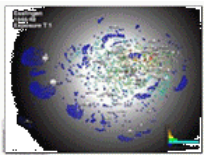

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Log-Periodic Oscillation Analysis Forecasts the Burst of the “Gold Bubble” in April – June 2011

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Keywords:
global economic crisis, the second wave, gold prices, crashes, bubbles, critical phenomena, complexity, power-law functions, log-periodic oscillations

Abstract:
The analysis of the gold price series for 2003–2010 employing both the methodology developed by Didier Sornette and the one of the authors allows forecasting the collapse in gold prices in April – June 2011. The article discusses both the scenarios that could allow avoiding this collapse, and the possibilities of the “gold bubble burst” leading to the second wave of the global economic crisis.

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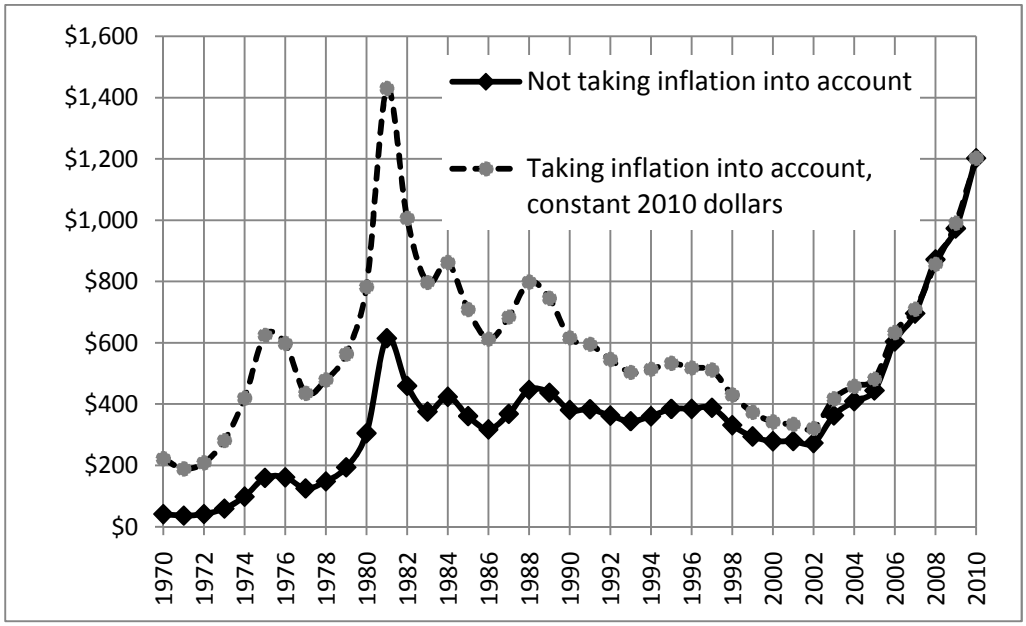
In a number of seminal works by Didier Sornette, Anders Johansen and their colleagues (Sornette, Sammis 1995; Sornette, Johansen 1997, 2001; Johansen, Sornette 1999, 2001; Johansen *et al.* 1996; Sornette 2004; etc.) it has been demonstrated that accelerating log-periodic oscillations superimposed over an explosive growth trend that is described with a power-law function with a singularity (or quasi-singularity) in a finite moment of time t_c, are observed in situations leading to crashes and catastrophes. They can be analyzed because their precursors allow the forecasting of such events. One can mention such examples as the log-periodic oscillations of the Dow Jones Industrial Average (DJIA) that preceded the crash of 1929 (*e.g.*, Sornette, Johansen 1997), or the changes in the ion concentrations in the underground waters that preceded the catastrophic Kobe earthquake in Japan on the 17th of January, 1995 (*e.g.*, Johansen *et al.* 1996), which are also described mathematically rather well with log-periodic fluctuations superimposed over a power-law growth trend.

* * *

After the gold standard policy (see, *e.g.*, Eichengreen, Flandreau 1997) had come to its end, gold began to be transformed into a “last reserve anchor”, a commodity in which the players tend to invest very intensively in such contexts when one observes the running out of other markets and commodities, and the investment into which one could preserve unsafe money. After the end of the gold standard era the first “gold bubble” formed in 1979–1980 during the second jump of the oil prices and was a symptom of global economic crisis (see Figs 1 and 2).

