

Chapter 2

The “Noisy Chaos” Hypothesis

Abstract The concept of “noisy chaos” is introduced in this chapter, based on the processes of bifurcation, entropy, and convergence which occur at the heart of the instability in the financial markets and take into account the sensitivities of the financial systems. The key here is to identify and measure indicators that allow us to construct a model that accounts for extreme consensus factors (undisseminated information, correlated investment horizons, and high leverage) in estimating market reversals. Instability is a relatively subjective notion. If we think in calendar time, the system is unstable as the daily fluctuations seem erratic when compared to periods of months and years. But if we think in intrinsic time, it is as if we are looking at the week as a year, the day as a month, and the minutes as days... in doing so, and as markets are “self-affine” then the L-stable process can be found at the day level and the erratic fluctuations will be at the seconds level.

Overshoot then crash, Joseph effect, then Noah effect, again and again. How big is the overshooting? It can only be estimated after the fact... but that is little consolation to anyone living in the real markets... we can never forecast when the bubble will burst: result prices gyrate, from boom to bust, from bust to boom (Mandelbrot 2008, p. 204).

2.1 Financial Systems at the Edge of Chaos

The discovery of chaos originated from the observation that some dynamic systems can attain autonomy over the course of their evolution. In 1961, the meteorologist Edward Lorenz discovered that this evolution is very sensitive to initial conditions.ⁱ The meteorological system is regulated by a chaotic dynamic, characterized by the existence of an amplifying effect, also called the “butterfly effect”. Lorenz (1963) states the following:

Can the flap of a butterfly’s wing in Brazil set off a tornado in Texas? The sensitivity to initial conditions finds its source in the non-linear character of systems, where the effect can be more proportional than the cause: these considerations explain why the validity of weather forecasts stays limited to several days.

Lorenz’s weather forecasting experiments demonstrated that after a certain period of time, all nonlinear dynamic systems that have attained a chaotic regime once again pass through neighboring states of paths they have already gone through. The trajectory of these systems has a tendency to occupy only a limited part of space because of its stationary characteristic and to converge toward a “strange attractor” of a fractal nature.¹ We cannot pinpoint their exact location on the strange attractor; it can only be determined *a posteriori*.

The attractor is defined as the level of equilibrium of the whole system. If a system is headed toward stable equilibrium, its equation is linear and has only a single solution called the “point attractor”. When the system is regulated by a nonlinear dynamic, the system’s trajectories are considered orbits in its probability space. The various points through which an orbit passes are the solutions of the equation. The solutions can be calculated and forecasted because the system always follows the same periodic orbits. In this case, the attractor is called the “limit cycle.” For some systems, however, the orbits are different each time, that is, the trajectories never pass through the same points. The orbits are nonperiodic and remain confined in their probability space; the attractor is called the “strange attractor.” The existence of different attractors demonstrates the complex mathematical phenomenon of deterministic chaos, that is, systems that appear to be totally random yet governed by a deterministic process. Ekeland (1995) wrote:

Chaos theory considerably enlarges the possibility of using deterministic models... To propose a deterministic model is to leave a space for randomness, a dimension of the unpredictable... The system is confined to its strange attractor, certainly, but its movement around the attractor escapes us, which is a prediction that we can make beyond the characteristic time... an admirable and subtle dosage of randomness and necessity (p. 101).

In essence, chaos appears in relation to self-reinforced mechanisms generated by positive feedback loops. Each of these loops can contribute to the auto enforcement of a phenomenon until it is curbed by other mechanisms. When the parameters of a system are stimulated beyond a threshold limit, an important and violent change in the dominance of the different positive loops is produced, a phenomenon known as “bifurcation”.² From its initial equilibrium state, a system bifurcates in a very orderly fashion until it reaches a chaotic state. According to Mandelbrot, strange attractors make it possible to consider both the Joseph and

¹ Mandelbrot defines fractals as strange attractors of all deterministic chaotic systems. These objects possess the particularity of having an infinite perimeter while being contained in a finite space. Mandelbrot does not assert that markets are chaotic but that the outcome of any process is sensitive to its starting point (Mandelbrot 2008).

² The Australian biologist, Robert May, was one of the first to discover bifurcations in 1976.

Noah effects. The fractality of the system, due to its self-affine characteristic, allows cycles to be identified; these limited nonperiodic cycles depend on the process at play and on the behavior of the market players. Historical analyses have shown that economic cycles cannot be predicted; that their ends cannot be determined and that they are not random. There are perfectly identifiable logical linkages between market players, their expectations and behavior, such as, for example, investors and the US Federal Reserve, their actions and the consequences of their actions on the interest rates.³ The cycles are a consequence of the complex system that regulates the economy.

