

Modern Economics as a Would-be Science

Mark Lindley

Kunda Datar Memorial Lecture, 2013

GOKHALE INSTITUTE OF POLITICS AND ECONOMICS

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Prof. Mark Lindley (b. 1937) studied at Harvard University, Juilliard School of Music (M.S.) and Columbia University. He is a noted musicologist and has written a number of papers on the subject. He is regarded as an expert on the history of tempered tunings, early keyboard fingerings and chromatic scale. His musicological writings include *Lutes, Viols and Temperaments* and *Ars Ludendi: Early German Keyboard Fingerings*, apart from joint writings and pieces in edited books.

He is also a historian of modern India. His research interests include Indian freedom struggle and Mahatma Gandhi and his associates. He is an ardent follower of Gandhian values. His books on Gandhi include *Gandhi and Humanism* and *Gandhi and the World Today: An American View*. His books *J.C. Kumarappa: Mahatma Gandhi's Economist* and *The Life and Times of Gora* have been acclaimed by critics both in India and abroad. Regarding his book on Kumarappa, Tadeusz Kowalik (Professor of Economics and Humanities, Polish Academy of Science) wrote, "I have read this book with great interest. It describes masterfully J.C. Kumarappa's fight for an alternative civilization based not on egoism and rivalry but on solidarity, cooperation and ecological principles."

He has contributed many articles in periodicals like *Journal of American Science, Economic and Political Weekly, Mainstream, Anasakti Darshan, Journal of Gandhian Studies, Journal of Literature and Aesthetics, Journal of Peace and Gandhian Studies, Journal of Social and Political Studies, Modern Historical Studies*, etc. Some of his works have been translated in other languages like German, Flemish, Hindi, Gujarati, Kannada and Malayalam.

He has taught in many universities including Columbia University, City University of New York, Washington University, London University, Oxford University, Istanbul Technical University, Chinese University of Hong Kong, Kerala University, etc. He has delivered special lectures and keynote addresses in numerous academic institutions across India on Mahatma Gandhi.

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Modern Economics as a Would-be Science*

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Since market-economic theory lacks predictive reliability, it is not scientific like physics. Nor has it ever really been “positive” like physics and chemistry. To become truly scientific, economic theory has to consider in detail the exosomatic physical aspects, including the ecological ones, of human activity, while medical science deals with the endosomatic physical aspects of the human organism.

The Earth is not, however, an organism (nor indeed is a market), and therefore, preserving wilderness will not suffice to solve the 21st-century problems caused by ecological degradation. Technological maintenance will also be required – and prudence when facing high-stakes risks in regard to which there is baffling scientific uncertainty. Some historical background to these theoretical points is given here.

Is market-economic theory scientific like physics? Many academic economists, especially those who liked to write algebraic equations, have thought so.¹ Opinions as to the extent to which it *can* be like a natural science were expressed in the German academic *Methodenstreit* of the late 19th and early 20th centuries.²

There has been a vast difference between physics and market-economic theory in regard to predictive reliability. If two competent physicists are given a

* Text of Kunda Datar Memorial Lecture delivered by Dr. Mark Lindley (Visiting Professor at Gujarat Vidyapith) at the Gokhale Institute of Politics and Economics, Pune, on March 22, 2013. Email: mirabene@yahoo.com.

1. Here are some illustrative snippets from a lecture delivered by Paul Samuelson (the most eminent American academic economist of the second half of the 20th century) when awarded in 1970 the Swedish Royal Bank’s Prize in Economic Science in Memory of Alfred Nobel: “[We praise] the followers of Galileo and Newton for taking the mathematical approach.... Often the physicist gets a better ... description of nature if he is able to formulate the observed laws by a maximum principle. Often the economist is able to get a better ... description of economic behaviour from the same device. Let me illustrate this by some very simple examples. Newton’s falling apple..... Let me illustrate the same thing in economics..... One of the pleasing things about science is that we do all climb towards the heavens on the shoulders of our predecessors. Economics, like physics has its heroes..... [L]et me recall the work I have done in formulating clearly and generalizing what is known in physics as LeChatelier’s Principle....”

For a survey of evidence that 20th-century economists suffered from physics-envy, see Philip Mirowski, *More Heat than Light: Economics as Social Physics, Physics as Nature’s Economics* (Cambridge University Press, 1989).

2. “*Streit*” (cognate with “strive”) means “struggle.” The categorical distinction in the *Methodenstreit* debate was between the *Naturwissenschaften* – the natural sciences – and the *Geisteswissenschaften*. “*Wissen*” (cognate with “wise”) is a verb meaning “to know” something objectively (whereas “*kennen*” means to be familiar with it subjectively); the suffix “-*schaft*” converts the word into a noun; the suffix “-*en*” makes it plural. “*Geist*” (cognate with “ghost”) means “spirit”. The *Geisteswissenschaften* would include theology, linguistics, history, psychology and so on, as well as sociology and market economics.

technical account of the design of, say, a proposed bridge and of where it is to be built, they will nearly always agree as to whether it will hold up, and will be right; but such has seldom been true of the market economists' predictions.³ If they had been our rocket scientists, many more of our spaceships would have crashed.

