# The Financial Bubble Experiment Advanced Diagnostics and Forecasts of Bubble Terminations Volume II–Final Document (12 May 2010 - 1 November 2010)

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This is the second installment of the Financial Bubble Experiment. Here we provide analysis of the 7 bubbles identified in electronic document [1], whose digital fingerprint was published on arxiv.org on 31 May 2010. The 7 assets, classified according to the nature of their forecast, are

H1	H1 and H2
Cotton futures, CHF	Palladium futures, CHF
Gold futures, CHF	Platinum futures, CHF
Oil futures, CHF	NASDAQ Composite Index
	FTSE EPRA/NAREIT US Index

# I. INTRODUCTION

The Financial Bubble Experiment (FBE) aims at testing the following two hypotheses:

- Hypothesis H1: Financial (and other) bubbles can be diagnosed in real-time before they end.
- Hypothesis H2: The termination of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance.

In a medical context, H1 corresponds to the diagnostic of cancer and H2 to the forecast of remaining life expectancy.

The motivation of the Financial Bubble Experiment finds its roots in the failure of standard approaches. Indeed, neither the academic nor professional literature provides a clear consensus for an operational definition of financial bubbles or techniques for their diagnosis in real time. Instead, the literature reflects a permeating culture that simply assumes that any forecast of a bubble's demise is inherently impossible.

Because back-testing is subjected to a host of possible biases, we propose the FBE as a real-time advanced forecast methodology that is constructed to be free, as much as possible, of all possible biases plaguing previous tests of bubbles. In particular, active researchers are constantly tweaking their procedures, so that predicted 'events' become moving targets. Only advance forecasts can be free of data-snooping and other statistical biases of ex-post tests. The FBE aims at rigorously testing bubble predictability using methods developed in our group and by other scholars over the last decade. The main concepts and techniques used for the FBE have been documented in numerous papers [2–6] and the book [7]. The FCO research team is currently developing and testing novel estimations methods that will be progressively implemented in future releases.

In the FBE, we propose a new method of delivering our forecasts where the results are revealed only after the predicted event has passed but where the original date when we produced these same results can be publicly, digitally authenticated. Since our science and techniques involve forecasting, the best test of a forecast is to publicize it and wait to see how accurate it is, whether the wait involves days, weeks or months (we rarely make forecasts for longer time scales). We will do this and at the same time we want to delay the unveiling of our results until after the forecasted event has passed to avoid potential issues of liability, ethics and speculation. Also, we think that a full set of results showing multiple forecasts all at once is more revealing of the quality of our current methods than would be a trickle of one such forecast every month or so. We also want to address the obvious criticism of cherry picking successful forecasts, as explained below. In order to be convincing, our experiment has to report all cases, be they successes or failures.

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The digital fingerprint of our first set of bubble forecasts was released on 2 November 2009 (with a hash update on 6 November 2009). We added a new bubble forecast on 23 December 2009. The original forecasts and post-analysis were presented publicly on 3 May 2010 and uploaded to the arxiv server on 14 May 2010. All versions are available at [8].

This second set of forecasts presents the methodology described in [8] and the digital fingerprint of a single document that identifies and analyses 7 current asset bubbles (H1). For 4 of those 7 bubbles, the document also provides windows of dates of the most likely ending time of each bubble (H2).

We now provide that document at http://www.er.ethz.ch/fco/ and analysis of our forecasts below.

## **II. EXECUTIVE SUMMARY OF THE RESULTS**

The three assets, currencies and their datasources that we identified as only H1 candidates are:

H1 asset	
Cotton future, CHF (Bloomberg: CT1	COMB Comdty)
Gold future, CHF (Bloomberg: GC1 C	OMB Comdty)
Oil future, CHF (Bloomberg: CL1 CO	MB Comdty)

TABLE I. H1 assets of the Financial Bubble Experiment as of 12 May 2010. All listed assets are candidates for H1 (identified bubble phase).