The L-stable process depends on the structure of the correlations between prices. The characteristic time, named hereafter the bifurcation moment (B), however, poses a strict limit for all quantitative forecasting, such that beyond it, the system acquires a certain degree of freedom.⁴ The evolution of a financial series at characteristic time B is completely erratic; as time passes. No trend can be clearly defined as H gets closer to 0.5; it is as if the memory of the system has faded. Although, the financial process seems to follow random motion, the system still retains its fractal nature and so stays confined to its strange attractor.

2.2 Constrained and Optimal Entropy Model in Noisy Information Systems⁵

The concept of constrained entropy (Dinkel 1979) refers to the fact that at all times and at different degrees there is noise constraining the speed of information dissemination in the financial markets systems and that information arrives following a sporadic jump process (Black 1976). The speed of the price adjustment process is constrained to some finite speed by taxes, transaction costs, information costs, assimilation time (the costs of acquiring and analyzing informationⁱⁱ), and divergence in perceptions. Finite speed of information dissemination and assimilation in the marketplace and discontinuous information process lead to disequilibrium conditions and prevent entropy from being maximized. Equilibrium and disequilibrium conditions in such a market are derived from Nicolis and Prigogineⁱⁱⁱ (Nicolis 1977): if we consider a variable (gt) as the amount of (undisseminated) information in the market, it acts as a measure of disequilibrium, i.e., the greater the amount of undisseminated information, the greater the divergence from

³ This concept is discussed in details in [Chap. 4](#).

⁴ Time is characteristic in the sense that it depends on the system in question and varies according to the stock, sector, and microstructure of the market. If the characteristic time of the solar system is 100 million years, then the forecasting time would be 1 month.

⁵ Ideas gathered from Pr. D Nawrocki research papers to fine-tune and support the concept of Noisy chaos proposed in this book (Nawrocki 1984).

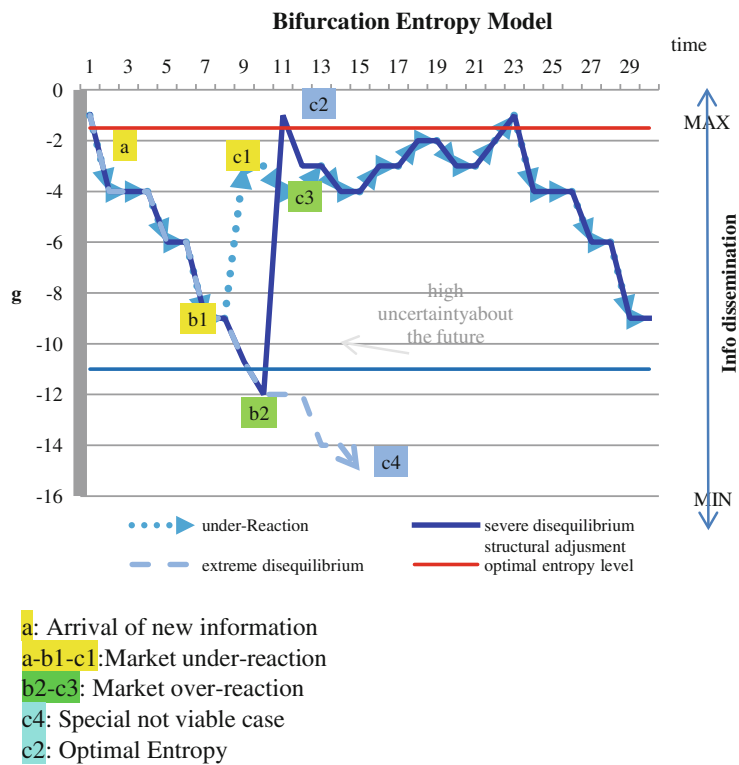


Fig. 2.1 Bifurcation entropy model

equilibrium. The bifurcation entropy (BE)⁶ model under different scenarios is explained in Fig. 2.1 and in the following subsections.