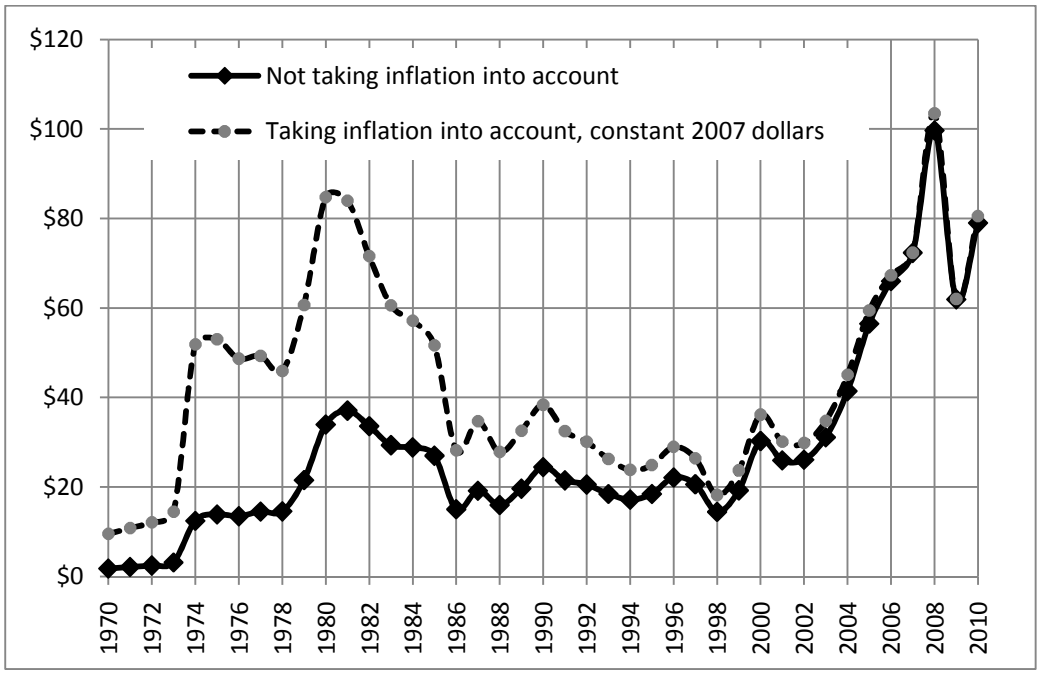
In 2008 during the global crisis the gold prices grew significantly whereas the oil and other raw materials dropped, as if indicating that currently gold is the main reserve currency. However, oil, gas, coal, and metals are not means of hoarding only; they are also very important raw materials for various industries; that is why the jump in their prices brought the global crisis nearer and accelerated it. Now, *post factum*, it is almost evident that the surge in raw materials’ prices is simultaneously an indicator of the closeness of crisis and a factor that brings it closer, but such an apparently self-evident idea only became obvious during the crisis itself. Thus, the jump in raw material prices IS the growing global crisis, amplified to a bubble that is overinflated and subject to collapse. Note also that from 1970 – present gold surges tend to lag oil surges by a year or so.

Fig. 1. Yearly gold price dynamics, 1970–2010



Note: yearly London fixing averages. *Sources*: World Gold Council database. URL: http://www.research.gold.org/prices/ (gold prices for 1970–2009); USA Gold Reference Library database. URL: http://www.usagold.com/reference/prices/history.html (average price for January 4 – November 12, 2010); World Development Indicators Online (Washington, DC: World Bank, 2010), URL: http://data.worldbank.org/data-catalog/world-development-indicators (data on USA inflation).

Fig. 2. Yearly oil price dynamics, 1970–2010



Note: 1970–1973 prices are the official price of Saudi Light, 1974–1985 prices are refiner acquisition costs of imported crude oil, 1986–2010 prices are spot prices for West Texas Intermediate at Cushing, OK. *Sources:* Earth

Policy Institute (Washington, DC, 2010) database (URL: www.earth-policy.org/datacenter/xls/update67_5.xls, oil prices for 1970–2006); U. S. Energy Information Administration database. URL: http://www.eia.doe.gov/dnav/pet/pet_pri_spt_s1_a.htm (цены на нефть за 2007–2010 годы); World Development Indicators Online (Washington, DC: World Bank, 2010), URL: http://data.worldbank.org/data-catalog/world-development-indicators (data on the inflation in the U.S.).