The four assets, currencies, their datasources and bubble termination forecast quantile windows that we identified as **H1** and **H2** candidates are:

H2 asset	Quantile windo	WS
Palladium future, CHF	20/80%:	2010-06-05/2010-07-05
(Bloomberg: PA1 COMB Comdty)	5/95%:	2010-05-16/2010-07-22
Platinum future, CHF	20/80%:	2010-06-02/2010-08-04
(Bloomberg: PL1 COMB Comdty)	5/95%:	2010-05-23/2010-09-16
NASDAQ, USD	20/80%:	2010-07-05/2010-08-12
(Yahoo: caret-symbol IXIC)	5/95%:	2010-05-28/2010-08-19
FTSE EPRA US	20/80%:	2010-05-18/2010-07-16
(Bloomberg)	5/95%:	2010-05-13/2010-08-22

TABLE II. H2 assets of the Financial Bubble Experiment as of 12 May 2010. All listed assets are candidates for H1 (identified bubble phase) and H2 (identification of end of bubble phase). Quantile windows of most likely dates of the end of the bubble phases are show.

We summarize the quantitative results in the following sections. A complete visual representation is available in the figures in Section IV.

## A. Note about publication date

We offer this short section in the spirit of full disclosure and nitty-gritty details. We had tracked these 7 assets, plus others that were not selected in the end, through early May. We confirmed our final selection of these 7 assets using data through 11 May 2010 (which was available on 12 May). On 12 May, we uploaded a one page report to arxiv.org as arXiv:submit/0039610. This short document contained the digital fingerprint of our assets document (with the 7 assets) and referenced Vol. I of our FBE experiment [1, 8], where the full explanation of our methods was presented. On 13 May, the arxiv.org administrators removed this submission, stating: "We accept only complete, self-contained submissions." On 14 May, we explained to the arxiv.org administrators the justification for the one page document and asked for permission to re-submit it. We followed-up on the issue on 26 May and they replied that our arXiv:submit/0039610 submission was "not appropriate", as it was considered "abstract-only." We expanded the document to include the background material from [1, 8] and uploaded this to arxiv.org on 31 May. Since our initial analysis, report and digital fingerprint of the assets document were, in a sense, made public on 12 May, even if only on some internal, possibly-backed-up, non-publicly-accessible mirrored server somewhere within the arxiv.org system, we chose to post this report on 31 May, even though, as seen in the post-mortem analysis, some of the bubbles had ended.

We are not criticizing arxiv.org at all—they do a great job. We have no problem with the decisions of arxiv.org and do not blame them for *our* poor timing in *our* experiment. We completely accept their judgement and appreciate their excellent system that we use as the vehicle to present our results. The above timeline is only included here to explain why we posted analysis from 11 May on 31 May. In the following, we use the convention that our results were made public on  $t_2 = 12$  May (our 'forecast date'), with the caveat of this section.

We further note that the major US indices—Dow Jones Industrial Average, NASDAQ Composite Index (one of our selections) and SP 500 Index—all began large periods of drawdowns on 3 and 12 May. Our results show that, of our 7 selected assets, only NASDAQ and oil futures in CHF suffered any substantial loss before 12 May. The other 5 all began large declines shortly after 12 May.

#### H1: Identification of a bubble

- 1. We support H1 by confirming that bubbles existed in five of the seven assets (cotton, gold, FTSE EPRA US, palladium and platinum) at the time of our forecasts,  $t_2 = 12$  May 2010.
- 2. We also confirm that bubbles in oil and NASDAQ did exist, but ended just before our forecast date.

## H2: Forecast of change of regime

- 1. Three of the four assets (FTSE, palladium and platinum) where we forecast quantile windows of the end of the bubble began large drawdowns in the narrow window just after our publication date and just before the start of the 5% quantile window.
- 2. The fourth H2 candidate, NASDAQ, as already mentioned, began a large decline just before our publication date and another on the publication date.

## III. ANALYSIS OF THE SEVEN ASSETS

In the following subsections, we include figures for each asset. The figures share some common features, explained here. Details for each individual asset and measure are discussed below.

**Axes and observations:** Price (or value of the asset) is shown on the left vertical axis and calendar days are indicated on the bottom horizontal axis. The circles represent closing price observations on trading days. Note that the price axis shows observations in their natural units on a logarithmic scale.

Large shaded region, vertical and horizontal black lines: The large grey shaded regions that begin near the left price axis and end at the solid black vertical line near the right vertical axis represent the domain of the observations used in our analysis. The vertical line itself sits at  $t_2 = 11$  May 2010: the last observation used in the analysis. The price at  $t_2$  is represented by the solid black horizontal line.

