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The science of inequality and the inequality of science

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Rising inequality at a global scale has been a matter of concern for quite some time. In an article published in *Science* more than a decade ago, the then UN Secretary General had said, 'A generation ago, people in the top 20% were 30 times as rich, yet will not give 0.3% of their income for the poorer 80% of the humanity'[1]. Estimates reported[2] last year showed that less than 1% of the global population owned more than 44% of the total global wealth, while 90% owned less than 15%. Two scathing reports by Oxfam, one of which also talked about inequality in India, recently made it to the front pages of many Indian newspapers[3].

As both inequality and growth are well-trodden areas of economics, should a physicist or a chemist dare to venture into an unfamiliar territory? The answer is a hesitant 'yes' for two reasons. First, history shows that extreme and persistent inequality is often a prelude to war between nations, violent social unrest and large-scale destruction of national wealth. India, with a large number of poor people, about 40% or more in 2010 both using US$ 1.25 a day and multidimensional poverty index measures, must be especially alert to such unpredictable events[4]. Second, economics unlike physical sciences has very little predictive ability as has been proved time and again in history. Furthermore contrary to the claim of many of its practitioners, it is not a value-free subject. Policy prescriptions and numbers that are supposed to deliver and indicate rapid growth must be subjected to special scrutiny because they often hide other crucial numbers.

Two centuries of data on the wealth of the rich nations, the historical distribution of such wealth, and a narrative largely free of technical jargon has been recently published[5]. It has attracted considerable attention and the overall validity of the data is well accepted. The most important finding is the following inequality illustrated as

$$r > g. \qquad (1)$$

It is found that from about the time of the Industrial Revolution, the average rate of return on capital (r) has always been greater than the rate of growth (g) of the economy. The overriding importance of eq. (1) therefore lies in the fact that it is based on hard, first of its kind, empirical data not reported till recently for economic theorizing.

A chemist may be forgiven if eq. (1) reminds him of a universal natural law that has been known for almost 200 years. The earliest analytical formulation of this law, namely the second law of thermodynamics (SLT), was published by Sadi Carnot who wondered about the maximum possible efficiency of an ideal steam engine and the source of its power[6]. Subsequent work after Carnot showed that in a steam engine, even under idealized conditions, all the heat can never be converted into useful mechanical work. If Q is the amount of heat supplied and W is the amount of work done by a moving piston, then as shown by eq. (2), some heat is always lost

$$Q > W. \tag{2}$$

Steam engines were the technological marvels that propelled the ongoing Industrial Revolution during Carnot's time[7]. Steam engine-based railway locomotives and steam ships contributed greatly to the growth, reach and might of capital. They were largely instrumental in the transformation of the historical era described as 'Age of Capital' into the one called 'Age of Empire'[8].

In Carnot's idealized steam engine, where there is no heat loss due to friction, etc. the relationship between heat and mechanical work is given as

$$W = Q(1 - T_L/T_H). \tag{3}$$

The engine operates between two temperatures only – the high (T_H) and the low (T_L). The temperatures are measured in Kelvin, where 0°C ≈ 273 K. The efficiency with which the engine converts heat into useful mechanical work is $(1 - T_L/T_H)$.

Given the validity of eq. (1) over the last 200 years, it is reasonable to ask if the economic engine of growth under capitalism, like Carnot's ideal steam engine, has in-built limits of efficiency. Elementary algebraic manipulation of what are called the 'two fundamental laws of capitalism' shows this to be the case. The first fundamental law, $\alpha = r\beta$, is an accounting identity which is valid at all times in all places. Here α is the contribution of capital to the annual income of a country, β the ratio of total capital or wealth at the country's disposal over national income, and r is the average rate of return on capital.

The second fundamental law, $\beta = s/g$, where g and s represent average growth and savings rate after depreciation respectively, is a dynamic law. It is valid in the long run, and supported by data of the rich nations over the last 40 years or so[5]. Simple combination and rearrangement of these two laws gives

$$I = r\,(1 - s/\alpha), \tag{4}$$

where I is the difference between the rate of return on capital and the growth rate, i.e. $I = (r - g)$.

The similarities between eqs (3) and (4) are coincidental, but instructive. The efficiency of a steam engine can never be 100%, as T_H by definition must always be greater than T_L. Under capitalism r is always greater than g, not because it has to be so by definition, but because in the long run the average rate of savings is less than that of return on capital. In Carnot's engine if T_H and T_L are equal, the efficiency is zero and no work could be obtained. In the engine of capitalism, only when s and α are equal to each other will g become equal to r.

Many years after Carnot, SLT was shown to be a fundamental law for the interaction of energy with matter and was statistical in nature. Before conversion to mechanical work, heat is distributed only among the gas molecules within the engine. After conversion to work, some heat is radiated out and distributed among molecules that are outside the engine. In other words, from being concentrated or 'ordered' within the engine, on conversion of heat to work the energy is more randomly distributed or more 'disordered'.

In the physical sciences, the randomness or disorder of a system is called entropy. In its most general form SLT simply states that the total entropy of the universe is always increasing. In fact at a cosmic scale the arrow of time is defined by the ever-increasing entropy of the universe[9]. The emergence of low-entropy structures with time such as that of a living cell, falls within the realm of what is called nonequilibrium thermodynamics and is an exquisite manifestation of the universality of SLT[10].

Scientists familiar with the concept of entropy had noticed long ago that much of the global economic growth was dependent on the consumption of energy and natural resources. The fact that there is a qualitative difference between material wealth such as food, housing, etc. on the one hand, and financial products, including money on the other, did not escape their attention. Frederick Soddy, a British Nobel Prize-winning chemist-turned-economist, was the first to articulate concern and tried to define 'value' using thermodynamic concepts[11]. He was largely ignored and summarily dismissed as a crank by most economists of his time.

