods, this paper contributes to the literature by proposing the wavelet concept of the phase angle to explore the lead–lag relation between these variables.

We compute the wavelet phase angle between excess S&P500 returns, i.e. returns obtained from the bubble component of stock prices, and two US sentiment indicators from 1970.M1 to 2014.M9. The analysis yields two important results. First, in the short run (until 3 months) sentiment is leading excess returns whereas in the longer run (between 3 and 36 months) this relation is reversed. Second, the fact that leading behavior of excess returns outweighs that of sentiment in the examined horizon range is also reflected in the stable pattern of leading excess returns in the entire time span. Hence, the wavelet phase angle whose merit it is to uncover time–varying patterns (if any) in this case does not detect any reversals in the bidirectional relationship of excess returns and sentiment.

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Nr.	Autor	Titel	CC
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