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## NEWTON'S APPLE, LORENZ'S COFFEE AND COMPLEXITY!

*"I can calculate the motion of heavenly bodies, but not the madness of people"*

*— Isaac Newton*

In 1665, London suffered an outbreak of the bubonic plague, which led to a lot of people leaving the city (social distancing!). Among them was a young man, Isaac Newton, who moved to his childhood home in Woolsthorpe Manor. One day, while in an orchard, an apple falling on the ground got him pondering and ultimately led to the formulation of the laws of motion. These laws had a profound impact on science for centuries and gave birth to the concept of 'determinism.' One could use these laws to precisely forecast the movement of not only large heavenly bodies but also of the smallest atoms, from the information about their initial conditions. Essentially, it was believed that the universe was one giant mathematical machine whose movements can be accurately calculated.

### THE COFFEE

Fast forward almost 300 years. In 1961, Edward Lorenz, an American mathematician and meteorologist, was working as a researcher at MIT. Lorenz entered atmospheric data in the computer to process it using certain equations that provided weather forecasts. One particular set of data caught his eye and he decided to reprint the calculation. To save time, he took the data from the earlier printout and input that data into the computer, for the computer to start the processing from midway. He started the simulation and left for a coffee break. On his return, he was surprised to see the second run had produced a different forecast from the first despite the same input. At first, he thought the computer was malfunctioning. However,

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he later realized that, though the computer stored data up to sixth decimal place, it printed only till the third decimal. Hence when Lorenz had input the data, the second run of the process started with a small rounding error. Lorenz discovered that even a slight change in the initial condition could produce wildly different results. Even when the differences were narrowed, the range of output was quite wide. One had to be absolutely precise about all the input parameters to make accurate predictions. Such precision was humanly impossible to achieve. While presenting this phenomenon in a conference in 1972, he used the title “Predictions: Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?”. This study later came to be known as the “Butterfly Effect” or “Deterministic Chaos”. These experiments showed the vulnerability of standard theory when used for making predictions in a complex system.

## PHYSICS ENVY

Max Plank, a Nobel Prize winner in Physics once told Economist John Maynard Keynes that he had once considered going into economics, but he decided against it because – it was too difficult. “Too Difficult” for a person who was responsible for the development of quantum physics! People also remember Newton losing his wealth in the South Sea bubble and exclaiming that “he can calculate the motions of heavenly bodies but not the madness of people”. Most physicists were obviously referring to the difficulty of forecasting human behavior. Under this context, it seems surprising that economics suffered what is called a “Physics Envy”. Physics has been regarded as a model of what science should be. It is high on quantitative specification, causal understanding and mathematical sharpness. Neo-classical economists in the 20th century have strived to provide mathematical models for the discipline that seem precise. They have endeavored to provide accurate cause and effect models like physics. To make the models amenable to mathematics, a lot of assumptions, like rational behavior, perfect knowledge etc. were built into the models. The approach also involved reductionism; breaking down complex phenomena into smaller components and studying them under “Ceteris Paribus” (other things being equal). Like physics, economics chased equilibrium for analytical convenience. For example: when a hot iron bar is put in cold water, the heat is exchanged to the point where the temperature of

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both items is same, and an equilibrium is reached. Economics tries to reach the same kind of equilibrium: say in an interaction between demand and supply curves. Unfortunately, this super structure, though seemingly rational and beautiful in its construct, provides a distorted picture of reality.

## **COMPLEXITY ECONOMICS**

In 1988 (sixteen years after Lorenz presented his observations), the Santa Fe Institute (SFI) put together a research program on exploring complexity within economics. The program was led by W. Brian Arthur, an economist from Stanford, who later became one of the prominent complexity thinkers and coined the term “complexity economics”. He has also written several research papers and books on the subject. Complexity economics is the study of economic systems as complex systems. Complex systems are systems which consist of interacting individuals that change their actions and strategies in response to the outcome they mutually create. The interest in complexity economics picked up after the 2008 financial crisis. People challenged the workings of the markets as defined by neo-classical economics and started using ideas from complexity theory.

Complexity economics uses inputs from other sciences and social sciences to put together a new framework of economics with more realistic assumptions. It studies non-equilibrium and regards the conditions of equilibrium as an exception. Hence Complexity economics sees the economy as being in motion, perpetually computing itself – perpetually constructing itself anew. The reasons for non-equilibrium being the base condition are:

### **➤ Fundamental Uncertainty**

Unlike neo-classical economics, complexity economics does not assume perfect knowledge. In the real world, all economic agents (firms, consumers, investors) must deal with forthcoming uncertainties and form subjective beliefs about them. They also have to form subjective beliefs about subjective beliefs of other participants (much like the Keynesian beauty contest problem).

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### ➤ Technology disruption

The economy and the businesses must keep pace with new technological developments. The rate of change in technology has been accelerating and hence it keeps the economy in a permanent state of disruption.

### ➤ Feedback Loop (Reflexivity)

Like we discussed in one of the earlier issues ([read here](#)), trends have feedback loops which are either self-reinforcing or self-correcting. Neo classical economics takes only the impact of self-correcting trends (negative feedbacks). Self-reinforcing (or Positive feedbacks) in fact are very much a defining property of complex systems. If a system contains only negative feedbacks (in economics – diminishing returns) it quickly converges to equilibrium. However, in reality, there is ample evidence of self-reinforcing trends.

### ➤ Interconnectedness

Interconnectedness leads to the snowball effect. If a bank is under stress, it passes that stress to the other banks connected with it, who in turn pass the stress further. Like the experience of Non-Banking Finance Companies (NBFCs) in India in last quarter of CY18, changes in one part of the economy can get transmitted to others if the system is closely interconnected. This breeds high volatility and keep the economy in constant state of flux.

## A BUDDING AREA OF RESEARCH

Complexity economics is a relatively new area of research as it takes a realistic view of the world. Investors have to accept this complexity to forecast better and to generate superior returns. Standard finance theory has its roots in neo classical economics and hence assumes perfect knowledge, rational behavior, mathematical cause-effect relationships and absence of boom-bust cycle. In practice, we see more complexity and chaos. Normal distribution curves form the foundation of the economic and financial models; however, empirical data shows fat tails and non-linearity. The efficient market hypothesis says small deviations get cancelled out. Complexity says there is a butterfly effect!

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**ABOUT STOIC INVESTOR:**

*The word “Stoic” is used to describe someone who remains calm under pressure and avoids emotional extremes. For the purpose of this newsletter we refer to the “Stoic investor” as an investor who is realist (avoiding extreme optimism and extreme pessimism), resilient (withstand difficult conditions) and rational (who acts with logic and reason).*

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