In the context of the crisis, gold started to restore the role of the reserve asset, which accelerated the growth of the gold prices. The countercrisis policy conducted by the leading Western governments influenced the growth of gold prices even more. As is known, it was based on large infusions of public funds into the economy, and, naturally, led to the acceleration in the process of gold prices increase that had begun before the crisis. The weakening of the existing world currencies and the reluctance of China to convert yuan into a world currency in some way returned to gold a part of its former functions. In the absence of a fixed price for gold (in other words, floating gold content of the major currencies), this leads to the formation of a bubble, rather similar to bubbles in commodity markets or real estate. It is quite obvious that this is no ordinary bubble, and the gold market or, conversely, the gold content of the major currencies, is not exactly a free market game, and even those laws that characterize the market game to some extent suit this case only conditionally. A Congress bill or simply Bernanke’s decision seems to be sufficient to significantly affect the process.

Nevertheless, we still make an assumption that in the first place we are not dealing with the complex relationships of the Central Banks of the great powers, but with a “market bubble”, which, as Sornette and others have shown (Sornette, Johansen 1997, 1998, 2001; Johansen, Sornette 1999, 2001; Johansen, Sornette, Ledoit 1999; Sornette 2004, etc.), is characterized by “log-periodic” price fluctuations. We also assume that central bank policy of great powers in the critical period of inflation and the collapse of the gold bubble will remain fairly stable. We use Sornette’s approach to try to estimate when the “gold bubble” could burst.

The basic equation derived by Sornette and tested on many historical examples of bubbles has the following form:

$$p(t) = A - m\,(t_c - t)^{\alpha}\,\{\,1 + C\cos[\omega \ln(t_c - t) + \varphi]\,\}, \qquad (1)$$

where $p(t)$ is gold price at the moment t (further on we operate with daily London gold fixings by PPI index to the 1982 dollar); t_c is the “critical time”; A, m, C, α, ω, and φ are constants which are to be defined on the basis of data on gold prices from the start of the bubble formation till the forecast moment.

In this equation $m\,(t_c - t)^{\alpha}$ describes the main trend of the growth dynamics; with the approaching of the critical point t_c, price $p(t)$ approaches the maximum value A. Against this background periodic oscillations with reduced period take place. These oscillations (Sornette calls them log-periodic oscillations) are described by the second member $C\,(t_c - t)^{\alpha}\cos[\omega\,\ln(t_c - t) + \varphi]$ multiplied by the first considered member (whose value decreases with the lapse of time). Thus, the oscillations amplitude is steadily declining.

Of course, not only infinite, but also very high frequency of the market price fluctuations is really impossible. Achieving the oscillation frequency of high values means an increased risk of crisis. On average, in the examples treated by Sornette (2004), the crisis occurs 1.4 months before the critical point t_c.

At the moment of crisis the growth of $p(t)$ stops and there frequently begins its sharp decline (market crash). The second option marked by Sornette is a scenario when the bubble softly “blows off”, the price starts to decline more or less in reverse order with respect to the sequence

