'Invisible hand' that drives the economy

ECONOMIC PROCESSES AND THE PROSPERITY OF COUNTRIES HAVE BEEN LIKENED TO THERMODYNAMIC SYSTEMS, SAYS **S ANANTHANARAYAN**

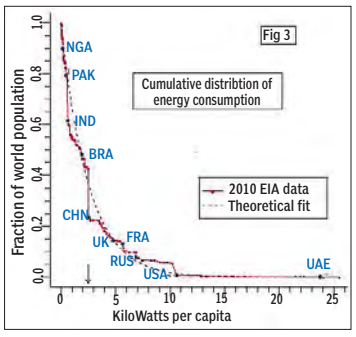
Adam Smith, the 18th century father of modern economics, said that there was an "invisible hand" that guided players in a market, always seeking their own gain, to act, nevertheless, in a way that led to a better distribution of goods and better prices for the consumer than any effort specifically in that direction could have.

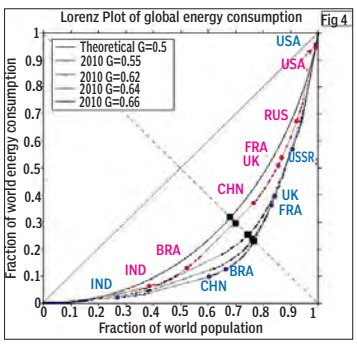
The laws of physics have it that any particle, stationary or in motion, interacts with other particles so that the energy of motion that it brings stays constant — either retained or passed on to the other particle. The other particle also follows this principle and the first particle may end up with more energy than it started with, but thanks to something given up by another particle. The result is that the speeds of millions of particles in motion — for example, the molecules of a gas distribute themselves so that there are very few particles with high energy or with low energy, but with a great many at a point in between. And this point can be shown to be the one where there is the greatest number of different ways for the particles, with various speeds of motion, to have the same total energy. It could also be called the point of most equitable distribution of energy, given the dynamics of collisions and the conservation of total energy.

Victor M Yakovenko, Qin Liu and Scott Lawrence of the Joint Quantum Institute, Department of Physics, at the University of Maryland, report in the journal *Entropy*, their finding that the way energy use and also CO_2 emissions are distributed in the world is just like the way energy is distributed among the molecules of a gas. This said, there follows the observation that thwo-thirds of all the energy produced is consumed by just one-third of the world population, who also produce two-thirds of all the CO_2 emissions, per capita.

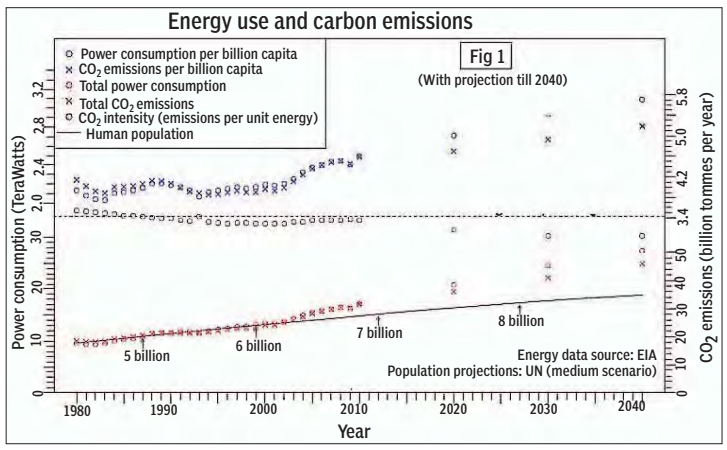
The paper in *Entropy* is based on US Information Administration International Energy Statistics, which show the historical and projected data of energy use and emissions, as in Figure 1. It can be seen that although there is an improvement in the efficiency of power generation, in terms of lesser emission, both power consumption and emission have been increasing, with the rising population. The paper notes that the energy consumption and population of developed countries have largely stabilised and it is the developing world, like China for energy and India and others for population, which account for the global increase. This trend, however, is the result of great energy inequality among countries, as is shown by Figure 2. While the total consumption by developing countries is still less than by other countries, the inequality becomes acute if population is taken into account and countries are characterised by consumption per capita.

