

A Financial Instruments Pricing Model as the physical two players problem^{*}

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State of the art (econophysics)

Nowadays simulation of the market pricing process is performed via taking an a priori given deterministic model and supplying it with a stochastic term(s)

Upon this, no physical justification on the choice of the model is provided

In doing so, the chance to guess the genuine model which would adequately describe the mechanism of real market pricing and hence possess permanent forecast strength is practically nil

Therefore, so far there is *no* physically justified statistical model which would provide an adequate description of the financial assets pricing dynamics¹

¹ R. Mantegna and H. Stanley, *Introduction to Econophysics: Correlations and Complexity in Finance*, Cambridge, Cambridge University Press, 2000

Our model

- Market pricing is considered as an open stochastic mechanical system
- The entire set of market agents is deemed as two macroscopic players (the “bull” and the “bear”), each “tugging” the price to the corresponding direction
- Market information that affects the price is likened to the energy introduced into the system

To find the law of dependence of the next price change Δx_{next} on the previous change Δx_{prev} , we formulate the original first principles:

- The more energy is required, the less probable the corresponding price change
- Price formation is being carried out simultaneously at diverse time scales

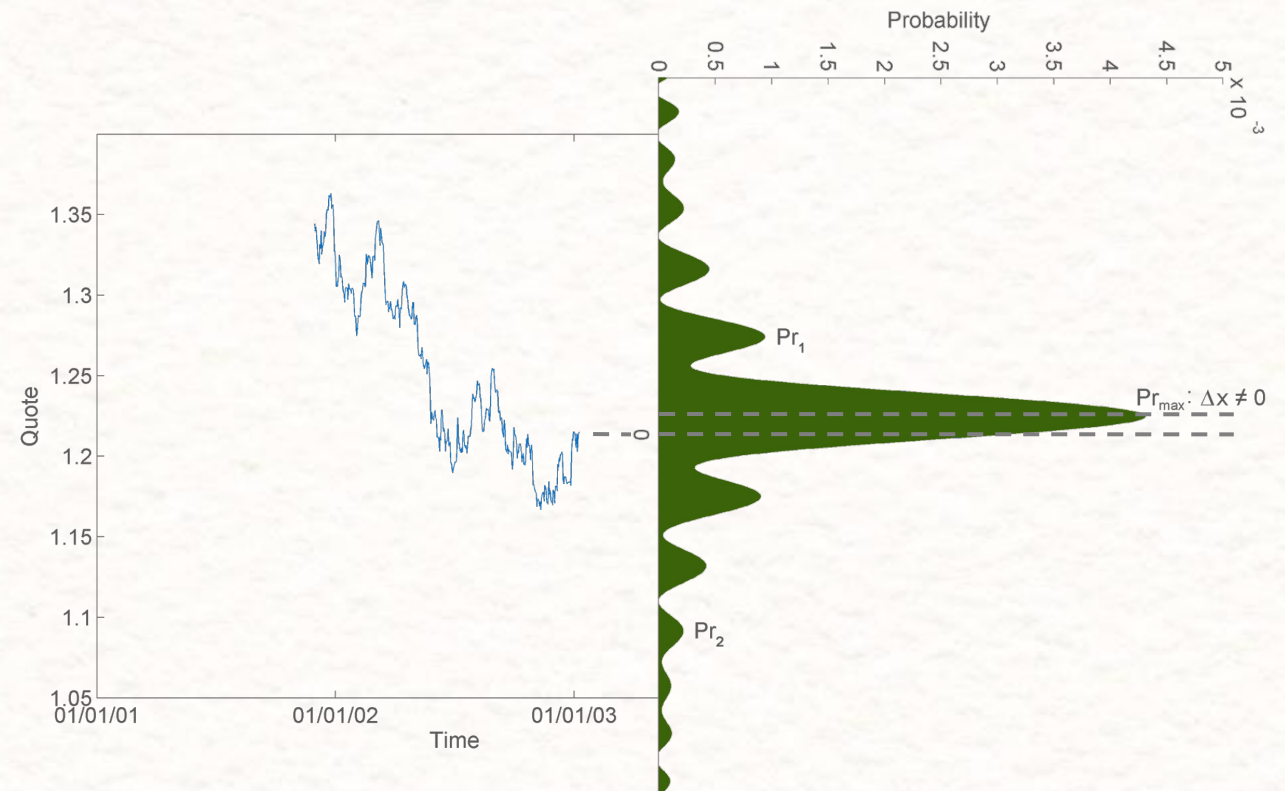
These yield a market pricing model as an original probability equation of motion having wave-like solutions

Why our model is superior

Our model possesses the properties evinced by real markets: it exhibits

- *fat tails*^{1, 2}
- *scalability*^{1, 2} to any time frame
- nonlinear “*market memory*”²

Besides, the asymmetry of the model’s wave-like solution* makes it possible to forecast not only the future volatility but also the direction of the price change



¹ R. Mantegna and H. Stanley, *Introduction to Econophysics: Correlations and Complexity in Finance*, Cambridge, Cambridge University Press, 2000

² B. Mandelbrot, *Fractals and Scaling in Finance*, N.Y., Springer, 1997

* The solution is shown smoothed: it conceals details to prevent reverse engineering

Our results

To check for the forecast strength, we have tested our model on real tick data over three years and artificial (random walk) data

The statistically significant skewness $\text{Fr}(\text{sgn } \Delta x_{\text{next}} \mid \Delta x_{\text{prev}}) - 50\%$ in the relative frequency of the right forecast of the direction of the future price change evinces that the model *detects a dependence* in the data

Similar results take place for minutely, hourly and daily quotes

Asset	$\text{Fr}(\text{sgn } \Delta x_{\text{next}} \mid \Delta x_{\text{prev}}) - 50\%$	
	original data	permuted data
EUR/USD ¹	1.32	0.00
Oil ²	2.26	-0.00
Gold ²	2.84	-0.01
Wheat ²	4.26	-0.05
Google ²	-1.10	-0.04
Apple ²	-1.48	0.04
Random walk	0.02	-0.04

Data source: ¹ Forex bank "Dukascopy", Switzerland (www.dukascopy.com)

² investment holding company "Finam", Russia (www.finam.ru)

Possible applications

A complete market pricing model based on the current prototype may be the basement for the following applications:

- Proprietary trading
- Estimation of market risks (e.g., value at risk, expected tail loss, etc.) and providing consulting services to financial institutions
- Creation of exchange-traded funds for the attraction of investments and subsequent portfolio management
- ?

What remains to do

The following tasks have yet to be completed to make the end-user product:

R&D stage:

- To supply the model with control parameters¹ which would make it possible to simulate the behaviour of financial assets of different types
- To determine the length of the market memory and the values of the control parameters for each particular asset forming the portfolio

Programming stage:

- To develop a software which would implement a set of auxiliary technical tools (real time market data flow, graphical user interface, etc.)

¹ H. Haken, *Information and Self-Organization: A Macroscopic Approach to Complex Systems*, Berlin, Springer, 2006

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