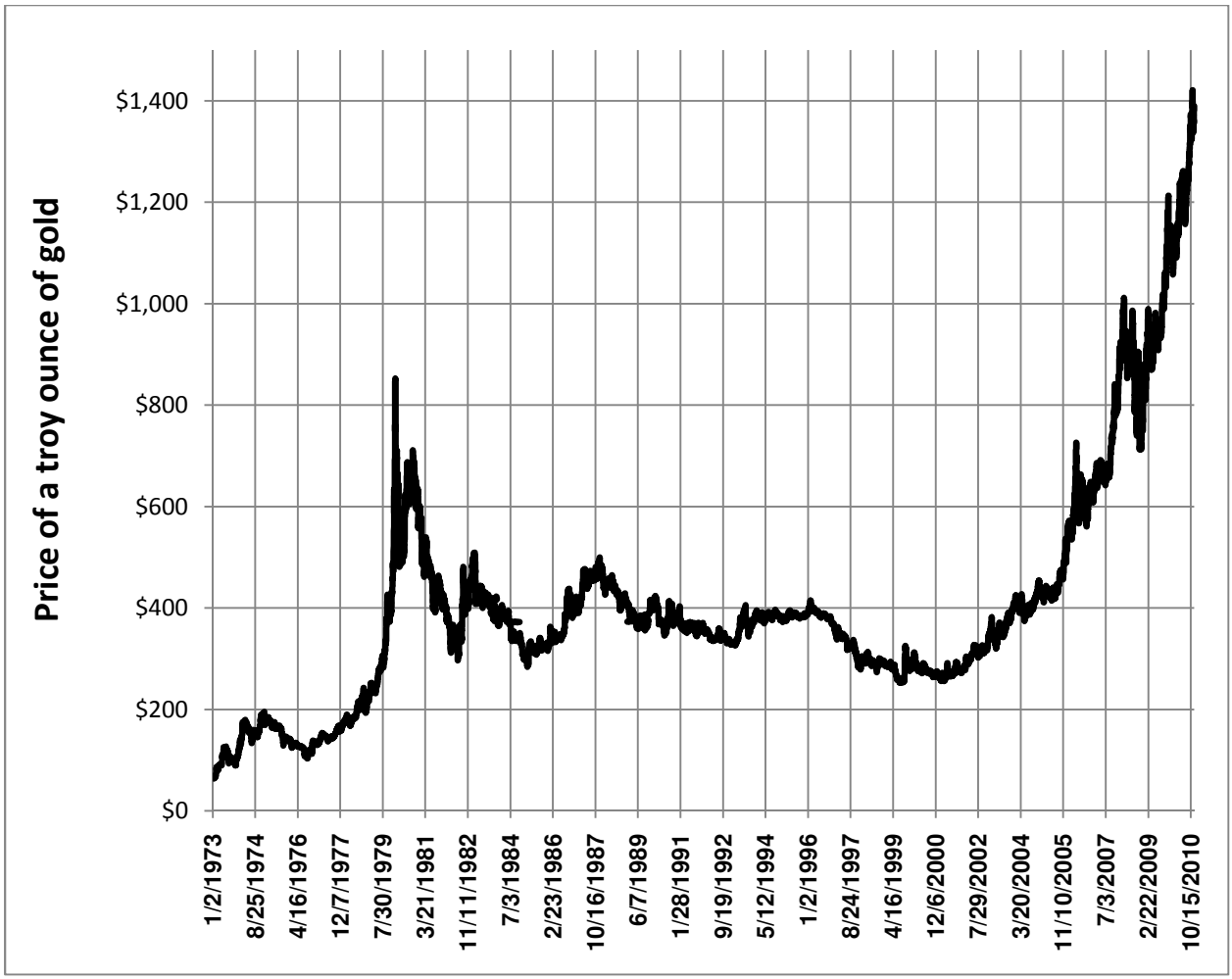
in which it grew up ("anti-bubble"). This scenario is the least damaging to the economic and socio-political perspective and in order to direct the process to a smoother path various state regulatory mechanisms are used.

In the practical implementation of the described methods of forecasting there rises the question of choosing the time interval for which the parameterization will be implemented. In Sornette's monograph (2004) this issue is solved empirically, *i.e.*, such an interval is chosen within which both the main growth trend and the oscillations with reduced periods described by equation (1) are clearly visible.

Analysis of the growth dynamics of the gold price from the beginning of 1973 to November 11, 2010 showed that the time interval that should be used to forecast the date of the collapse of the gold market lies roughly after 2002.

Growth dynamics of the nominal price of gold is shown in Fig. 3:

Fig. 3. Daily gold price dynamics, 1973–2010, US dollars

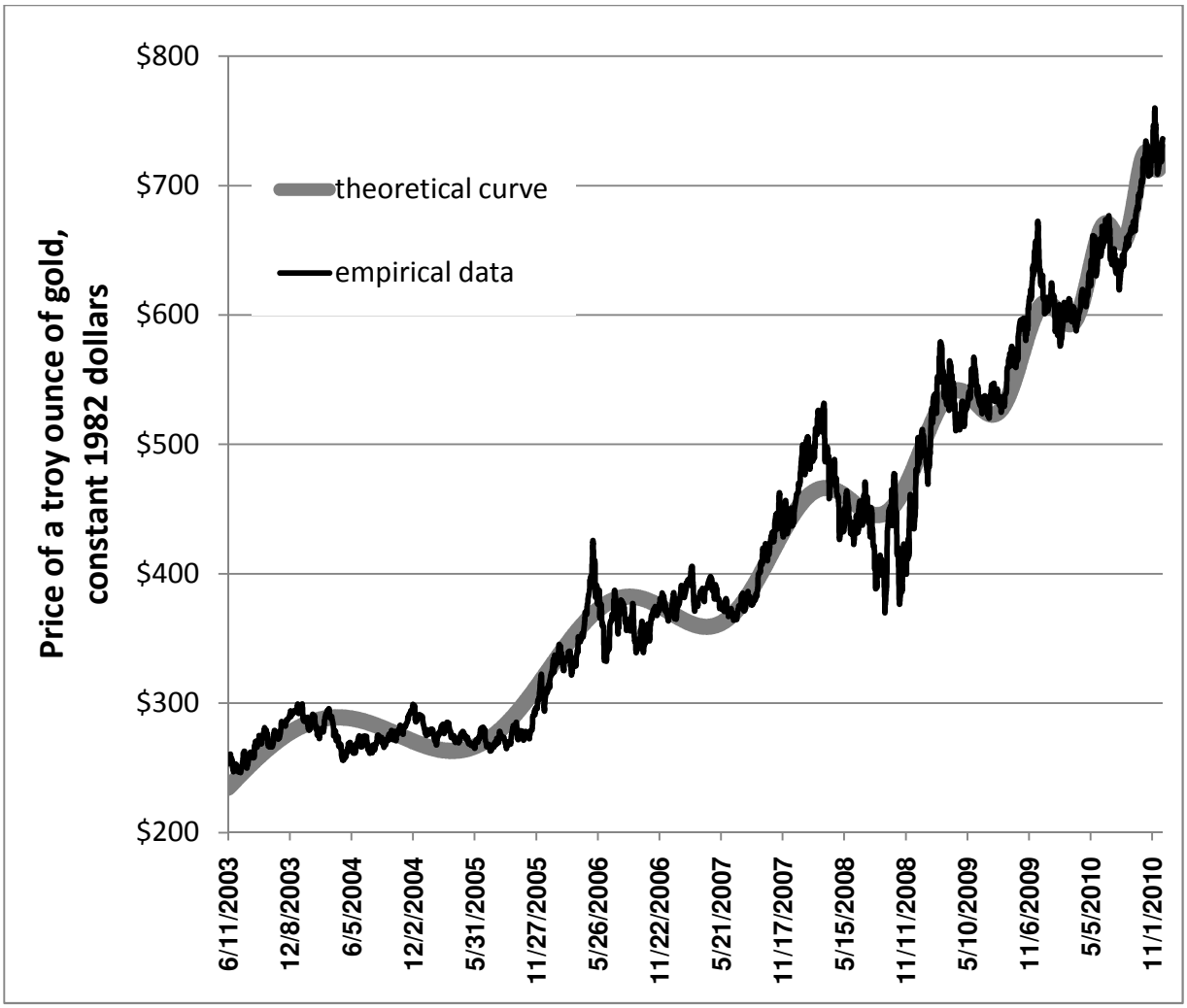


Note: London Afternoon (PM) Gold Price Fix. *Source*: USA Gold Reference Library database. URL: http://www.usagold.com/reference/prices/history.html. The dates at x axis are separated with 600 day intervals. Fig. 1 has been given in yearly prices for purposes of comparison with Fig. 2.

As shown in Fig. 3, rapid price growth began approximately after 2002 against the background of relatively small oscillations. Namely this growth, as Sornette was the first to note, is well described by equation (1).

In the scale considered after 2002 the oscillations are seen not very clearly. In a larger scale, oscillations in the real price have the form shown in Fig. 4:

Fig. 4. Log-periodic oscillations in the gold price dynamics, daily prices, June 11, 2003 – December 2, 2010 (taking inflation into account; constant 1982 dollars)



In Fig. 4, the thin black line indicate daily gold price dynamics between June 11, 2003 and December 2, 2010, whereas the smooth thick grey line has been generated by equation (1), with parameters chosen by the least squares (see equation (1a) below). As our calculations have shown, the critical/singular point can be identified here as $t_c = 2011.45$ (*i.e.*, June 14, 2010). The smooth thick line in Fig. 4 has been generated by the following equation:

$$p(t) = 1220.41 - 570.35\ (2011.45 - t)^{.267}\ \{\ 1 + .036\ \cos[15.86\ \ln(2011.45 - t) - 34.8]\ \}. \qquad (1a)$$

Note that the main parameters of equation (1a) mainly lie in the range of characteristic values calculated in Sornette's monograph (2004). For example, in this book the parameter ω (= 15.86 in our case) in different cases varies in the range between 2.9 and 15. This parameter is related to the so-called scaling factor $\exp(2\pi / \omega) = 1.487$, which shows by how many times the duration of oscillation is reduced from period to period. Exponent (0.267) is close to its characteristic value 0.3, according to Sornette's calculations. In general, the calculations described above fit well in a series of calculations performed by the method's author.

