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Forecasting the Global Financial Crisis in the Years 2009-2010: Ex-post Analysis

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Abstract

The ex-ante forecast of the SP500 index discussed in Fantazzini (2010a), covering the time sample 14/04/2009 - 09/10/2010, and originally submitted to the Economics Bulletin on the 15/05/2009 is analyzed. It is found that the realized values of the SP500 index trailed the forecasted values quite well, moving inside the forecast confidence bands for over a year. Interestingly, it is also found that the confidence bands worked very good as resistance levels, while the forecasted values as support levels. Moreover, an important turning point in April 2010 was also correctly forecasted. However, in July-August 2010, the SP500 started to diverge upwards, and after the speech by the FED Chairman at Jackson Hole (Wyo., USA) on the 27/08/2010, the stock market index never returned inside the forecast confidence bands. Additional evidence is then provided to show that the anti-bubble started in October 2007 ended almost three years later in August 2010, similarly to the first anti-bubble on the SP500, which started in August 2000 and ended in August 2003.

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1 Introduction

Fantazzini (2010a) used log-periodic power law models to model and forecast the global financial crisis of 2007-2009 as a special case of "anti-bubble". He then compared a set of log-periodic models with standard times series models in terms of long-term out-of-sample forecasting performances using the American SP500 stock index, and found out that the AR(1)-GARCH(1,1) log-periodic model clearly outperformed standard financial models. Moreover, he reported in Figure 2 an *ex-ante* out-of-sample forecast produced by the AR(1)-GARCH(1,1) log-periodic model from the 14/04/2009 till the 09/10/2010, together with 95% bootstrap confidence bands. We remark that the paper was submitted to the Economics Bulletin on the 15/05/2009 (submission number: EB-09-00287).

What we do in this paper is to review that forecast by comparing it with the realized values of the SP500 index. We found that the SP500 trailed the forecasted values quite well, moving inside the forecast confidence bands for over a year. Interestingly, we also found that the confidence bands worked very good as resistance levels, while the forecasted values as support levels. Moreover, an important turning point on April the 23rd 2010, which worked as temporary market peak, was also correctly forecasted: in this regard, Fantazzini (2010a) expected that ... "the current market rebound should peak at the beginning of 2010". Besides, we also show how the market behavior before this turning point could have been modelled as a short-term bubble nested in a longer-term anti-bubble, and how the author diagnosed the end of this small bubble ex-ante by uploading on `www.scribd.com` a preliminary analysis about it on the 13th of March 2010. Furthermore, the importance of this temporary market peak and the following market fall is also highlighted by the Zivot-Andrews (1992) and Lee-Strazicich (2003) unit root tests allowing for possible structural break(s): using the SP500 daily data from 2009 till 2011, these tests reject the null hypothesis of a unit root in favor of a stationary model with a structural break at the beginning of May 2010, that is in the middle of the market fall following the (temporary) market peak on the 23/04/2010.

However, in July-August 2010, the SP500 started to diverge upwards, and after the speech by the FED Chairman at Jackson Hole (Wyo., USA) on the 27/08/2010, the stock market index never returned inside the forecast confidence bands, thus highlighting the end of the anti-bubble pattern. This conclusion is further confirmed by the recursive estimated parameters of the AR(1)-GARCH(1,1) log-periodic model, as well as by the test proposed by Zhou and Sornette (2005) to detect the possible end of this log-periodic structure. Therefore, we found that the anti-bubble started in October 2007 ended almost three years later in August 2010, similarly to the first anti-bubble on the SP500, which started in August 2000 and ended in August 2003. It may well be the case that the severity of the market downturn in the spring and summer 2010, together with the potential worsening of the US economy, may have prompted the US Federal Reserve to act decisively to stave off a potential renewed economic recession: this decision was then strongly signalled to the financial markets by the FED Chairman's speech at Jackson Hole (Wyo., USA) on the 27/08/2010, thus paving the way to an additional round of Quantitative Easing. See the full transcript of the Chairman's speech at http://www.federalreserve.gov/newsevents/speech/bernanke20100827a.htm for more details.

The rest of the paper is structured as follows. In Section 2 we provide a literature review regarding bubbles and anti-bubbles, whereas in section 3 we compare the ex-ante forecast discussed in Fantazzini (2010a) with the realized values of the SP500 index. In Section 4 we provide an additional ex-post analysis about the temporary market peak in April 2010 and the short-term bubble that preceded it, while in Section 5 we test the end of the anti-bubble with the approach proposed by Zhou and Sornette (2005). Section 6 briefly concludes.