Subsequently, Nicholas Georgescu-Roegen, a mathematician-turned-economist used entropy-based arguments to draw attention to the finiteness of Earth's resources[12]. His pioneering studies and strong advocacy for sustainable growth had much to do with the current interest of many economists on the impact of economic growth on ecology, environment and climate.

In Carnot's theoretical steam engine, the increase in entropy is given by the difference between Q and W. The metaphorical entropy of the growth engine under capitalism is given by I. It is directly proportional to the dissipated part of the national income that is reflected in the book of accounts as wealth, but does not contribute to growth. At a qualitative level its impact on inequality is obvious. A wealthy person will always have spare income to invest and earn a return which is more than the average rate at which the economy grows. His income will therefore keep growing at a faster rate than that of the others who do not have spare capital. In the jargon of academic economics, it is easy to show 'that the coefficient of Pareto distribution (which measures the degree of inequality) is a steeply increasing function of the difference $r - g$'[5].

As mentioned, eq. (4) is valid under dynamic conditions where the parameters β, s, g and r influence each other and change with time. In the 'long run' they tend towards equilibrium and reach average equilibrium values. In other words, the time-dependent rates of change like that of a chemical reaction under equilibrium, at some point of time balance each other out. It could therefore be argued that eventually s and α would become equal and inequality would stabilize. It is a condition that has been speculated upon in academic economics under catchy titles such as the 'golden rule of capital accumulation', 'modified golden rule', etc.

What motivates people to save or consume – frugally or conspicuously – is a vexing question and economic determinism alone cannot provide convincing and complete answers. According to Max Weber, the celebrated sociologist of the 19th century, it was the 'Protestant ethic' that encouraged people to save in the West. Weber referred to it as the 'spirit of capitalism'. What 'ethic' if any, may motivate the global and the local super-rich not to consume any more but to give the return on capital back to society, i.e.

the conditions under which s is equal to α, is anybody's guess.

Leaving ethical considerations apart, the theoretical condition under which s may become equal to α is one where the ratio of the capital stock over yearly income, i.e. β is extraordinarily high. So high that the entire return on private capital must be used to take care of the capital depreciation. Based on available data and past trends, the rich countries will take at least another half a century or more to reach such a hypothetical condition. For the less privileged parts of the world, it will be much longer. One could therefore only repeat Keynes' famous saying that in the long run we are all dead, be done with pointless speculations, and look for practical ways of reducing I in the short run.

Unlike productive capital, I represents fictitious wealth. Such wealth does not promote either big or incremental innovations, the life blood of capitalism[13,14]. It grows without creating jobs to any significant extent. Jobless growth means a large section of the society is excluded from the growth process and does not benefit from it. A large part of I, the metaphoric entropy of capitalism, exists as finance capital, legitimate and illegitimate. It travels across the continents at the blink of an eye and promotes shadow banking and financial products of dubious value. Barring what has been termed in recent times as 'catastrophic market failure', the return on finance capital, unlike that of risk-aware productive capital with a longer time horizon, is quick and assured.

Junk bonds and penny stocks have been around for ages. In recent times many variants touted as 'innovative' financial products and backed by impressive mathematical models have been added to the list. The derivative-based 'credit default swap' episode that shattered the myth of 'self-regulating market' in 2008, had its origin in the once celebrated but now questionable model of Black, Scholes and Merton[15]. A complex network of bankers, regulators, rating agencies and other institutions is supposed to keep an overall check on the excesses of finance capital. When this network deliberately goes to sleep because of conflicts of interest, financial meltdown like that of 2008, from which the global economy is yet to recover, becomes inevitable[16].

Mistaking impressive-looking mathematics as truth does no good to the credibility of economics as a science, but more important is the fact that society pays a heavy price for such mistakes[17]. Writing in the last century between two devastating wars and an era of hyperinflation and recession, Soddy had commented 'The ruling passion of the age…is to convert wealth into debt'[18]. Financial products and services have undergone a sea change from Soddy's time, but the passion to convert store of real value to fictitious value, and profiting from it continues unabated.

In Carnot's time heat was thought to be a weightless invisible fluid called caloric. About steam engines Carnot's conclusion was that the power in them was not due to actual consumption of 'caloric', but its 'transportation from a warm body to a cold body'. An early formulation of the second law of thermodynamics stated the impossibility of building a 'perpetual motion machine (PMM) of the second kind'. Such a machine, if it could be built, would take heat from a cold to a hot body. The fact that Carnot's theoretical machine must take into account the external environment was incorporated later. A refrigerator or an air-conditioner does not defy the entropy-based statement of the second law, though both may appear to be PMMs of the second kind.

Well-known economists in Carnot's time theorized that supply always generated enough demand and led to equilibrium. Prosperity through increased supply would automatically flow down to all sections of the society – an ideology known as 'trickle down theory' in its new avatar and much favoured by the politicians and policy makers in the developing world. With a hint of sarcasm Carnot had called such theorists 'economistes modernes'. Had he been alive, the data on the distribution of global prosperity would have intrigued him. He would have concluded that unlike heat going from a warm body to a cold body, in the PMM of capitalism, prosperity climbs up instead of trickling down.

Recent data on the increasing wealth of Indian politicians and the super rich would have surprised him further. In just five years, from 2009 to 2014, the approximate average assets of the members of the Indian parliament increased from 5 to 15 crores, a rate of increase of about 24% per year[19]. The increase in the number of dollar billionaires in India kept pace; it went up from about 20 in 2009 to 90 in 2015. The average growth rate of the economy, however, was just about one-fourth of these astounding rates of increase. Carnot's conclusion would have been that in the PMM of capitalism of the Indian kind, prosperity instead of trickling down cascades up with a little help from the political class.

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