Based on Sornette's observation that collapses tend to occur *c.*1.4 months before the moment of singularity calculated according to his method, **one would forecast that the collapse in gold prices (or the termination of their growth) is most likely to occur in late April – early May 2011.**

Note that the oil price dynamics between January 18, 2007 and April 25, 2008 can be approximated with the following version of equation (1) with parameters chosen by the least squares (for WTI oil prices in constant 1982 dollars):

$$p(t) = 66.9 - 22.84\ (2008.67 - t)^{.915}\ \{\ 1 + .056\ \cos[22.1\ \ln(2008.67 - t) + .47]\ \}. \qquad (1b)$$

The calculated critical moment in this case has turned out to be August 31, 2008. As was mentioned above, according to Sornette (2004), the actual start of the collapse of a respective indicator tends to start *c*1.4 months before the critical moment, which in our case corresponds to *c*July 18, 2008. Note that the actual crash of the oil prices started on July 14, 2008. Thus, with the log-periodic fluctuation methodology the burst of the 2008 oil bubble could be forecasted quite accurately on April 25, 2008 (that is 80 days before the start of the crash), or later. In the meantime, our calculations indicate that if we use data for an earlier period (say, for January 18, 2007 – April 1, 2008, or for January 18, 2007 – March 1, 2008), the error starts growing in a rather significant way; thus, we would not be able to provide such an accurate forecast on April 1, 2008, let alone March 1, 2008. This point is connected to a considerable extent with the fact that the log-periodic fluctuations preceding the burst of the 2008 oil bubble can only be traced since early 2007, and for earlier periods (say, for January 1 – December 31, 2007) we do not have a sufficient number of log-periodic oscillations and data points to calculate the exact critical time. Note that with the gold price dynamics the situation differs in a rather significant way, as here we can detect the log-periodic oscillations since 2003, and by the early December, 2010 we seem to have a sufficient number of observed log-periodic oscillations and respective data points to forecast the burst of the "gold bubble" about 200 days in advance.

Comparison to Deviations from Hyperbolic Growth

The analysis of many processes of rapid price increases in recent years (for example, the process of oil prices' growth in 2000–2008) has demonstrated that the amplitude of respective log-periodic oscillations had no pronounced trends. We can see that in Fig. 1, first crisis. Also in oil, Fig. 2, 2002 – forward, in contrast to gold. So, in addition, an attempt was made to forecast the point of collapse using log-periodic oscillations superimposed on a hyperbolic trend typical for many social processes (population growth before the demographic transition, global GDP growth and energy production per capita, *etc.*) (see, *e.g.*, von Foerster, Mora, Amiot 1962; Johansen,

Sornette 1999; Tsirel 2004; Khaltourina, Korotayev, Malkov 2006; Malkov, Korotayev, Khaltourina 2006; Korotayev, Malkov, Khaltourina 2006; Markov, Korotayev 2007; Korotayev 2005, 2006, 2007, 2009, *etc*.). Such a method of calculating the point of collapse is deprived of many advantages, which Sornette’s method possesses: a simultaneous detection of the crash moment through the trend and the oscillation periods, the lack of a significant influence of the weight of events (recent observations at the highest price play a greater role for the trend, while the first observations are more important for the periods, as the periods were longest then and each period contained a lot of data points), and the possibility to take into account the oscillation amplitude.

The unification of the estimation of the collapse point position through the trend analysis and through the analysis of the oscillatory process proposed by Sornette is based on rather rigid assumptions, because the effects that they experience are not identical – the trend strongly depends on more general and long-term tendencies, while variations depend on the current events. Estimates free of such a rigid connection possess some independent value. Thus, because there are processes of rapid price increases with no pronounced trends of the amplitude of the log-periodic oscillations, our results using Sornette's method are usefully compared to a two-stage analysis of deviations that begin with the following equation:

$$p(t) = A\ (t_{c1} - t)^{B} + C\cos[\omega\ \ln(t_{c2} - t) + \varphi]. \quad (2)$$

In this equation (unlike in equation 1) the amplitude of log-periodic oscillations does not change.