2.2.1 Instability at *n* [Milliseconds; Days] and High Frequency Trading

To verify the stability of the distributions of price changes, Peters (1996) compared the H exponent of daily distributions for a daily series from the S&P 500 index. While carrying out the stability tests, Peters observed that the H values increased progressively from 0.59 to 0.78 between $t = 0$ and $t = 30$ days, after that it fluctuated between 0.78 and 0.81. Peters attributed the lower values of the H exponent to the existence of noise in the system. This noise disappeared after

⁶ BE can be thought of the verb “be” referring to the existence/survival of the system.

approximately 30 days, which indicates that short-term price fluctuations are characterized by a very short memory, otherwise known as the Markovian memory, which is an autoregressive process characterized by a very short-term dependency.⁷ This implies that for n [milliseconds; days], there is an exponent H_e $[0.5; H]$. During this period the series has more noise which disappears after a very short time. As such, this type of dependency must not be confused with long-term dependencies that stay in the system and where present events affect the future. To illustrate a short-term dependency where erratic daily movements have no effect on future prices, we take as an example the sudden stock price increase when the company's CEO is being interviewed on TV. During this period of time (approximately 10 min) the price can increase by 5 % or more. Afterwards, the price returns to its initial level or its value prior to the interview. This explains why volatility is higher in the short-term than in the long-term.

A more general cause of erratic daily movements is the high-frequency trading (HFT) effect. An intraday is viewed as a cycle itself, where the investment horizon can vary between milliseconds and hours. On May 6 2010, Wall Street experienced a temporary blackout. The Dow Jones Industrial Average plunged around 700 points in minutes before recovering. Everyone suspected that HFT aggravated this sudden decline, although no one confirmed it. HFT strategies can vary from providing liquidity (rebate trading and market making), trading the tape (filter trading and momentum trading), and statistical trading (statistical arbitrage and technical trading). Critics say that HFT's powerful algorithms equipped with ultra-low latency solutions give high-frequency traders an unfair advantage by detecting on time markets imbalances within nanoseconds and then executing millions of orders in less than one millisecond,⁸ HFT takes advantage of price movements, leaving other investors behind the curve. That said, most of these types of trading is legitimate, reducing trading costs for ordinary investors and ensuring market liquidity. Problems occur only when strategies are used to confound other investors by issuing then cancelling orders almost simultaneously. In this case, regulators should monitor trading activity and penalize such trades, for example, when The Financial Services Authority (FSA) successfully pursued online brokerage company Swift Trade for manipulative trading layering⁹ that triggered a series of small price movements on the London Stock Exchange between January 2007 and January 2008 and from which Swift Trade profited about £1.75 million (Library 2011).

We would like to point here that instability is subjective. If we think in calendar time, the system is unstable as the daily fluctuations seem erratic when compared to months and years periods. But if we think in intrinsic time, it is as if we are

⁷ The function can have the following form: $\mathbf{X}_{(t)} = \mathbf{X}_{(t-1)} + \varepsilon$, with ε a random Gaussian variable with null average.

⁸ Sub-microsecond (or nanosecond) delivery for level 1 markets and end-to-end through put of only 2 microseconds for complex markets. NovaSparks.

⁹ In trade layering, orders are entered onto an exchange to artificially improve the price of a stock. Once this is achieved, the orders are then cancelled.

looking at the week as a year, the day as a month, and the minutes as days... in doing so, and as markets are self-affine¹⁰ then the L-stable process can be found at the day level and the erratic fluctuations will be at the seconds level.

2.2.2 Lévy-Stable Process

At $n < T$ (n is the time and T is the characteristic time), the evolution of the markets follows a fractional Brownian motion (fBm). The Brownian motion is biased, the probabilities of distribution of the price changes lean toward one direction. Prices are generated by a persistent, fractal, Lévy-stable process. This process is determined in part by the structure of the correlations of the series measured by the Hurst exponent and the positive feedback or reflexive relations synchronized by the attitudes of the financial players who rely on technical analysis. In addition to the L-stable process, another process is at play, one that is regulated by a Markovian memory. However, the L-stable process dominates the Markovian one. Each individual has his own perception and makes his decision according to that perception. These heterogeneous perceptions create some uncertainty and differences, albeit minimal, between the market price and the fundamental price.

In the short- and medium-term, the financial markets are dominated by investors who have appropriate investment horizons characterized by their own processes, the integration of which leads to Lévy distributions. As we go further in time, this process loses its pertinence. In other words, when the system's memory is not backed up by the arrival of confirming information or on the contrary, by divergent information, its effect decreases until it becomes impossible to measure. Sequentially this is what happens referring to Fig. 2.1.

1. a: Arrival of new information
2. Lags in information process creates greater disparity between the equilibrium price and the actual price
3. Arbitrageurs enter the market in greater volume as they can generate enough profit to cover transaction and information costs
4. Higher volume of trading
5. a-b1-c1: gradual increase in the speed of info dissemination, reinforcing the market trend. Gradual but not continuous (stable) assimilation of information over time (memory effect). Autocorrelation varies with the amount of disseminated info and its speed. The speed of information dissemination increases so that undissemminated information does not have a chance to accumulate to a bifurcation point. Within the context of the bifurcation model of conditional market returns proposed by David Nawrocki and Tonis Vaga (David Nawrocki 2011), in this case returns execute a biased random walk and

¹⁰ Re. Chap. 1.

if the mean return exceeds the associated costs, the markets may offer profitable trading opportunities.