2 Literature Review

2.1 Bubble Modelling: The Log Periodic Power Law approach

Johansen, Ledoit and Sornette (2000) proposed a model that assumes the presence of two types of agents in the market: a group of traders with rational expectations and a second group of so called "noise" traders, that is irrational agents with herding behavior. These traders are organized into networks and can have only two states, that is buy or sell. Moreover, their trading actions depend on the decisions of other traders and on external influences, so that agents can form groups with self-similar behavior which can lead the market to a bubble situation, which can be considered a situation of "order", compared to

the "disorder" of normal market conditions. Furthermore, this model allows for positive feedbacks which are generated by the increasing risk and the agents interactions, so that a bubble can be a self-sustained process. Interestingly, this approach allowed to diagnose bubbles ex-ante, as shown in a series of real-life tests, see Sornette and Zhou (2006), Sornette, Woodard and Zhou (2008) and Zhou and Sornette (2003, 2006, 2008, 2009). See Jiang et al. (2010), Geraskin and Fantazzini (2011) and Fantazzini (2010c) for a recent review of these type of models and for some extensions with applications.
The fundamental equation that describes the temporal growth of (log) prices before a crash or a simple bubble deflation is given by the following Log Periodic Power Law (LPPL),

$$\ln[p(t)] \approx A + B(t_c - t)^{\beta} + C(t_c - t)^{\beta} \cos[\omega \ln(t_c - t) + \phi] \tag{1}$$

where $t < t_c$ is any time before the end of the bubble, $A > 0$ is the value of $[\ln p(t_c)]$ at the critical time, $B < 0$ the increase in $[\ln p(t)]$ over the time unit before the crash if C were to be close to zero, $C \neq 0$ is the proportional magnitude of the oscillations around the exponential growth, $0 < \beta < 1$ should be positive to ensure a finite price at the critical time t_c of the bubble and quantifies the power law acceleration of prices, ω is the frequency of the oscillations during the bubble, while $0 < \phi < 2\pi$ is a phase parameter.
Even though eq. (1) can be estimated by Nonlinear Least Squares, Fantazzini (2010b) resorted to the Taboo Search (TS) algorithm by Cvijovic and Klinowski (1995), as well as the Pure Random Search (PRS), with 1 million draws. These algorithms do not need the computation of gradients and hessians, and are usually preferred for highly nonlinear functions. See Geraskin and Fantazzini (2011) for a recent discussion of different estimation methods for the LPPL approach.

2.2 Anti-Bubbles

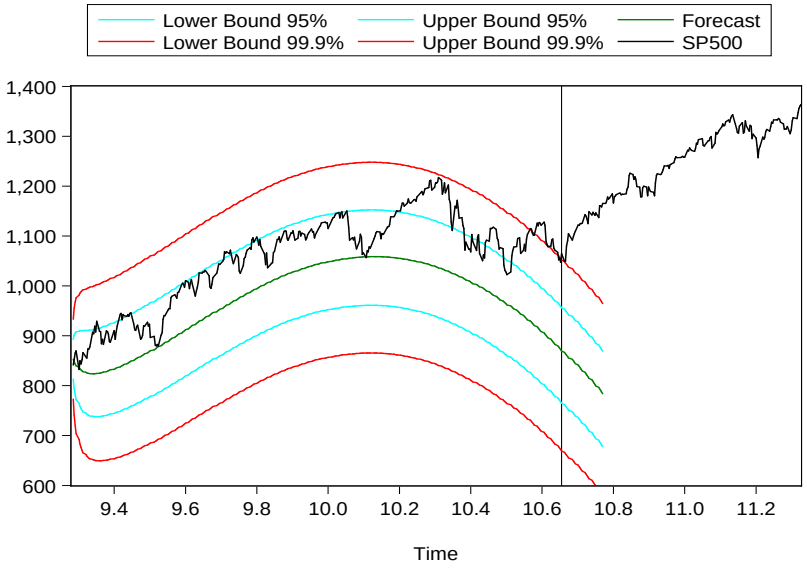
An "anti-bubble" is symmetric to a bubble, and represents a situation when the market peaks at a critical time t_c, after which it follows a power law decrease with decelerating log-periodic oscillations. Johansen and Sornette (1999) and Zhou and Sornette (2005) explained this phenomenon by showing how traders' herding behavior can progressively occur and strengthen itself in bearish decreasing market phases, thus forming anti-bubbles with decelerating market devaluations following market peaks.
As discussed in Zhou and Sornette (2005) and Fantazzini (2010a), as time flows, the cumulative effect of exogenous news may detune progressively the anti-bubble pattern, and this phenomenon may be accelerated in the presence of strong exogenous shocks such as the Federal Reserve interest rate and monetary policies.