The first step was to describe the hyperbolic trend. It should be noted that the trend equation is highly dependent on the starting point of the hyperbolic growth (though log-periodic deviation from the trend is much less dependent on the starting point). Also, as in Sornette’s method, the selection of the starting point was made “by eye”, referring to the analyzed curve. For the selected starting point in August 2002 we have arrived at a hyperbola of the following kind (Fig. 5).

$$p(t) = A\ /\ (t - 2015)^{1-1.05} \quad (3)$$

In this equation gold prices would theoretically go to the infinity (singularity point 1) approximately at the end of December 2014 (or autumn 2014 with an earlier starting point of hyperbolic growth trajectory).

The second step was the approximation of the deviations from the trend in the form of log-periodic oscillations. First, each point (the same as in Sornette’s method) was given the same weight. Herewith, the end of this process (singularity point 2) fell on July 6, 2011 (Figs 6 and 7), which is just about a month different from the estimation by Sornette’s method.

Fig. 5. Hyperbolic trend in the gold price dynamics, 2002–2010

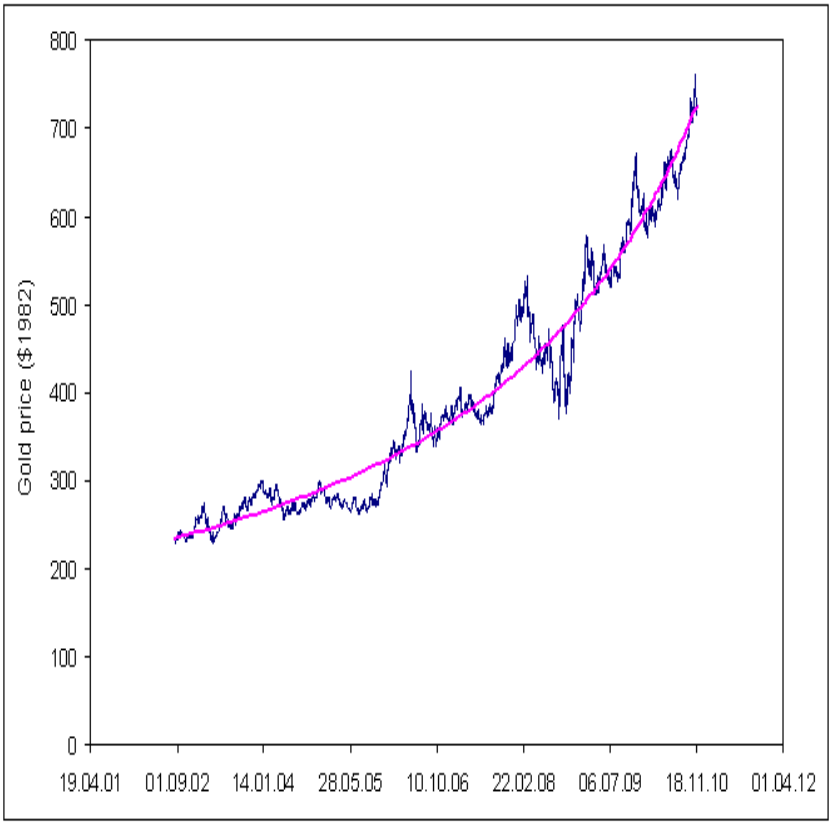


Fig. 6. Deviations from hyperbolic trend in the gold price dynamics, 2002–2010

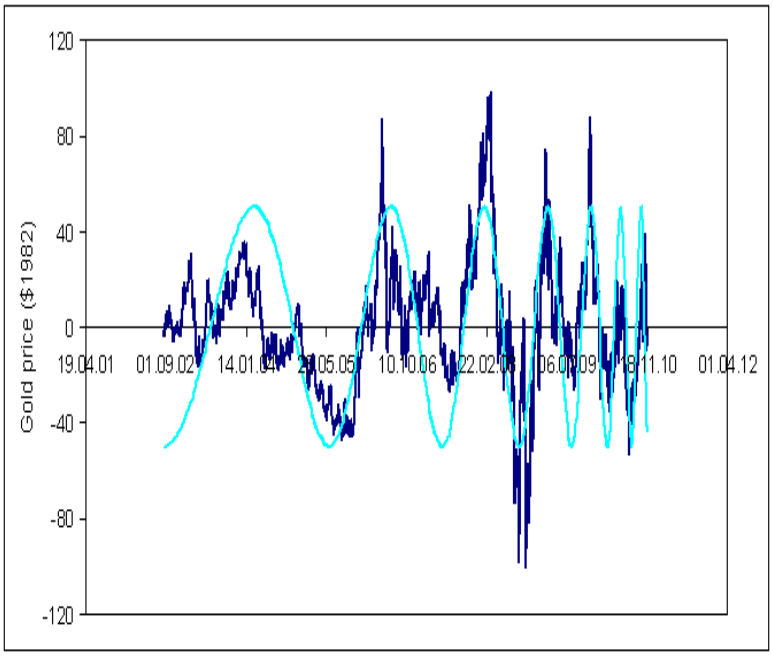
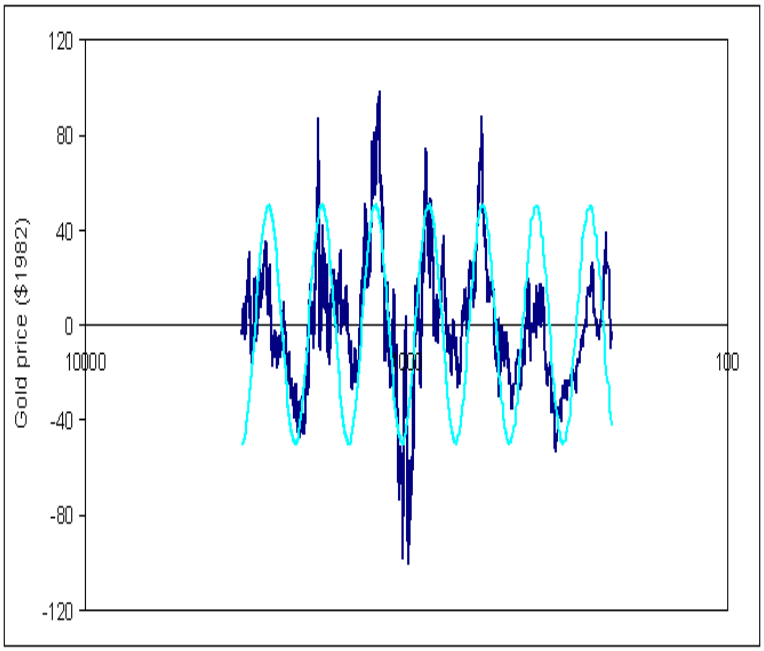


Fig. 7. Logarithmic scale deviations from hyperbolic trend in the gold price dynamics, 2002–2010 (X-axis indicates temporal distance in days from the critical time point)



Therefore, the most likely estimate of the period when the “gold bubble” is likely to burst is April–June 2011.

Conclusions

As stated in the beginning of this article, all these calculations should not be given the meaning of an accurate prediction of the events. The calculations performed by Sornette’s method and other estimates are based on the idea that all players will try to maximize profit just in this market, and will not believe in forecasts like the one we propose (otherwise we shall deal with a “non-self-fulfilling prophecy”). If a very large player, such as the Central Bank of China, intervenes with other goals (longer-term, depending on political calculations, etc.), then the foundation upon which all such forecasts are based disappears.