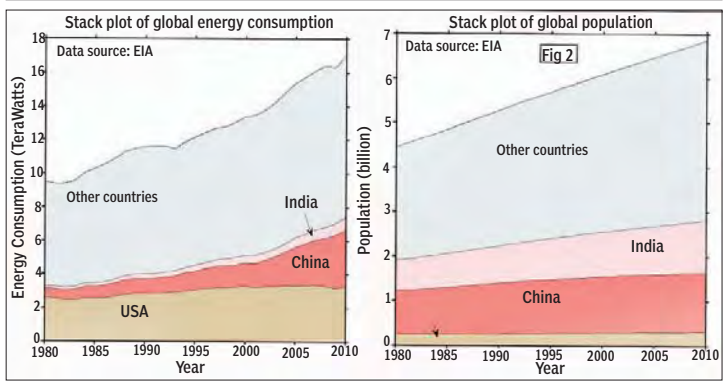
The comparison of economic activity with the properties of the molecules of a gas comes about by treating the money with an individual as equivalent to the speed of a molecule. In transactions between individuals, like in collisions of molecules, there would be an exchange and redistribution of money. The comparison is valid because the total money in a system, like the total energy in a gas, is conserved or stays constant. The proposition then was that, after allowing for the possibility of debt, which does not exist in molecules of a gas, money also distributes itself, with mathematical precision, in the same way as the speed of molecules. In studies of actual distribution of money, to verify the notion, there is a difficulty of different currencies and purchasing power, in cross-border comparison. Studies have, hence, been made of the distribution of income in the USA, UK, Australia, European Union countries, Romania and others, and the results have been that the distribution of the number of persons in increasing income ranges, in most cases, over a group of 97 per cent of the population, is exactly like in the case of a gas.





For making a comparison between countries, the differences in currency and purchasing power have been gotten over by using the *energy consumption per capita* as representing physical living standards. Studies were first made using data of the World Resources Institute, of 130 countries from 1990 to 2005 and now, in the present work, with wider data from the US Energy Information Administration, which covers 220 countries over 1980 to 2010. In using energy consumption as a measure, the worldwide energy resources are being considered, first as redistributable and, second, as constant, and so also the population of countries, at least for a time. The proposition, again, is that the proportion of persons with higher energy consumption should fall, as the level of energy considered is raised, in the same way as the distribution of the molecules of a gas. The data is found to strongly support the proposition and the current data shows a progression from highly unequal distribution in 1980 to more uniform, and closer to theory, distribution in 2010, a feature which the authors of the paper in the journal attribute to globalisation of the world economy.





Another representation of the data is with the help of the so-called *Lorenz curve*, which plots the fraction of energy consumption against fraction of the population at that level of consumption. The curves for different years, 1980, 1990, 2000 and 2010, have been shown. A case where the numbers of consumers increase uniformly as we consider larger fractions of energy would be complete equality and this is the straight, diagonal line in the graph. The other lines, the curves, indicate actual conditions, from 1990 to 2010, with the deviation from the ideal reducing every decade.

There is a measure of inequality called the *Gini coefficient* (G) of the Lorenz curve, which measures how far the curve deviates from the ideal, diagonal, straight line. We can see that G=0 is the diagonal itself, where everything is equal, and the opposite is G=1, where all except one, who receives everything, receive nothing. The figure shows that the G value has been falling from 0.66 to 0.55, approaching the value of G=0.5, which is the equilibrium state of natural distribution, with large numbers of interactions and transactions, as in a volume of gas. The fall from 0.66 to 0.55 is again attributed to the globalisation of the economy in recent decades.

The authors draw a parallel with temperature inequality and the tendency of nature to equalise temperature, which amounts to dismantling an element of *order*, being the driving force in physical systems. This is also the tendency to *maximise disorder*, and another word for the level of disorder is *entropy*. The authors note that developed countries now have ageing populations and reducing consumption, inclusive of energy, and stagnating growth. But developing countries, China particularly, have become rising consumers of energy, per capita. And even this growth is slowing down and there is talk in the media of an "economic ice age", the paper notes. While different causes have been suggested, the authors propose that the slowdown can be explained in terms of thermodynamics, as arising from falling inequality and increasing entropy.

