Exchange rate behaves like particles in a molecular fluid

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Scientists demonstrate parallels between activity on financial markets and the behaviour of bacteria under the microscope. Credit: Digital montage / Keystone

The swings in market prices and exchange rates have the same foundations as molecule movements in physics. This has been demonstrated by a team of scientists from Switzerland and Japan.

When scientists observe minute particles like nanoparticles or bacteria in fluid under a microscope, they don't see a motionless image. What they do see are particles making the tiniest irregular twitches not unlike the nervous ups-and-downs of market prices and exchange rates. These two forms of random twitching – microparticles in fluid and price

developments on the financial market – are not just similar at first sight as a Japanese-Swiss team has now demonstrated. The underlying mechanism is the same too.

Brownian motion, the name given by scientists to the microtwitching of particles in fluid, results from the impact of the universal thermal agitation of the individual molecules in the fluid. The renowned French mathematician Louis Bachelier observed back at the beginning of the 20th century that there were parallels between this random walk behavior and exchange rates. However, it is only now that Didier Sornette, Professor of Entrepreneurial Risks at ETH Zurich together with colleagues from Japan, has been able to demonstrate exact correlations between the two. The scientists have published their work in the reputed journal *Physical Review Letters*.

Stock exchange meets Einstein's theorem

"Microparticles are surrounded and moved around by the molecules in the fluid. Similarly, the price at which securities or currencies are traded on a financial market should not be examined in isolation either", explains Sornette. It is far more the case that this price is embedded at all times in a larger whole, in the total sum of buying and selling orders of stockbroker's clients. When the number of these orders is far higher than that of the actual transactions, many bids won't lead to any transactions. This is the case, for instance, when an interested party is only willing to pay a relatively low price for a security but no holder is willing to sell for such a low price. Or when someone wants to sell a security for a relatively high price but can't find a buyer.

Exchange rates and bids influence each other – spurred on by the ongoing efforts of all market players to make a profit by exploiting the differences in the prices. This means that the order book of stockbrokers is in constant motion. "This – dynamic – behaviour of all orders is

comparable to the physical behaviour and influence of fluids on a Brownian particle, in the sense that the dynamics of the order book influences the observed transaction price in a precise way ", says Sornette.

The scientists checked their theory against available market data. To this end, they used the data of a global brokering company on the dollar-yen exchange rate. They were, for instance, able to demonstrate that the totality of orders for the buying and selling of the two currencies even met one of the most important theorems of statistical physics, the fluctuation-dissipation theorem that was developed by Albert Einstein in 1905, and still is a very active domain of research for its many applications.

More information: Yura Y, Takayasu H, Sornette D, Takayasu M: Financial Brownian Particle in the Layered Order-Book Fluid and Fluctuation-Dissipation Relations. *Physical Review Letters*, 2014, 112: 098703, DOI: 10.1103/PhysRevLett.112.098703

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