3 Empirical Analysis: Forecast vs Real Values in 2009-2010

We report in Figure 1 the original ex-ante forecast of the SP500 reported as Figure 2 in Fantazzini (2010a, p.6) and covering the time sample between 14/04/2009 and 09/10/2010, the 95% and 99.9% forecast confidence bands over the same period, together with the realized values of the SP500 between 14/04/2009 and 29/04/2011 (i.e. the last data available at the time of writing this paper), as well as a vertical line highlighting the day of the FED Chairman's speech at Jackson Hole (Wyo., USA):
The previous figure shows that the SP500 trailed the ex-ante forecast quite well, moving inside the 95% forecast confidence bands till the end of March 2011, and inside the 99.9% forecast confidence bands till the end of August 2011. Interestingly, we can observe that the confidence bands worked very good as resistance levels, while the forecasted values as support levels. Moreover, Figure 1 also highlights that the FED Chairman's speech at Jackson Hole (Wyo., USA) had a significant impact on the financial markets: without the assurance of a second round of Quantitative Easing which was given that day, the SP500 would have most likely kept going down below the critical 1000 level and beyond. Needless to say, such an outcome would have paved the way to a renewed economic recession.
In this regard, it is important to remark that Bernanke himself openly confirmed on the 13/01/2011 that the FED's actions led to the stock market rally that began at the end of August 2010[1].

[1]During a forum sponsored by the Federal Deposit Insurance Corp., the government agency that backs bank deposits, the FED Chairman said that "*...the stock market rally that began last summer was fueled by the FED's efforts which improved U.S. economic activity...*", and "*I do think that our policies have contributed to a stronger stock market, just as they did in March of 2009*". See the full article by Chris Isidore at CNN-Money at http://money.cnn.com/2011/01/13/news/economy/bernanke_qe2_stock_market/index.htm for more details.

Figure 1: *SP500 ex-ante forecast, SP500 realized values, 95% and 99.9% confidence bands over the time sample* ***14/04/2009 - 29/04/2011****. The vertical black line on the 27/08/2010 signals the day of the Chairman's speech at Jackson Hole (Wyo., USA). Time* `t` *converted in units of one year (0 is set at Jan. 1st 2000).*



Clearly, discussing the advantages and disadvantages of Quantitative Easing is out of the scope of this paper, and we leave it as avenue for further research.

4 Empirical Analysis: The Turning Point in April 2010

The temporary end in April 2010 of the market upward trend which started in March 2009, may be one of the reasons behind the FED decision to proceed with QE2. In this regard, the AR(1)-GARCH(1,1) log-periodic model used in Fantazzini (2010a) was clearly expecting such an event, as shown by the previous Figure 1.
However, additional evidence can be provided about the criticality of this turning point: for example, the market behavior from February 2010 till April 2010 could have been modelled as a short-term bubble nested in a longer-term anti-bubble (see section 4.1 below). Moreover, the importance of this temporary market peak and the following market fall is also highlighted by unit root tests allowing for possible structural breaks, which show that the market suffered a significant structural break at the beginning of May 2010 (see section 4.2 below).