On a brighter note, they ask if economic slowdown may bring in reduced carbon emissions and slowing climate change. But the progression from 1980 to 2010 only shows changes in distribution, not control of total emissions. Given the serious inequality that persists, the international parleys on climate change have had no effect in the last 20 years, while developed countries maintain high consumption and developing countries strive to "catch up". The study also shows that inequality appears to be "intrinsic", just as there is inequality in the motion of molecules of a gas. While the parallel with thermodynamics helps with insight into mechanisms at work, the answer may lie only in a changeover to renewable energy sources, viz, wind or solar, which are both emission-free and also equally distributed around the world, the authors say.

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Victor Yakovenko, Qin Liu and Scott Lawrence.

PUTTING 'WASTE' TO USE

OF 6,800 CASES OF STEM CELL TRANSPLANTS CARRIED OUT LAST YEAR TO CURE VARIOUS MALIGNANT AND NON-MALIGNANT DISEASES, MORE THAN 3,000 CASES WERE DONE USING STEM CELLS COLLECTED FROM UMBLICAL CORDS. **DEBAMEETA BHATTACHARYA** FINDS OUT ABOUT THE PROCESS

The umbilical cord represents a special bond between mother and child, nourishing, protecting and playing a vital role in the growth and development of the foetus during pregnancy. Cord blood, or "placental blood", is what remains in the umbilical cord and placenta following birth after the cord is cut. Till recently, this cord blood, along with the placenta and umbilical cord, constituted a delivery room's regular medical waste. Now stem cell banks retrieve and test this product to determine whether it meets strict eligibility criteria and then cryopreserves it in a sealed container at -196° Celsius for possible future need. CordLife, the largest stem cell bank in the Asia-Pacific arena and internationally accredited is one such bank that stores these stem cells. Of 6,800 cases of stem cell transplants carried out last year to cure various malignant and non-malignant diseases, more than 3,000 cases were done using stem cells collected from umbilical cords.

Cord blood is easy to retrieve and is readily available whenever needed, unlike bone marrow, for example, where it is tough to find a donor matching your DNA. Cord blood banking is provided by both private and public centres. In a public centre, what is donated is tissue typed and added to a public database, where it is visible for any hospital facility to request its use in case of a need. In a private centre, the donor has to pay a fee for storage and the product will be reserved for future use for his/her family needs only.

Upamannyue Roy Chowdhury, general manager, sales and marketing, Cordlife, India, answers some frequently asked questions about stem cell banking. Excerpts:

What make stem cells so unique?

Stem cells are the master cells of the body. They have the potential to become any type of cell. One of the main characteristics of stem cells is their ability to self-renew or multiply while maintaining the potential to develop into other types of cells. They can become cells of

the blood, heart, bones, skin, muscles, brain, etc.

Why are doctors and scientists so excited about human embryonic stem cells?

Embryonic stem cells are the youngest possible form of stem cells. These are so naïve that there is a high possibility of converting them into various types of specialised cells. Like heart or liver cells. But the biggest constraint is the source, because if the cells are collected from the embryo, invariably the pregnancy is terminated. So there are a lot of restrictions regarding the source. Umbilical cord and cord blood is the next source from where stem cells can be collected, and these are also very young because they are collected immediately after birth and processed within 48 hours.

Have human embryonic stem cells been used to successfully treat any human diseases yet?

Some unconfirmed reports mention cases where stem cells have been used, but most of the work is under clinical trials and used in animal models.

What are the potential applications of stem cell research?

Stem cells have the ability to replace or repair damaged cells. This property is already used in the treatment of extensive burns and to restore the blood system in patients with leukaemia and other allied disorders. Stem cells, if they can be directed to differentiate into specific cell types, offer the possibility of a renewable source of cell and tissue replacement to treat diseases that include Parkinson's, stroke, heart disease and diabetes.

What are the current challenges for embryonic stem cell research?

Embryonic stem cells means cells collected from the embryo and its source is the prime challenge.

Could the same research be done with other types of stem cells?

Yes, umbilical cord blood and cord tissue is the other source. The collection is not ethical and is done only after acquiring the client's consent.

Where can one donate umbilical cord stem cells?

Well, there are two types of stem cell banks — private banks where expectant parents can store their child's stem cells by paying a fees, and public banks with installment facilities as low as Rs 1,900. However, there aren't many banks in India.