Will the probable collapse of the “gold rush” signify a new wave of crisis?

On the one hand, it is obvious that such a collapse leads to huge losses or even bankruptcies of many of the major participants of exchange games and their dependent firms and banks. Therefore, the immediate market reaction will be entirely negative. Negative impact on the market will be amplified by numerous publications in the media and business press, drawing analogies with the events of the early 1980s and earlier similar events, as well as by losses of the shareholders of bankrupt companies. The current instability of major world currencies and the most powerful world economies, unfortunately, does not preclude the escalation of a short-term downswing into the second wave of economic and financial crisis.

On the other hand, investments in gold, which caused the very “gold rush”, are also a diversion of money from stock market investments and a reduction in the production of goods

and services. If at the time of the collapse some promising areas of investment appear in the developed and / or developing countries, the investment can move to those markets which, on the contrary, will contribute to the production of new goods and services and accelerate the way out of the crisis.

Rather than relying on the most optimistic scenario presented in the previous paragraph, let us suppose that the burst of "the golden bubble" will be followed by a short-term downswing, and further proceeding will depend on the amount of perspective directions of investment at the moment, as well as on the reaction of the U.S. Federal Reserve and the Central Bank of China to the events. In absence of sharp uncoordinated actions there could be certain grounds to expect the reduction of the influence of gold prices on world markets and the continuation trend of slow and unstable recovery.

Acknowledgement

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