2.2.3 Bifurcation Entropy Process

When undisseminated information accumulates to a Bifurcation point, it leads to increased uncertainty and widening of the competence-difficulty (C-D) phenomenon.¹¹

Following a shock, the system moves to an unstable state where the margin of trading and the trend are broken up. Shocks are produced at the positive feedback loops of the system, when a parameter is stimulated beyond a certain critical threshold. Laszlo (1987) defined a theoretical framework for the analysis of markets, categorizing the parameters that influence the dominance of economic system loops into: technological innovations; conflicts and conquests; and economic and social disturbances such as shortages and financial crises.

For instance, after the introduction of technological innovations, a shock is produced as scientific discoveries stimulate productivity and profit margins of leading technology companies. Multiplier effects, self-reinforcement of growth expectations, and other factors also stimulate growth throughout the economy. During this period of growth, however, key financial players, such as investors, analysts, and regulatory authorities will not have the appropriate valuation tools to analyze and assess the risk of new financial and economical changes. The difference between the stock market price and its fundamental value at the beginning of the period can be justified by the economic growth resulting from the innovations. It is human nature, however, to overestimate the potential growth and advantages that innovations will bring to the economy, which leads to an overvaluation in the equity market (overconfidence and gain seeking taking over loss aversion is human nature). On top of that, social contamination encourages the progressive formation of a highly positive consensus in the market. The overvaluation is amplified when profits get reinvested in the markets. The overvaluation bias continues to grow until it reaches a “consensus extreme” and becomes unsustainable. Shocks are amplified by the actions of the economic agents themselves. As financial conditions worsen, market participants risk aversion increases. The increasing difference between reality and perception is adjusted through the phenomenon of bifurcation by a

¹¹ This is the spread between the competence of the investors and the complexity of the information. (Nawrocki 1995) (Heiner 1983) (Kaen and Roseman 1986).

radical change in perception through which financial disengagement begins. It is then necessary to add consensus extreme as a fourth parameter to Laszlo’s list.

A high consensus level is a tangible sign for the beginning of a major market reversal. Let’s take an example of two states of price equilibrium. State 1 is where we have equal notional amounts on each side of the market (buying/selling) and where buyers and sellers are of equal size and quality. State 2 is where we have equal notional amounts on each side of the market (buying/selling) and where buyers and sellers are of different size and quality. The difference between state 2 and 1 lies in the quality and size of the buyers/sellers. Some practitioners suggest a contrarian¹² approach wherein one acts contrary to the market consensus peak. According to Tvede (2000, p. 117), if the majority of the market is buyers, the average seller must be larger than the average buyer in order to fulfill the large demand. If 90 % of the market is buyers, then sellers must be about 10 times larger than the average buyer; if 95 % of the market are buyers, then the average seller must be 20 times larger than the average buyer. As such, it is important to know who is behind the trades. What would you think if you know that the current market price is heavily sold by few big entities while large number of retail investors is still buying it? As long as the big players can find counterparts to their trades they will execute them and decrease their long exposures. When the numbers of small traders decrease, traded volume decreases exponentially to smaller and smaller levels. Prices start going south to get trades executed, small players end up aligning willingly (perceiving finally the risks ahead) or unwillingly (due to margin calls) with sellers’ original view.

Investment horizons alignment on the short side is the prelude to a crash, while alignment on the long side is the prelude to a long rally. Either way it leads to tail risks. To clarify the idea of consensus we outline here that is not only in the market direction but in the investment horizon. Would it be possible to know in advance when this alignment is becoming dangerous? To do so, it would be wise to start by understanding the dynamic behind investment horizon alignment; that can be:

- The emergence of short-term flash traders, such as hedge funds; mixed signals from clients; short-term incentive systems; HFT.
- Behavioral biases, such as herding and recency biases.
- Shorter period of management mandates (3 years).
- Volatile markets and changing macroeconomic conditions.
- High turnover and volatility cycle: this is a cycle as we can wonder if the market volatility pushes higher turnover, or does higher turnover lead to increased market volatility?

¹² It is important to note, however, that the success of the contrarian approach depends on timing, which can only be determined through guesswork. The adoption of Bayesian principles might help as well, where the probability of the occurrence of an event is related to the occurrence or nonoccurrence of an associated event. In this case, it would be wiser to base one’s decisions on the analysis of the roughness and the level of risk in the market.

