Chaos theory economics pdf

Preview Preview View PDFVolume 119, 2017, Pages 368-375 rights and content LAWRENCE — Jeff Goldblum’s character in “Jurassic Park” famously popularized the concept of chaos theory as it relates to science. But one University of Kansas professor is applying that theory to the economy. William Barnett, the Oswald Distinguished Professor of Macroeconomics, has co-written “Shilnikov Chaos, Low Interest Rates, and New Keynesian Macroeconomics.” The research paper argues that an active monetary policy, using feedback to interest rates, may introduce a chaotic attractor, initiating long-term unpredictability in financial markets. “The puzzling decline in nominal and real interest rates over the past 20 years may not have been intentional,” Barnett said. “By attaching a Taylor interest-rate feedback rule to the macro economy’s dynamics, the central bank inadvertently bifurcated the economy into Shilnikov chaos — which we have shown can produce drift of interest rates down to below their natural rate.” Those familiar with “Jurassic Park” likely understand how chaos applies to the natural sciences, causing solution paths to wander in unplanned directions. “In ‘Jurassic Park,’ dinosaurs unintentionally got out of control. That’s possible from one kind of chaos. There could be another kind of chaos, which can do the opposite. It could cause the extinction of the dinosaurs. So that movie was assuming the existence of a particular kind of chaos, which had a very negative consequence,” he said. But Shilnikov chaos (named for Russian mathematician Leonid Shilnikov) generates its own distinct kind of dynamical drift. “We have found it can cause interest rates inadvertently to decline, even if not intended by the Federal Reserve,” Barnett said. The KU professor explained that people often confuse this with something called catastrophe theory. “In mathematics, catastrophe theory produces discontinuous jumps in solution paths. Chaos doesn’t do that. It just produces jiggly, stochastic-appearing solutions that are not smooth — such as the weather, which is chaotic, never converges to a steady state and is not perfectly predictable,” he said. Although the concept may be tricky to grasp, the outcome is quite tangible. He said, “There is much concern in the media about what central banks throughout the world will do the next time there is a recession. Central banks try to offset recessions by lowering interest rates. But if those rates are near zero at the so-called lower bound, called the ‘liquidity trap’ by economists, it’s not clear that the bank’s normal policy instruments can deal with the consequences of another recession.” This research not only provides an explanation of a source of the problem but also proposes solutions. Barnett co-wrote the paper with four other economists. While collaboration is typical for a project of this sort, the way in which it was accomplished proved rather unique. Three of the researchers — Giovanni Bella, Paolo Mattana and Beatrice Venturi — are based in Italy. Taniya Ghosh, a former KU doctoral student of Barnett’s, works in India. “My correspondence with the Italians goes back and forth through Taniya,” Barnett said. “It’s an unusual way to do research, but surprisingly it’s been working out very well in a very cooperative manner.” In fact, some of the paper’s revisions were suggested by Andrey Shilnikov, son of the mathematician upon whose theory the research is based. A native of Boston, Barnett was originally a scientist for Rocketdyne, a Los Angeles company that created rocket engines for the Apollo program. “Chaos in nonlinear dynamics were very important to us when we were trying to understand what was going on with rocket engines on test stands,” he said. He then spent eight years on staff of the Federal Reserve Board in Washington, D.C. He said this introduced a personal interest in his subsequent research as to why the board’s policy “seems to have had unintended consequences in recent years.” Barnett has worked at KU for the past 16 years as an expert in econometrics and macroeconomics. He is founder and editor of the Cambridge University Press journal Macroeconomic Dynamics and the Emerald Press monograph series International Symposia in Economic Theory and Econometrics. Barnett founded the Society for Economic Measurement and served as its first president. Additionally, he is director of the Advances in Monetary and Financial Measurement program at the Center for Financial Stability in NYC. He is also the namesake of the “Barnett critique.” “To produce monetary aggregates, many central banks just add up imperfect substitutes without weights — such as currency, demand deposits, passbook accounts and certificates of deposit — despite the fact they contribute different amounts of liquidity to the economy. For example, currency produces much more liquidity than non-negotiable certificates of deposit. The Barnett critique says using those added-up data creates the appearance of instability of the demand for money function, when in fact, the economy’s structure, including the important demand for money function, is not necessarily unstable,” he said, noting that the Bank of England has officially adopted his Divisia monetary aggregates. Barnett hopes his “Shilnikov Chaos” paper will also generate real-world adjustments. “I would like economists to take more seriously what is known as systems theory by physicists, engineers and mathematicians,” he said. “Clearer comprehension of systems theory would produce more sophisticated understandings of how best to conduct policy in Washington, D.C.” Top photo: iStock Chaos theory is a complicated mathematical theory that seeks to explain the effect of seemingly insignificant factors. Chaos theory is considered by some to explain chaotic or random occurrences, and the theory is often applied to financial markets as well as other complex systems such as predicting the weather. Chaotic systems are predictable for a while and then appear to become random. The first real experiment in chaos theory was conducted by a meteorologist, Edward Lorenz. Lorenz worked with a system of equations to predict the weather. In 1961, Lorenz wanted to recreate a past weather sequence using a computer model based on 12 variables including wind speed and temperature. These variables, or values, were graphed with lines that rose and fell over time. Lorenz was repeating an earlier simulation in 1961. However, on this day, Lorenz rounded his variable values to just three decimal places instead of six. This tiny change drastically transformed the whole pattern of two months of simulated weather. Thus, Lorenz proved that seemingly insignificant factors can have a huge effect on the overall outcome. Chaos theory explores the effects of small occurrences that can dramatically affect the results of seemingly unrelated events. There are two common fallacies about stock markets. One is based on classical economic theory and claims that markets are 100 percent efficient and unpredictable. The other theory is that markets are, at some level, predictable. Otherwise, how do big trading houses and investors consistently make