4.1 A Short-Term Bubble Nested in a Longer-Term Anti-Bubble?

On the 13/03/2010, Fantazzini (2010b) uploaded a preliminary analysis on `www.scribd.com`, about a possible small bubble developing in the future E-mini SP500 using hourly data from February 2010 till March 2010. More specifically, he employed the Log Periodic Power Law (LPPL) approach by Johansen, Ledoit and Sornette (2000) reviewed in Section 2.1 to verify the presence of a possible bubble.
Fantazzini (2010b) fitted the LPPL formula (1) to the hourly data of the E-mini SP500, using a rolling estimation window of 250 data to be robust against parameter variation, considering both the TS and the PRS algorithms. Given the stochastic nature of the initial parameter selection with the TS and PRS algorithms and the noisy nature of the underlying generating processes, after saving the parameters that minimized the cost function, he re-estimated the model a large number of times in order to build an empirical distribution for the estimated parameters. The estimation results were then filtered by the

following LPPL conditions, which were also used in Jiang et al. (2010) and Geraskin and Fantazzini (2011): $t_c > t_N$ (where t_N is the last observation in the estimation sample), $B < 0$ and $0 < \beta < 1$.
The main empirical quantiles for the critical time t_c when the bubble should have ended (at least temporarily), either by a market crash or by a simple bubble deflation, and for $\exp(A) \approx p(t_c)$, that is the price at time t_c, are given below:

Table 1: Quantiles of the empirical distribution of the estimated parameters t_c and $\exp(A)$

Quantile	t_c (converted in units of 1 year)	t_c (date)	$\exp(A) \approx p(t_c)$
2.5%	10.167	02.03.2010	1113
5.0%	10.169	03.03.2010	1115
25.0%	10.174	05.03.2010	1127
50.0%	10.179	11.03.2010	1145
75.0%	10.209	17.03.2010	1198
95.0%	10.266	08.04.2010	1632
97.5%	10.291	19.04.2010	1880

The results are quite encouraging, also considering that the SP500 reached a first peak on the 15/04/2010 at 1211.67, quite close to the peak reached on the 23/04/2010 at 1217.28. The strongly skewed distributions of the parameters were expected, see Jiang et al. (2010) and Geraskin and Fantazzini (2011) for similar results.

4.2 The End of the Short-Term Bubble: Was There a Structural Break in the SP500?

The previous subsection highlighted that an end to the short-term bubble in the SP500 was expected around March-April 2010. Therefore, the temporary market peak observed in April 2010 could have been a matter of concern if it represented a structural break in the upward market trend started in March 2009. To verify such a possibility, we considered a battery of unit root tests allowing for structural breaks in the level and the slope of the time series:

- *Zivot and Andrews (ZA, 1992) unit root test with endogenous structural break*: this is a sequential test which utilizes the full sample and uses a different dummy variable for each possible break date. Three types of structural breaks are allowed: *i*) a break in the level (or intercept) of the series; *ii*) a break in the slope; *iii*) a break both in the level and in the slope of the series. Zivot and Andrews (1992) proposed a test which endogenously determines the most likely occurrence of a structural break: more specifically, the break date is selected where the t-statistic from the (modified) ADF test regressions is the most negative, thus reaching a minimum. Due to space limits, we refer to Zivot and Andrews (1992) for more details and the test critical values, Pfaff (2008) for an implementation with `R` software, the routines by prof. J. Lee available at `http://www.cba.ua.edu/ jlee/gauss` for an implementation with `Gauss`, and the ZA add-in for Eviews software at `www.eviews.com`.

- *Lee and Strazicich (LS, 2003) minimum Lagrange Multiplier (LM) unit root test*: Lee and Strazicich (2003) highlighted that the previous test (and others similar to it) is derived assuming no break(s) under the null hypothesis, which may lead to a potential spurious rejection of the null hypothesis when there is a unit root with breaks: in such a situation, one may erroneously conclude that the time series is trend stationary when it is non-stationary with break(s). Moreover, Lumsdaine and Papell (1997) and Maddala and Kim (2003) argued that only one endogenous break may not be enough and lead to a loss of information when actually more than one break exists. In order to deal with these issues, Lee and Strazicich (2003) developed a two-break minimum LM unit root test, which allows for endogenous break(s) both under the null and the alternative hypothesis: therefore, this test avoid both the spurious rejection and the trend misspecification problems, and the rejection of the null hypothesis unambiguously implies trend-stationarity. Due to space limits we refer to Lee and Strazicich (2003) for the full description of the test implementation.