It becomes obvious that the main lead to follow, in order to identify signs of alignments, is the shift in market liquidity i.e. the flow of money between sectors, industries, strategies, investment products, and the portfolio turnover level in some style type strategies. This is a clear explanation of how and why correlations tend to 1 at panic juncture.

Now to integrate the above-mentioned phenomenon we proceed as follows:

As stated in the fractal market hypothesis, the distribution of price changes is marked by a large number of small fluctuations.¹³ An important question arises concerning a third process which produces these fluctuations.¹⁴ The passage from an L-stable state to an unstable state is the result of a long process set free parallel to the L-stable process. An understanding of this process requires the review of the entropy notion.

At any point in time, a system is distributed across N microstates, each denoted by i , and having a probability of occupation, p_i , and energy, E_i . These microstates form a discrete set. The internal energy is the average of the system's energy, expressed below:

$$U = \{E\} = \sum_{i=1}^N p_i E_i$$

This is the microscopic statement of the first law of thermodynamics. A macrostate characterizes observable average quantities, such as temperature, pressure, and volume. When applied to finance, the macro-factors are indicators, such as volatility indices, unemployment, and inflation. The microstates define a system's molecular details including the position and velocity of each molecule. When applied to finance, it defines financial agents' behavior, including reaction time, intensity, and the tendency for under- or over-reaction. Entropy measures the degree to which the probability of the system is spread out over different possible microstates. It is expressed by the second law of thermodynamics as follows:

$$S = -K_B + \sum_i p_i \ln p_i$$

where k_B is the Boltzmann's constant.¹⁵

¹³ This large number of small fluctuations is different from those at the base of the Markovian process, of which the effects, while they are of short duration, have been totally integrated into the system.

¹⁴ Under-reaction leads to over-reaction at time T owing to the information ignored due to the prospect and disposition effect. The tendency of some investors to hold on to their losing stocks creates a spread between a stock's fundamental value and its market price, as well as price under-reaction to information.

¹⁵ Boltzmann's constant defines the relation between absolute temperature and the kinetic energy contained in each molecule of an ideal gas. It is named after the Austrian physicist Ludwig Boltzmann (1844–1906), and is equal to the ratio of the gas constant to the Avogadro constant: $K = R/NA = 1.3807 \times 10^{-23} \text{ J.K}^{-1}$ (joule per Kelvin).

Based on the various definitions of entropy on a macroscopic scale,¹⁶ and in fields, such as statistical mechanics,¹⁷ cosmology,¹⁸ and information theory,¹⁹ we can postulate that: Entropy is an indicator of the level of undisseminated information in a system after taking into account observable macroproperties. Not all information is readily integrated into the market price. The lost/ignored or undisseminated information in the L-stable process is therefore assimilated into another endogenous process, the bifurcation entropy process (BE process). This process evolves until the arrival of supporting information (the amount of “lost” information) that hits a threshold which triggers a shock in the financial system and takes over the L-stable process. The shock depends in part on the relative importance of the arrival of new information as well as on the accumulated information previously. A glass of water overflows not only because of the last drop of water, but because of the drops of water that have accumulated. Overconfidence feeds the BE process. When too much information is ignored (because financial agent react only to comforting news), the market gets into a high consensus state. Severe market disequilibrium (Boulding 1981) (Thom 1972.) (Nicolis 1977) are observed leading to the following extreme scenarios:

7. Market over-reaction: unable to disseminate the valuable info, the financial system triggers the bifurcation phenomenon (g hits a bifurcation point b2). A mean regressive force propels the returns back toward the mean after over-reaction to prior news (Nawrocki and Vaga 2012). The market restructures itself to improve the flow of information and the speed of dissemination to reach a stable comfortable disequilibrium condition a-b2-c3 that can ensure the system survival. In the case of the nonlinear dynamic financial system, this process obeys a power law and is exponential, so very abrupt.
8. Special not viable case c4: no or few information is disseminated; the markets fail to properly allocate financial resources. The disequilibrium becomes so severe that investors and borrowers refuse to participate in the market. This action by the participants threatens the survival of the market system.

At bifurcation time, overwhelming disequilibrium triggers large fluctuations as uncertainty about what has been missed is shaking the markets’ participants. Unable to assess the fundamentals, their view is blurred with no clearness about the trend ahead. In short, domino effects are observed where there are losses and

¹⁶ On a macroscopic scale, entropy is a function of thermodynamic variables (such as temperature, pressure, or composition). It is a measure of the energy that is not available for work during a thermodynamic process. A closed system evolves toward a state of maximum entropy.

