Passing trade

Perhaps nothing in science is as delightful as learning that seemingly unique phenomena are actually the same, or nearly so; that the differences are superficial. Visible light, radio waves and X-rays are all just electricity and magnetism. The pleasure comes, I suppose, in realizing that the world is simpler than it outwardly seems.

We've come to have deep faith in finding this kind of simplicity. As physicist Bernd Matthias once expressed it, "If you see a formula in the *Physical Review* that extends over a quarter of a page, forget it. It's wrong. Nature isn't that complicated."

Every day in financial markets around the globe, people buy and sell a vast range of financial instruments. Nothing in the spectrum of human activity looks quite as chaotic. Yet we keep finding hints that behind the chaos may lie a fairly simple mechanical process. The latest hint comes from studies of the detailed mechanism by which markets actually operate — the so-called continuous double auction.

In most markets, people or firms place orders to buy or sell stocks or other financial instruments into an 'order book', a kind of registry. An algorithm then tries to execute these orders in pairs, whenever their prices match. If an order to sell at $100 or higher coexists with an order to buy at $100 or less, then the transaction happens and these orders disappear. At any moment, the order book typically has a number of sell orders at higher prices, buy orders at lower prices, and a gap between — the 'bid–ask spread'. Orders remain in the book until finding a match or until they get cancelled.

Obviously, a world of real economic activity and human psychology lies behind the two streams of orders to buy or sell, and most economists and traders believe such factors drive the markets and account for their rich dynamics — their unpredictability, susceptibility to large fluctuations, as well as frequent sustained rallies, crashes and bubbles. But there's another possibility.

Imagine a long corridor with streams of people walking in opposite directions. They meet in the centre where they pass through a narrow doorway. This situation arises in train stations, airports and office buildings, and interesting things happen at the doorway, which acts as a bottleneck. Researchers have found in experiments and computer simulations that the flow of people through the bottleneck doesn't settle down

The dynamics of the order book looks like those of two streams of people passing through a narrow corridor.

to some steady state, but rather fluctuates erratically, the flow sometimes jamming and at others flowing freely. Much the same thing happens again for interfering flows of particles such as grains of sand or salt.

The precise nature of these fluctuations is rather special — they show pretty much all the rich features of price fluctuations in financial markets. That seems bizarre, yet perhaps makes sense if we think that the order book brings together two streams of buy and sell orders that meet and trigger transactions in a narrow window of prices. Could much of market dynamics simply arise from two streams of orders getting jammed up as they try to pass through a constricting barrier?

The idea — proposed recently by physicist Daniel Parisi and colleagues (http://arxiv.org/abs/1205.2915; 2012) — looks like more than a curiosity. In the order book, orders don't actually flow, but there is movement as investors issue and cancel orders, seeking the best price, and frequently crossing the bid–ask interval to make a transaction. Any crossing order immediately finds a match and executes. This really is like the two streams of counterflowing people.

The resulting dynamics take a central place in a new theory of how markets work, and more specifically on what controls market liquidity — the ease of trading. Economists for many years have argued that information about the real values of stocks and other things should flow rapidly into markets as people gather information and use it to trade for profit. If a big investor gets a tip on a lucrative new drug, they'll buy up the inventing firm's stock, raising its price. As the information spreads rapidly, the stock price will go higher, soon coming to reflect the new realistic value of the firm with their new drug.

But this story doesn't quite make sense — because people with valuable information don't actually want to share it so freely. Indeed, trying to buy up a lot of stock has the unfortunate (for the buyer) effect of raising its price. A buyer desiring 10,000 shares may pay one price for the first thousand, but will pay progressively higher prices for the rest. This is a simple consequence of a big order eating into the order book, going to higher prices, to find sell orders making up 10,000 shares. Sensing this big-buy pressure, other traders may also adjust their sell orders, moving them to higher prices. Because of this 'price impact', traders making large trades try to break them up and hide them in a series of smaller trades, thereby minimizing the impact.

The result, as physicist Bence Toth and colleagues have argued (http://arxiv.org/abs/1105.1694; 2011), is that the actual buy and sell orders resting in the order book play the role of 'probes' or 'feelers' that detect and register trading demand, making information reveal itself. These represent only a tiny fraction of the actual demand for buying and selling, most of which remains latent and unexpressed in the minds of market participants. One direct consequence, Toth and colleagues argue, is that the dynamics of the order book looks much like those of the two streams of people passing through a narrow corridor, where free space for passage is always in critical supply. The role of the door in this case is played by a sparsity of buy or sell orders near the best price, so price-conscious traders have precious few orders waiting to conduct their trades.

This perspective explains, among other things, why the price impact (change in price) caused by trade varies empirically as the square root of the trade volume (number of shares). This isn't obvious, but comes out of a theory in which this kind of two-stream collision takes place. An implication is that the marginal impact, on a per-share basis, becomes infinite in the limit of small trades. The interpretation proposed by Toth *et al.* is that the market is poised at a kind of critical point of vanishing liquidity — that is, standing buy or sell order availability — because traders actually hoard information rather than expressing it.

The really interesting things is that both effects seem driven by the jamming of a flow, either in real space or in one rather more abstract. At the root of market dynamics, we again find geometry. Who'd have thought that. ❐

MARK BUCHANAN