Since we want to check whether there was a structural break in the upward market trend, which could have been of great concern for policy makers, we consider Model *iii*) for both tests (i.e. possible breaks in the levels and the slope). The results using the time sample 14/04/2009 - 29/04/2011 are reported in Table 2.
The two tests find indeed a structural break in May 2010, with significant negative dummies after the trend break and the date for the break ranging between May 4 till May 19: this period of time was

Table 2: Zivot-Andrews Test and Lee and Strazicich Minimum LM Two Breaks Unit Root Tests

	Zivot-Andrews Test			Lee and Strazicich - LM Two Breaks					
	Test	Break	LM Test	First Break			Second Break		
	Statistic	Date	Statistic	Date	B_1	D_1	Date	B_2	D_2
SP500 (logs)	-5.18**	04/05/2010	-5.20*	01/09/2009	-0.01	0.00	19/05/2010	-0.395	-0.01
					(-0.84)	(1.67)		(-3.62)	(-3.68)
SP500 (levels)	-5.60**	04/05/2010	-5.00*	11/05/2010	24.46	-13.01	20/09/2010	-5.10	8.95
					(2.01)	(-4.82)		(-0.43)	(-4.24)

[The symbols * and ** denote statistical significance at the 10% and 5% levels. See Zivot and Andrews(1992) and Lee and Strazicich (2003) for the critical values of the test statistics. T-statistics for the dummies B_1,D_1,B_2 and D_2 are reported in parentheses. B_1 and B_2 are the dummies for the levels, while D_1 and D_2 for the slope.]

characterized by a strong market fall following the (temporary) market peak on the 23/04/2010. Once the structural breaks are included in the analysis, the null of a unit root is rejected by both tests. Moreover, if we consider the LM unit root test for the SP500 in levels, we can observe a second structural break in September 2010, that is after the FED Chairman's speech at Jackson Hole, with a positive dummy after the trend break. However, this structural break is not present if we consider the SP500 in logs and the LM test statistic is lower when considering the SP500 in levels, so that the evidence for this second break is weaker.

5 Testing the End of the Anti-Bubble: The Approach by Zhou and Sornette (2005)

The evidence reported in section 3 seems to point out that the anti-bubble pattern started in 2007 may have ended. However, in order to find more precise and conclusive evidence, it is necessary to use a statistical approach which is able to consider the specific nonlinear structure of the log-periodic anti-bubble pattern. Therefore, we decided to follow Zhou and Sornette (2005), which suggested to check the stability of the recursive estimates of the log-periodic model and proposed a test which belongs to a large class of pattern recognition methods.

5.1 Stability of the Anti-Bubble Equation Parameters

The stability of the parameters is an important condition to verify whether the anti-bubble pattern is a correct approach to model market prices. Therefore, similarly to Zhou and Sornette (2005), we fitted the SP500 with the AR(1)-GARCH(1,1) log-periodic model used in Fantazzini (2010a, eq. 4),

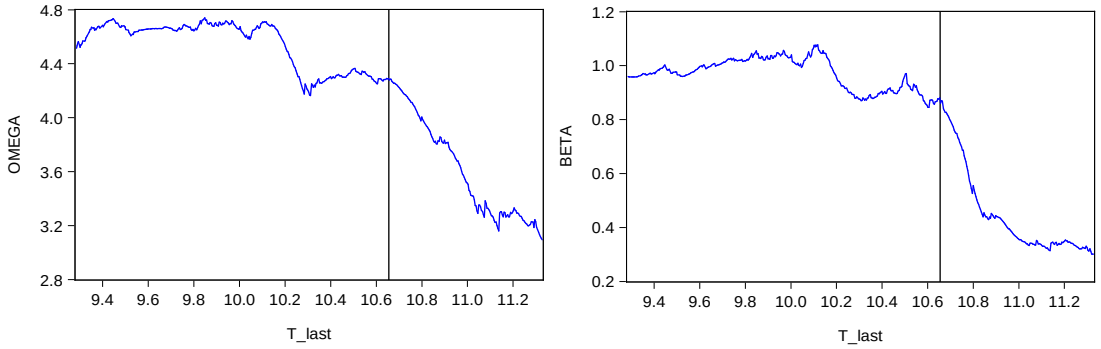
$$\begin{aligned} p_t &= A + B(t-t_c)^\beta + C(t-t_c)^\beta \cos[\omega \ln(t-t_c) + \phi] + \rho p_{t-1} + \eta_t \\ \eta_t &= \sigma_t \varepsilon_t, \quad \varepsilon_t \sim N(0,1) \\ \sigma_t^2 &= \alpha_0 + \alpha_1 \eta_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 \end{aligned} \tag{2}$$