¹⁷ In statistical mechanics, entropy is a measure of the randomness of the microscopic constituents of a thermodynamic system.

¹⁸ In cosmology, entropy is a hypothetical tendency for the universe to attain a state of maximum homogeneity in which all matter is at a uniform temperature, or a state known as “heat death”.

¹⁹ In data transmission and information theory, entropy is a measure of the loss of information in a transmitted signal or message.

bankruptcies. Consequently, uncertainty about the future reaches its maximum, volatility reaches new highs and correlations tend to 1.

Complexity occurs at the edge of chaos to invoke self-organization,²⁰ thus defining new structures insuring the survival of the financial system. In this process, the economic system evolves from a complex state to an even more complex one, after the disengagement, oscillating between equilibriums, the number of which increases exponentially. This phenomenon manifests itself through bifurcation; the market consensus is divided as uncertainty broadens. The market oscillates between several equilibriums, driven by uncertain perception, which is the predominant variable here. The entropy process takes into account all unstable subjective variables. At $t = B$ bifurcation point, the crucial indicators are the fundamental financial valuations which depend on economic parameters (the strange attractor) which are uncertain at this moment.²¹

9. Following the bifurcation, the market over-reacts and the entropy process takes over hastily. This is observed in Fig. 2.1 at point c2. It is a special point referring to Optimal Entropy. Full dissemination of information refers to maximum entropy, and occurs when the speed of information dissemination is infinite (Cozzolino 1973). Optimal entropy refers to optimal information dissemination limited to transactions and tax costs. It is the maximum entropy relaxed under finite speed conditions where no enough arbitrage opportunities are available and the state is close to a random walk. Once bifurcation is triggered in the system, the c2 point hit the optimal entropy level line that is the optimal equilibrium state following the abrupt (in intensity and hasty reaction time) increase in the speed of information dissemination. The market is then said to be effective. According to Nawrocki and Vaga working paper (David Nawrocki 2011).

...An efficient market occurs at the equilibrium points R_{bull} and R_{bear} . At these points the average conditional return is equal to zero and on a short-term basis, conditional returns fluctuate in a random walk around zero due to the new information arrival process. This is where there is no undisseminated information. The market neither over-reacts, nor under-reacts. It is neither mean regressive nor trend persistent at these dynamic equilibrium points, where conditional returns operate as a random walk in response to new information arrival (zero mean)...

Entropy depends on the probabilities of the microstates—the more microstates are available to the system, the greater the entropy. Opinions are divided about what should be the market fundamental value. Uncertainty is conditioned by the

²⁰ According to M. Barranger “Emerging behavior results from global interaction between the scale’s constituents, the combination of structure and emergence leads to self-organization” (Barranger 2000).

²¹ To determine the trajectory of a deterministic system, it is enough to know its initial position. For two different initial positions, there are two different trajectories. A system is chaotic if it amplifies, even a little, the initial difference, and attains freedom, however, limited, by its attractor. It is in this amplification of short durations that randomness is found.

ability to make future prediction. At this stage, the market follows a less biased random walk and uncertainty about the future trend poses a limit. The Hurst exponent moves closer to 0.5.

These differences are then amplified by subjective biased investor's perceptions. The increase in the microstate possibilities means more randomness; the more efficiently the information is integrated into the market prices, the smaller the difference between fundamental value and market price, but also means high uncertainty about the future trend of the financial market. This uncertainty is inherent to the interpretative or perception models. Note that the characteristic time B is unstable because it depends on the moment where the critical consensus level is reached and on the system's initial conditions. This is like the critical point in phase transition cited by Barranger (Barranger 2000), the place where long range correlations are most important. As with correlations, T varies according to circumstances and is a function of the attitudes of the market players and their perception of risk; as new categories of investors appear with each cycle; the degrees of aversion to risk also change. Accordingly, it is difficult to establish preset relations which would allow the forecasting of the occurrence of financial disengagement.²² Investors do not react in the same way; and when they do, an extreme consensus is reached. On top of that, we cannot accurately predict the reactions of individuals especially during periods of panic. The following are some of the indicators for the consensus level estimation:

- Volume strength analysis and market liquidity: an indication of the flow of money (energy) in or out of the market open system. Volume can validate²³ a price, infer liquidity, give weight to new information, and reveal convictions and market disparity.²⁴ In brief, if price changes reflect the average change in market expectations, trading volume reflects idiosyncratic reactions across all traders (Verrecchia 1991).
- Correlated/diversified investments horizons (liquidity shifts and portfolio turn-over levels).
- Correlation, volatility, and leverage level²⁵: The volatility index or the Fear index as its spike translates the Noah effect born from fear, market withdrawal, and consequent illiquidity. When volatility and correlation levels are too low; it is an indicator that the market is overleveraged and most of the time ignoring contrarian information. This is usually followed by a sudden rise to historical

²² Management techniques which are based on the analysis of fixed ratios, like the PER (Price earnings ratio), are often found to be too premature.