profits? The truth is that markets are complex and chaotic systems and their behavior has both systemic and random components. Stock market forecasts can be precise only to a certain extent. As Lorenz proved, complex chaotic systems are vulnerable to minor changes, and these can disrupt a system, pushing it far away from its equilibrium. Market system dynamics can be described as two basic feedback and causal loops that influence various aspects of the stock market. A positive feedback loop is self-reinforcing. For example, a positive effect in one variable increases the other variable, which, in turn, also increases the first variable. This leads to exponential growth in the system, moving it out of its equilibrium and eventually leading to a collapse of the system (a bubble). Conversely, a negative feedback loop has a similar effect, the system responds to a change in the opposite direction. Periods with high uncertainty may not be caused just by system dynamics. Environmental factors such as natural disasters, earthquakes, or floods can also cause markets to be volatile as can sudden drops in a single stock. In finance, chaos theory argues that price is the last thing to change for a security. Using chaos theory, a change in price is determined through mathematical predictions of the following factors: a trader's personal motivations (such as doubt, desire, or hope, all of which are nonlinear and complex), changes in volume, the acceleration of changes, and momentum behind the changes. While some theorists maintain that chaos theory can help investors boost their performance, the application of chaos theory to finance remains controversial. The hottest new topic in mathematics, physics, and allied sciences is "chaos theory." It is radical in its implications, but no one can accuse its practitioners of being anti- mathematical, since its highly complex math, including advanced computer graphics, is on the cutting edge of mathematical theory.In a deep sense, chaos theory is a reaction against the effort, hype, and funding that have, for many decades, been poured into such fashionable topics as going ever deeper inside the nucleus of the atom, or ever further out in astronomical speculation. Chaos theory returns scientific focus, at long last, to the real "microscopic" world with which we are all familiar.It is fitting that chaos theory got its start in the humble but frustrating field of meteorology. Why does it seem impossible for all our hot-shot meteorologists, armed as they are with ever more efficient computers and ever greater masses of data, to predict the weather?Two decades ago, Edward Lorenz, a meteorologist at MIT stumbled onto chaos theory by making the discovery that ever so tiny changes in climate could bring about enormous and volatile changes in weather. Calling it the Butterfly Effect, he pointed out that if a butterfly flapped its wings in Brazil, it could well produce a tornado in Texas.Since then, the discovery that small, unpredictable causes could have dramatic and turbulent effects has been expanded into other, seemingly unconnected, realms of science.The conclusion, for the weather and for many other aspects of the world, is that the weather, in principle, cannot be predicted successfully, no matter how much data is accumulated for our computers. This is not really "chaos" since the Butterfly Effect does have its own causal patterns, albeit very complex. (Many of these causal patterns follow what is known as "Feigenbaum's Number.")But even if these patterns become known, who in the world can predict the arrival of a flapping butterfly?The upshot of chaos theory is not that the real world is chaotic or in principle unpredictable or undetermined, but that in practice much of it is unpredictable. And in particular that mathematical tools such as the calculus, which assumes smooth surfaces and infinitesimally small steps, is deeply flawed in dealing with much of the real world. (Thus, Benoit Mandelbrot's "fractals" indicate that smooth curves are inappropriate and misleading for modeling coastlines or geographic surfaces.)Chaos theory is even more challenging when applied to human events such as the workings of the stock market. Here the chaos theorists have directly challenged orthodox neoclassical theory of the stock market, which assumes that the expectations of the market are "rational," that is, are omniscient about the future. If all stock or commodity market prices perfectly discount and incorporate perfect knowledge of the future, then the patterns of stock market prices must be purely accidental, meaningless, and random ("random walk"), since all the underlying basic knowledge is already known and incorporated into the price.The absurdity of believing that the market is omniscient about the future, or that it has perfect knowledge of all "probability distributions" of the future, is matched by the equal folly of assuming that all happenings on the real stock market are "random," that is, that no one stock price is related to any other price, past or future. And yet a crucial fact of human history is that all historical events are interconnected, that cause and effect patterns permeate human events, that very little is homogeneous, and that nothing is random.With their enormous prestige, the chaos theorists have done important work in denouncing these assumptions, and in rebuking any attempt to abstract statistically from the actual concrete events of the real world. Thus, the chaos theorists are opposed to the common statistical technique of "smoothing out" the data by taking twelve-month moving averages of monthly data-whether of prices, production, or employment. In attempting to eliminate jagged "random elements" and separate them out from alleged underlying patterns, orthodox statisticians have been unwittingly getting rid of the very real-world data that need to be examined.These are but a few of the subversive implications that chaos science offers for orthodox mathematical economics. For if rational expectations theory violates the real world, then so too does general equilibrium, the use of the calculus in assuming infinitesimally small steps, perfect knowledge, and all the rest of the elaborate neoclassical apparatus.The neoclassicals have for a long while employed their knowledge of math and their use of advanced mathematical techniques as a bludgeon to discredit Austrians; now comes the most advanced mathematical theorists to replicate, unwittingly, some of the searching Austrian critiques of the unreality and distortions of orthodox neoclassical economics.In the current mathematical pecking order, fractals, non-linear thermodynamics, the Feigenbaum number, and all the rest rank far higher than the old-fashioned techniques of the neo-classicals.This does not mean that all the philosophical claims for chaos theory must be swallowed whole—in particular, the assertions of some of the theorists that nature is undetermined, or even that atoms or molecules possess "free will." But Austrians can hail the chaos theorists in their invigorating assault on orthodox mathematical economics from within.

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