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PLUS POINTS

Jurassic age cleaners

Cockroaches are known for their ability to adapt and survive. Over 100 million years ago, in the era of the dinosaurs, they survived by feeding on dinosaur dung. During most of the Mesozoic era (252-266 million years ago), dung beetles and flies, which generally clean up faeces, were rare. A study suggests that the function of cleaning up at that time was being done by cockroaches.

Researchers from Slovakia, Russia, Lebanon and Japan studied a 125-million-year-old fossil of a cockroach found in Lebanon. It belonged to the now extinct *Blattulidae* family. The immature cockroach was found trapped in tree resin in a forest. Trying to escape, it defecated and left five coprolites still extruding from the body. When the researchers studied the fossil using a synchrotron X-ray microtomography to figure out the cockroach's diet, they found small pieces of smooth-edged wood particles in its gut.

They postulate that this wood originated from dung — the pieces were smooth — suggesting predigestion. As dinosaurs dominated the period, the researchers say the wood came from dinosaur faeces. The team has studied roughly 30,000 more or less preserved specimens from the *Blattulidae* family.

The study shows that the first insects to process wood might have originated to clean up after dinosaurs, says lead author Peter Vrsansky, associated with the Slovak Academy of Sciences and Russian Academy of Sciences. The study also indicates a relation between modern day termites and cockroaches. The findings suggest that the micro-organisms involved in the breakdown of dinosaur faeces would have passed on from these cockroaches to the modern day termites.

However, Srini Kambhampati, chair, department of biology, University of Texas, Tyler, USA, says the evidence that cockroaches may have been feeding on dinosaur faeces is less than convincing.

A cockroach fossil trapped in tree resin been found in Lebanon. (Source: harunyahya.com.)

"It seems unlikely that a cockroach would feed on a large piece of wood that it cannot digest. The authors do not consider the possibility that the cockroach in question ate wood. If this was the case, the cockroach could have excreted smooth, partially digested wood. The authors have drawn pretty broad conclusions based on one fossil specimen and sparse data," he says. The paper was published online on 4 December in *PLoS ONE*.

MEGHA PRAKASH/CSE-DOWN TO EARTH FEATURE SERVICE

Parkinson's trigger

Mouldy surfaces in households release volatile compounds that trigger reactions ranging from watery eyes to severe allergies in people. One such chemical, 1-octen-3-ol, commonly called "mushroom alcohol", has been found to induce symptoms typical of Parkinson's disease in fruit flies.

The chemical has a similar effect on human cells, although at much higher levels of exposure.

Parkinson's is among the most common disorders impacting movement and muscular coordination. It typically causes degeneration of neurons that carry the neuro-transmitting chemical, dopamine, to the brain (dopaminergic neurons). Although the potential causes behind Parkinson's are many, environmental triggers identified so far have been only man-made, such as paraquat, a strong neurotoxic herbicide.

Fruit flies exposed to 0.5 parts per million of volatile mushroom alcohol had impaired movement as early as 24 hours after exposure. Half the population died in 17 days, while flies that were not exposed did not die in that period. Analyses of the brains of the flies exposed to the chemical showed there was a significant reduction of dopaminergic neurons.

The research was conducted by the Department of Plant Biology and Pathology in Rutgers, the state university of New Jersey, USA. "This study is the first to show a mechanistic link between a natural biogenic cause and Parkinson's disease," says Arati Inamdar, lead author of the paper published online in *PNAS* on 11 November 2013. It was also found that flies lacking a dopamine transport protein were hypersensitive to mushroom alcohol while those given an extra dose of it were resistant, suggesting that dopamine transport is, indeed, impacted. The researchers then tested the chemical on human embryonic kidney cells and found that at high concentration of three parts per million, 95 per cent of dopamine uptake was effectively blocked.

The trigger for the study came from a personal experience of Joan Bennett, who heads the lab at Rutgers. Her house in New Orleans was hit by Hurricane Katrina in 2005. Soon, a mouldy growth came up that caused her to have headaches and nausea, an experience that reinforced her desire to study fungal volatiles.

LAAYSA SAMHITA/CSE-DOWN TO EARTH FEATURE SERVICE