²³ Here, it is important to look out for the misrepresented current volume flows due to high-frequency trading (HFT) strategies such as tape trading (filter trading and momentum trading) and statistical trading (statistical arbitrage and technical trading). Volumes emanating from these strategies have to be deducted.

²⁴ For an in-depth analysis on volume, read Buff Dormeier *Investing with Volume Analysis* (Dormeier 2011).

²⁵ Ideas backed and found in (Bookstaber 2011), (Nawrocki and Vaga 2012), (Nawrocki 1984).

levels. Following bifurcation the market will be characterized by a mean jump process as well as non-stationary covariance process.

- Put to call ratio (open interest): This ratio is directly derived from options trading and is used by options traders around the world as a contrarian indicator of market sentiment. But it lacks over the counter (OTC) options.
- Three month volatility skew: for instance, it illustrates the fact that the implied volatility is higher as put options go deeper out of the money (strikes below current market levels). Volatility skew may reflect investors' fear of market crashes, which would cause them to bid up the prices of out of the money options.
- Volatility term structure: This indicates how the skew will respond to the passage of time and swings in the underlying values.
- Hedge funds net stance: This captures the difference between the proportion of hedge fund holdings in long and short positions. On 5 August, 2011, this stance was at 40 % long instead of a high of 70 %; during bear markets, it can fall to as low as the mid-teens.
- Tracking of funds and hedge funds leverage level to trace their level of engagement or disengagement.
- Borrowed shares: This is an indication of short selling. According to data compiled for Bloomberg by the London-based research firm, Data Explorers, borrowed shares have risen in August 2011 to 11.3 % of stock available for lending, from 9.5 % in January during the same year.
- Credit Default Swaps (CDS): When the price of a credit default swap goes up, it indicates investors' perceptions that default risks have risen.
- Bid-Ask Spreads of prices. Specially those of the debt market.
- Bond yields: Falling bond yields is an indicator that the economy is slowing down and trouble is ahead for stocks markets.
- Treasury market ...

Figure 2.2 summarizes the noisy chaos process.

*High volatility seems to destroy trend persistence. It is the critical temperature above which the dynamic disequilibrium ordered state vanishes and give way to a mean regressive state. **Indicators of correlated investment horizons consensus.²⁶

Portfolio turnover

Some management style rely less on momentum and shorter term drivers than other style types might. A level of portfolio turnover higher than expected indicates a shift to short-termism.

²⁶ As per Dr. Brock book (Brock 2012):

“it turns out that what matters to market prices and volatility is not merely that people's bets are wrong, but additionally how *correlated* their mistakes are. It is when most investors are wrong in the same direction that the greatest portfolio adjustments occur, and that prices change the most; for most everyone will either sell or buy, and the price swings accordingly... A classical example of a “correlated mistake” where bets on US house prices as late as 2006. Almost no one assigned high probability to the inconceivable 35 % drop in house prices that transpired. The market response was fast and furious”.