Small hatched, shaded regions: Two hatched shaded regions begin in the vicinity of  $t_2$ . They represent our forecast "danger" zones, where changes of regimes are most likely to occur. The inner, narrow one with diagonal hatching represents the 20-80% quantile interval and the outer, wider one with horizontal hatching represents the 5-95% quantile interval. That is, these two numbers imply a 60% (respectively, 90%) probability for the end of the bubble to be located within the diagonally (respectively, horizontally) hatched zone. The hatched shaded regions are presented only for the four assets, listed in table II, that we identified as H1 and H2 candidates.

**Drawdown analysis:** Drawdown analysis figures show a solid red line connecting the path of the largest drawdown observed between  $t_2$  and the most recent observations used in this document (26 October 2010). The percentage drop and duration of this drawdown is indicated in text in the lower right corner of each figure. A drawdown is simply defined as the largest peak-to-trough drop in price in a given region. Note that the drawdowns for oil, NASDAQ and FTSE begin **before**  $t_2$ , as indicated. Since this is the 'natural' beginning of those drawdowns, we calculated the maximum drawdown percentage using these natural starting points. **Fraction of up days in a running window:** We calculate one day close-to-close returns for each asset and mark them as positive (up) or non-positive (zero or down). The ratio of up days relative to the sum of up and down days in a running window of 60 days is plotted on top of the price observations. The right vertical axis shows this fraction on a linear scale. Note that we do not include returns with a value of zero in the calculation of this ratio. Also, the running window *ends* at the value plotted on the time axis. That is, only present and past data is used in the running window, not future data.

**Derivative of observations:** Another measure of the change of regime is provided by an estimation of the local growth rate. We use the Savitzky-Golay smoothing algorithm to calculate the first derivative of the observations, using a third order polynomial fit centered within windows of 120 days (60 days past, 60 days future). The scale of the estimated derivative is shown on the right vertical axis using linear scaling. Note that this right vertical axis has different limits for each asset, to reflect the different orders of magnitude of some assets.

**Bubble index** We have developed a bubble index that measures the strength of the bubble signal through the LPPL model fits to the data. The index can range from 0 to 1 and is shown on the right vertical axis in logarithmic scale. There are gaps in this measure on the plots; gaps indicate a value of zero for the bubble index.

- [3] A. Johansen, D. Sornette, and O. Ledoit, J. Risk 1, 5 (1999).
- [4] A. Johansen and D. Sornette, Brussels Economic Review 49 (2006), (http://arXiv.org/abs/cond-mat/0210509).
- [5] D. Sornette and A. Johansen, Quant. Financ. 1, 452 (2001).
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- [7] D. Sornette, Why Stock Markets Crash: Critical Events in Complex Financial Systems (Princeton University Press, Princeton, 2003).
- [8] D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, and W.-X. Zhou (The Financial Crisis Observatory), "The Financial Bubble Experiment: advanced diagnostics and forecasts of bubble terminations," (2009), http://arxiv.org/abs/0911.0454.

### IV. FIGURES

D. Sornette, R. Woodard, M. Fedorovsky, S. Reimann, H. Woodard, and W.-X. Zhou (The Financial Crisis Observatory), "The Financial Bubble Experiment: advanced diagnostics and forecasts of bubble terminations, Vol. II–assets document," (2010).

<sup>[2]</sup> Z.-Q. Jiang, W.-X. Zhou, D. Sornette, R. Woodard, K. Bastiaensen, and P. Cauwels, Journal of Economic Behavior & Organization 74, 149 (2010), ISSN 0167-2681, http://www.sciencedirect.com/science/article/B6V8F-4YK2DY8-1/2/ 3e0bc3155eed4914a7987ddd9ca7789e.



FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.



FIG. 5.



FIG. 6.



FIG. 7.



FIG. 8.



FIG. 9.



FIG. 10.



FIG. 11.



FIG. 12.



FIG. 13.



FIG. 14.



FIG. 15.



FIG. 16.



FIG. 17.

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FIG. 18.

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FIG. 19.

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FIG. 20.

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FIG. 21.

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FIG. 22.

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FIG. 23.

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FIG. 24.

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FIG. 25.

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FIG. 26.

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FIG. 27.

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FIG. 28.