

## Adaptive markets: financial evolution at the speed of thought by Andrew Lo

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Andrew Lo has never been afraid to challenge conventional thinking. *Adaptive Markets* is a brave, majestic and ambitious book that both challenges the conventional foundations of finance and economics. Lo's iconoclastic, courageous intellect, his serious scholarship, and his gift for explaining complex ideas with simplicity and grace are evident on all 420 pages. It is thus a must read not just for financial economists, but for all who want to understand the power and the shortcomings of financial markets.

Full disclosure: I'm an Andrew Lo fan. When setting up the Office of Financial Research, I recruited him to serve on the OFR Financial Research Advisory Committee. In fact, he co-authored the first OFR working paper, a path-breaking catalogue of 31 financial stability indicators, which he presented at the first OFR-FSOC Financial Stability Conference. I nonetheless tried to be completely objective in reviewing *Adaptive Markets*. And I have tried to show how Andrew Lo's ideas helped us—and hopefully will continue to help—to make the financial system more resilient.

Using the powerful metaphor of biological evolution, in *Adaptive Markets* Lo shows how, far from following the widely accepted finance paradigm of being static, rational, resilient, self-correcting and efficient, financial markets are constantly evolving in response to changing circumstances, can be prone to panics, are inherently fragile and are full of asymmetries and inefficiencies.

In contrast, the conventional paradigm is comfortably familiar, amenable to closed form, micro-founded

modeling and conclusions. Promoted by Eugene Fama as the Efficient Markets Hypothesis, asset prices in this paradigm fully reflect all available information. Further articulated in Burton Malkiel's (1973) *A Random Walk Down Wall Street*, in this world investors can't beat the market. That markets are rational is assured by assuming that rational *Homo economicus*, Economic man, possesses expectations based on economic (and financial) equilibrium. Efficient markets are also resilient; random shocks may produce only temporary deviations, from which equilibrating forces permit only fleeting buying or selling opportunities.

Now, the conventional paradigm has produced extraordinarily useful ideas, which Lo highlights up front. For example, Jack Bogle's implementation of them spawned mutual funds that follow market-wide stock price indexes that offer efficient diversification at low cost—like an S&P500 index fund. The power of markets to allocate resources and solve problems sets the pulse racing, even for veteran economists. Indeed, good policymaking often seeks to harness market discipline to produce favorable outcomes for both individuals and society. But as Lo concludes at the end of Chap. 1, "So what are members of *Homo economicus* to make of the savings and loan crisis of the 1980s and 1990s, the Internet bubble, the financial crisis of [2007–2009], and all the dumb economic decisions that we make every day?"

Andrew Lo obviously isn't the first to try to answer that question, and he takes us on a journey through the history of financial economics to explain this evolution, starting with Keynesian animal spirits. In "Prospect Theory: An Analysis of Decision Under Risk," Daniel Kahneman and Amos Tversky showed that people often use rules of thumb rather than optimizing, rational calculus. Richard Thaler, who created behavioral economics and finance, showed

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that people depart from rationality in consistent ways, so their behavior can still be anticipated and modeled. George Akerlof and Robert Shiller in *Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism* describe how information asymmetry, adverse selection and moral hazard can erode confidence and trust and contribute to market failure or even financial crisis.

Notice a common theme? Lo quickly does: Far from destroying rationality, he sees that all of these thinkers embrace adding psychology and emotion to cold rationality to understand how humans, as opposed to *Homo economicus*, make decisions. When information is complete, symmetric, and the game is fair so the odds can be calculated, rationality can dominate. In contrast, when sellers have more information than buyers, or when Knightian uncertainty rules, in Lo's words, "Human nature simply doesn't allow us to view uncertainty with indifference. Fortune favors the brave, and market prices reflect our innate tendency to avoid uncertainty."

But it's not enough to simply add psychology and emotion to the mix. *Why* is losing more painful than winning is pleasurable? Lo takes us on another journey, this time through psychology and neuroscience to help understand the tension between rational and behavioral. Far from being destructive, that tension is basic for survival; as Lo explains: "to be fully rational, we need emotion." Fear may instinctively prevent us from embracing risk, but it also teaches us how to learn from the environment *and adapt to it*.

One useful example of adaptation in the recent finance literature is in the learning model of Kozlowski, Veldkamp and Venkatasawaran. They outline a "simple theory about how agents form beliefs about the probability of rare, tail, events"; specifically, they show how the financial crisis persistently changed beliefs about the distribution of future financial and economic outcomes, depressing interest rates.