over a running window from t_c = 09/10/2007 (the date of the SP500 market peak) to t_{last}, where t_{last} ranges from 2009/04/14 (the first date of the ex-ante forecast reported in Fantazzini (2010a)) till 2011/04/29, that is the last data available. Due to space limits and for sake of interest, we report in Figure 2 only the recursive estimates of ω and β, which are the key parameters of the log-periodic model in (2), since A, B, C and ϕ are just units distributions of betas and omegas, see Sornette and Johansen (2001) and Geraskin and Fantazzini (2011) for more details. However, the results for the remaining parameters are qualitatively the same, and are available from the author upon request.
Figure 2 clearly shows that the market underwent a change of regime after the Chairman's speech at Jackson Hole (Wyo., USA) and the FED policies quickly detuned the anti-bubble pattern.

5.2 The Test by Zhou and Sornette (2005)

Zhou and Sornette (2005) proposed a test to verify the possibility that an antibubble may have ended, with a potential regime switching. Following Zhou and Sornette (2005), we considered the SP500 from the beginning of the antibubble t_c to the time t_{last} = 27/08/2010 and we then simulated $N = 1000$ price trajectories, from t_{last} up to six months into the future (i.e. up to 28/02/2011), for the following two classes:

Figure 2: *Recursive estimates of ω and β with the log-periodic equation (2), where t_{last} ranges from 2009/04/14 till 2011/04/29. The vertical black line on the 27/08/2010 signals the day of the FED Chairman's speech at Jackson Hole (Wyo., USA). Time* `t` *converted in units of one year.*



- Class I: Continuation of the log-periodic formula with noise added to it, where the noise follows a GARCH model with parameters given by the LPPL fitted values using data from t_c till t_{last};
- Class II: Random walk with daily volatility equal to the historical volatility over the same period (we also tried GARCH noise, but the results remain qualitatively the same).

Class I represents the continuation of the anti-bubble pattern, whereas Class II corresponds to a regime switch at t_{last} from the antibubble to a random walk price trajectory. We then fitted each trajectory by the anti-bubble formula (2) and obtained two sets of N parameters vectors for each class.
The idea of the test by Zhou an Sornette (2005) is to quantify the differences in the distributions of the parameters vectors in the two classes, to decide whether the realized values of the SP500 belongs to Class I or Class II: if the anti-bubble pattern proceeds up to t_{last} + 6 months with a price trajectory close to the extrapolation of the log-periodic formula made at t_{last}, then we can expect that the fitted parameters of (2) using data from t_c up to t_{last} + 6 months should be rather close to the values found for Class I and far from those found for Class II. Instead, if the market prices switch to a random walk after t_{last}, we should find the estimated parameters of (2) to be closer to the values found for Class II and far from those found for Class I. This specific test belongs to a a large class of pattern recognition methods and we refer to Zhou an Sornette (2005) and references therein for more details. Particularly, a key element in pattern recognition methods is to define two types of errors that can occur in a classification scheme using a parameter x: a type I error occurs when the hypothesis, which is true, is rejected (i.e. a so-called "false negative") and it is measured as the proportion of the objects in class I with a deviation $|X - x_0|$ greater than a certain $|x - x_0|$:

$$P_1(x) = \lim_{N\to\infty} \frac{\sharp\{X : |X - x_0| > |x - x_0| \& X \in I\}}{N} \tag{3}$$

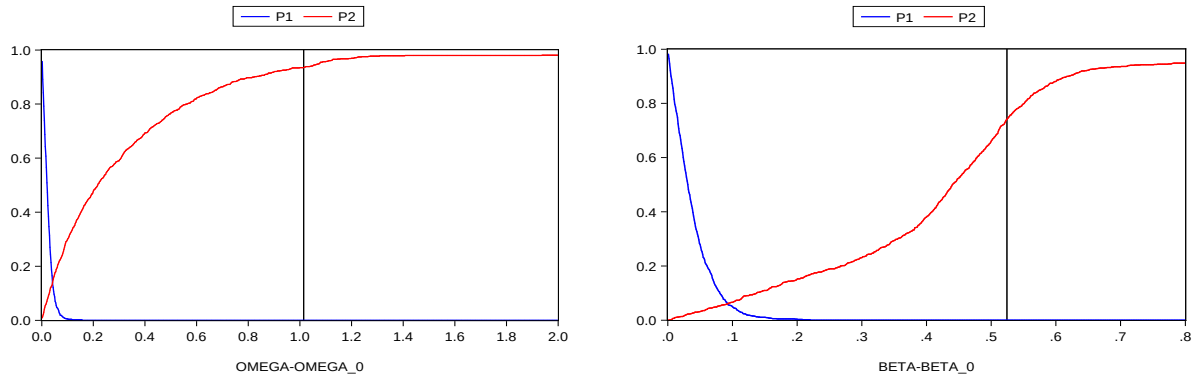
where $\sharp$ is the operator counting the number of elements in a given set. Instead, an error of type II takes place when an hypothesis, which is false, is accepted (a so called "false positive") and it is measured as the proportion of the objects in class II with a deviation $|X - x_0|$ smaller than $|x - x_0|$:

$$P_2(x) = \lim_{N\to\infty} \frac{\sharp\{X : |X - x_0| < |x - x_0| \& X \in II\}}{N} \tag{4}$$

and where $\lim_{x\to x_0} P_1(x) = 1$, $\lim_{x\to x_0} P_2(x) = 0$, $\lim_{|x-x_0|\to\infty} P_1(x) = 0$, and $\lim_{|x-x_0|\to\infty} P_2(x) = 1$. In order to have a confirmation for the continuation of the anti-bubble, the ideal case would be to have both $P_1(x)$ large and $P_2(x)$ small: the first condition informs us that the realized deviation of the estimated parameter x is within the normal fluctuations of objects in Class I, whereas the second condition highlights that it is improbable to obtain such a value when the SP500 does not follow an anti-bubble. Moreover, Zhou and Sornette (2005) highlight that P_1 can also be interpreted as the probability of existence of the LPPL antibubble. Summarizing, a small P_1 and a large P_2 are good signals of the end of the LPPL anti-bubble. Instead, a large P_1 and a small P_2 are good signals of the continuation of the LPPL anti-bubble.

We now apply this test to the realized values of the SP500, and we report in Figure 3 the probabilities P_1 and P_2 corresponding to the reference anti-bubble from $t_c = 09/10/2007$ to $t_{last} = 27/08/2010$ as functions of ω and β, i.e the key parameters of the log-periodic model (2). The vertical lines indicate the realized values of $|x - x_0|$, where x_0 is the reference value of the parameter estimated with data up to $t_{last} = 27/08/2010$, while x is the estimated parameter using data up to t_{last} + 6 months = 28/02/2011. The results with the remaining parameters are qualitatively the same and are not reported here for sake of interest and space.

Figure 3: *Probabilities P_1 (blue line), and P_2 (red line) corresponding to the reference anti-bubble from $t_c = 09/10/2007$ to $t_{last} = 27/08/2010$ as functions of ω and β. The vertical lines indicate the realized values of $|x - x_0|$, where x_0 is the reference value while x is the estimated parameter using data up to t_{last} + 6 months = 28/02/2011.*



It is immediate to see that the P_1's are very small while the P_2's are very large for both the parameters: this evidence therefore suggests that the anti-bubble in the SP500 has ended and seems to confirm the findings already emerged in the previous sections.

6 Conclusions

This paper reviewed the *ex-ante* forecast of the SP500 index discussed in Fantazzini (2010a) which covered the time sample 14/04/2009 - 09/10/2010. We showed that the realized values of the SP500 index trailed the forecasted values quite well, moving inside the forecast confidence bands for over a year. Moreover, an important turning point in April 2010 was also correctly forecasted. However, we also found that the speech by the FED Chairman at Jackson Hole (Wyo., USA) on the 27/08/2010 had a significant statistical impact on the stock market: had additional rounds of Quantitative Easing not been granted that day, the SP500 would have most likely kept going down below the critical 1000 level and beyond, with the all the potential negative effects on the real economy that such an event would have probably determined. Therefore, we found that the anti-bubble which started in October 2007 ended almost three years later in August 2010, similarly to the first anti-bubble on the SP500, which started in August 2000 and ended in August 2003, see Zhou and Sornette (2005). This similarity seems to suggest that it takes almost three years of aggressive monetary policies to gradually detune and end the decreasing market phases following the burst of serious bubbles like the "dot-com" bubble in 2000 and the real estate and oil bubbles in 2007-2008. Further research concerning the monetary policies necessary to deal with the aftermath of bubble bursts is therefore called for.

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