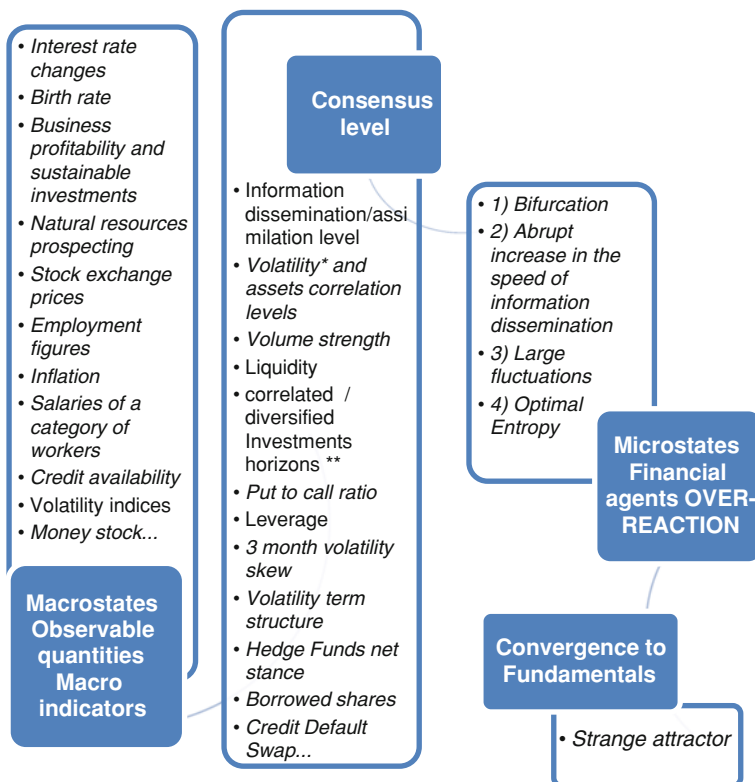


Fig. 2.2 Noisy Chaos (Consensus indicators align in the same outlook → maximum consensus is reached. Microstates start bifurcating into multiple opinions that is different probability spaces. This triggers collisions in market velocity, where reactions intensify as players ruminate their trade decisions; implying higher entropy and so higher uncertainty is observed)

- value managers
- large cap strategies
- (SRI) strategies

Liquidity shift

- Style type
- Equity life cycle (starts-up, star, cash cow, dog)
- Fixed income duration
- Hedge funds strategies flow (event vs. relative value)
- Private equities
- Mergers & acquisitions
- Safe heaven investments

Understanding market events and their effects on the market system is an essential element toward building a financial warning system. The key here is to

identify all pre-switching points (amplitudes magnitudes = max consensus or before, max entropy is too late); implement it in algos that can trigger a warning signal beforehand.

2.2.4 *The System Learns, Changes, and Converges*

The chaos theory refers to the identification of some order in the nonlinear dynamic process regulated by uncertainty. Order is observed when the system, although in a state of freedom, remains confined to its strange attractor. Freedom and uncertainty remain limited to the fractal nature of the series. Conversely, a series that follows a random walk has no particular shape; it evolves in the same way gas takes the shape of the container in which it is placed. These random series do not hold any correlation structure that would permit them to evolve while retaining their dimension, contrary to economic and financial series that do at different levels. Fractals retain their dimension in whatever space they evolve; In *Le Chaos*, Ekeland (1995), notes:

Admirable and subtle dosage of randomness and necessity! Resolved here in one blow is a whole army of false problems concerning human freedom in a deterministic universe. We don't see, as Laplace did, a free sky opening onto an infinite horizon, so clear that we have the impression that we can touch it. Nor is it an open sky, full of fog that catches our gaze and reveals to us the entire horizon. What we see are both together, like a sky full of rain, where the gusts of wind give us glimpses toward the horizons far away where the sun is shining. (p. 104)

As we are not in a closed system, entropy evolves from low to high levels and vice versa according to financial agents' perceptions. After the market collapse, investors' reaction to news and information is almost simultaneously integrated in the stock market. The main participants are the surviving professional investor, the gap between the fundamental value and the market price diminishes until the arrival of enough information to trigger again a new cycle. The market converges to its attractor, the macro fundamentals. Some period of time must elapse before we can identify the new tendency of the market and evaluate the new values for the L-stable process variables.

...A bifurcation parameter, which is related to the slope of the conditional return map in the neighborhood of moderate prior day returns, illustrates that the bifurcation dynamic may change over time. Therefore markets can be viewed as restructuring their information structure both on a short-term basis in response to volume and volatility and on a longer time scale as a function of changing market conditions such as the advent of negotiated commissions and computerized trading. (Nawrocki and Vaga 2012)

Beyond its characteristic time B, the financial system cannot be predicted with certainty but it still retains its fractal nature. The system attains a certain degree of freedom, a kind of complex system prevails after optimal bifurcation entropy (BE) has been reached, and during which it moves back toward its strange attractor.

Fractal theory allows us to uncover the dynamic that regulates the financial system which in turn allows us to identify the underlying processes including the L-stable process, entropy, and convergence. The concept of noisy chaos considers traditional approaches as cases of a more general dynamic approach. Today’s managers need to think beyond the classical paradigm. Their aim should be to achieve uniqueness and innovation, to survive in ever-changing financial markets, and to deliver performance through market cycles. As Oscar Wilde said:

Be yourself, everyone else is already taken

Subjective interpretations lead to economic and financial unpredictability. In the next chapter, we focus on the human behavior a critical variable of the financial process. The aim of chapter three is to be aware of the diversity of interpretations after the arrival of information in the market. Behavioral finance tries to group these different behaviors but that doesn’t mean that we can systematically and at all times be certain of market behavioral interpretation that we make. Each one of us ends up guessing according to his perception. Being aware of that allows us to build a shield layer against ourselves and consequently build a strategy while always estimating a margin of error.

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hayek kobeissi, y.

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