As important as adaptation is for individuals, it is critically important for species and societies. In Lo's words, "We can use our brains to test ideas in mental models, and to reshape them if they are found lacking. *This is still a form of evolution, but it is evolution at the speed of thought.*"

In Lo's view, what applies to species and societies also applies to markets, which reflect our behavior and the governance we apply to make markets work. With the Adaptive Markets Hypothesis (AMH), Lo thus stands on the shoulders of the giants mentioned above to extend our vision of how markets evolve, succeed, and fail. Five principles matter:

1. We humans possess features and behavior that are shaped by evolutionary forces, and are neither always rational nor irrational
2. While we are biased and can make poor decisions, we can learn from experience.
3. We can analyze alternatives and blend experience with abstract reasoning to adapt to our environment
4. Our interactions in society, markets, and other environments shape their dynamics and evolution
5. Survival drives competition, innovation, and adaptation.

Lo is quick to acknowledge that he also stands on the shoulders of other giants who have analyzed economic evolution, like Malthus, Veblen, Schumpeter and others. Moreover, he asserts that "An efficient market is simply the steady-state limit of a market in an unchanging financial environment." The EMH is just a special case of the AMH. Brilliant, but is that closure?

No, that's far from the end of the story. The true test of any theory is how well it explains reality, and whether it can be operationalized. No one knows this better than Andy Lo, who puts his money on the line as the founder of a hedge fund.

Beyond portfolio management, the principles and beliefs outlined by Lo shape modern techniques of risk management. Today, chief risk officers understand that the workhorse tool for assessing worst-case scenarios—Value at Risk (VaR)—can be helpful or misleading. Standard VaR models depend on contemporaneous volatility (e.g., no autocorrelation); they cover only local price moves and may not capture correlations across a firm's portfolio; and do not differentiate among the liquidity of market risk factors. But the AMH can help improve VaR by considering the implications of today's volatility for tomorrow's returns, to look more broadly, and to add adjustments for liquidity. Risk management is influenced by risk attitude and behavior, so best practices must also include advance agreement on risk appetite that ties risk managers to the mast when the sirens of risk are singing loudly. Taking a longer look back and forward, doing stress tests through regime changes, considering whether the risk-mitigating actions of other firms are potentially procyclical and improving the dialogue with supervisors all can help adapt to the environment.

Related, the AMH adds to our understanding of the volatility paradox. In the traditional model, declining volatility, interest rate spreads, CDS spreads, and repo haircuts are signs of declining financial market risks. But the opposite is true: These developments most often signal rising market risks, because they give investors and risk managers incentives and wherewithal to take on leverage. Risk managers and policymakers thus now understand that



volatility and leverage are co-determined and are *procyclical*; that is, together, they amplify the impact of shocks. The mechanism, to be specific, is that declining volatility reduces the cost of taking on more leverage and furthers a buildup of risk. The lesson: Risk managers must resist the temptation to sell volatility when it is low and falling. The AMH implicitly embraces modeling such behavior with heterogeneous agents that use heuristics.

In addition, markets and the institutions that comprise them are influenced by the norms and governance we adopt to assure their functioning. The law and the system of financial regulation that derives from it must also be adaptive, in Lo's view, and he explores the feedback loops that should be strengthened to accelerate change. Some can be wired into regulations directly, for example, to mitigate procyclicality, policymakers may use tools to lean against the leverage-volatility wind by increasing the cost of risk. Among them: the countercyclical capital buffer, and the Financial Stability Board's recommended system of collateral haircut floors for non-centrally cleared securities financing transactions. In any case, it is essential to recognize the way that changes in regulation will induce changes in firms' business models and in the structure of financial markets that may influence their functioning, especially under stress.

To better assess such issues, Lo recommends that forensic analysis would be helpful to understand, learn from and change the behavior leading to financial blowups; in effect, creating the National Transportation Safety Board of finance. Lo sees the same challenges with this suggestion that I do: The independent NTSB is supposed to critique failures; financial regulators are less likely to criticize their own failures. Our balkanized regulatory system creates coordination problems even in the forensic assessment of systemic failures.

If Lo's paradigm seems complicated, uncomfortable and uncertain, it's worth remembering that he intends it to help tackle and solve truly consequential problems like poverty, cancer (using cancer bonds, securities that pool the risk of investing in a portfolio of uncertain therapies), and climate change. I think you can see its influence in work by three leading proponents of innovative approaches to climate change: Bill Nordhaus of Yale, winner of the 2018 Nobel Prize in economics, Bob Litterman, former Chief Risk

Officer at Goldman, Sachs, and Rob Engle, my colleague at Stern, and his coauthors.

You might complain that the Adaptive Markets Hypothesis is incomplete. You would be right. In fact, that's by design. What appears to be a shortcoming is really a strength: The flexibility to evolve and adapt to changing circumstances, often unforeseen.

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