I can think of two main reasons (apart from possible *ad hominum* factors, e.g. that some economist or other may have been intellectually dishonest⁴) for this characteristic defectiveness of the market-economists' theorizing. One big reason was pinpointed by Keynes:

"Economics is a science of thinking in terms of models_[,] joined to the art of choosing models which are relevant to the contemporary world. It is compelled to do this [i.e., to choose historically opposite models] because_[,] unlike the typical natural science, the material to which it is applied is, in too many respects_[,] not homogeneous through time."⁵

The other reason is that market-economic theory has normally been based on radically defective postulates. Two of the most important among many historic examples which could be cited are (1) that everyone's sole proper concern is to become a wealthier individual in ways which can be measured in terms of money (the "Economic Man" premise), and (2) that the proper subject of market economics is the wealth of nations rather than the welfare of communities or of people regardless of which community or nation they belong to (Hence the predominance, in market-economic theory, of "Gross National Product" and "Gross Domestic Product"; and hence also George Bush's tragically foolish declaration, at "The Rio Earth Summit" in 1992, that "The [wealthy] American way of life is not subject to negotiation").

Some market economists say there is another way – in addition to the fact that both, they and the physicists, use algebra – in which their discipline is like

3. Many market economists have admitted this. Two snippets from Kenneth Arrow's presidential address (1973) to the American Economic Association can provide a token of the fact: "I must express my unabashed admiration for the accomplishments of the neoclassical viewpoint.... Of course the implications of neoclassical theory have ... been falsified in important ways."

4. See e.g. www.academia.edu/3291616/The_Strange_Case_of_Dr._Hayek_and_Mr._Hayek.

5. *The Collected Writings of John Maynard Keynes* (30 Vols., 1972-89), XIV, 297. Keynes was implicitly elaborating upon a precept, set out toward the end of the *magnum opus* of his mentor, Alfred Marshall, that "every change in social conditions is likely to require a new development of economic doctrines" (Marshall, *Principles of Economics*, 1890 and later editions, Ch. 37, Section iii, conclusion). Notice Marshall's specification of *social* conditions, both Marshall and Keynes were oblivious to ecological aspects of economics. And yet a leading mid-19th century German economist, Karl Knies, had pointed implicitly to food and fuel as the most vital ingredients of a modern economy: "The changes due to long-term effects upon the territorial [i.e., geographical] basis of an economy are changes not just in the land, but also in the conditions dependent upon water. Further changes in the natural basis of the political economy can be seen in historical developments when one considers the significance, particularly in the culturally higher stages of commerce, of the utilization of natural sources of chemical and mechanical energy" (*Die politische Ökonomie vom Standpunkt der geschichtlichen Methode*, 1853, pp. 76-77; my translation).

physics: namely, that it is not “normative”, that is, not based like medical science on any moral precept(s). The accepted term for this negative characteristic is “positive”.⁶ An example of why some sociologists and economists call physics a positive science (I have never heard physicists discuss the issue; they have no claim to make about it) is that Robert Oppenheimer is considered to have been just as good a physicist when he directed the “Manhattan Project” to invent the atom bomb as when he later opposed on moral grounds the invention of the hydrogen bomb. I recall also that at Harvard College in the mid-1950s, a Professor who was renowned as an experimental chemist, Louis Feiser, complained in one of his lectures that he ought to have been awarded a Nobel Prize in Chemistry. In 1940s he had devoted himself assiduously for several years to the invention of napalm.⁷ If you feel that this invention was horrible but that he was, even so, a good chemist, then you may be said to regard chemistry as a positive science. If, however, you do *not* regard George Soros as a fine theorist of market economics by virtue of his alleged ability to wreak havoc upon a nation’s monetary currency⁸ – or Ivan Boesky and Michael Milken by virtue of their diligent use of insider information to become very rich⁹ – then your own sense of market-economic science is that it is normative. And, it has been

6. “Welfare economics” is not “positive” in this particular 20th century sense. (An ethics-laden concept of positive sciences goes back to Auguste Comte in the 1830s and ’40s.)

Gandhi in a forum in 1916 took exception to a statement made by Herbert Stanley Jevons (son of William Stanley Jevons) to the effect that market-economic theory is scientifically true but has to be morally neutral (*See The Collected Works of Mahatma Gandhi*, 100 Vols., 1958-1994, Vol. XLVIII, pp. 316-317).

In 1920s, Herbert J. Davenport was renowned among academic economists in the USA for the following definition, in his book *The Economics of Enterprise*, of productive labour: “All labour ... that commands a price, though it be the poisoning of a neighbour’s cow or the shooting of an upright judge, all durable goods commanding a rent or affording a valuable service – lands, machines, burglars’ jimmies, houses, pianos, freight cars, passenger cars, pleasure boats – all patents, privileges, claims, franchises, monopolies, tax-farming contracts, that bring an income, all advertising, lying, earning, finding, begging, picking, or stealing that achieve a reward in price or a return that is worth a price – are productive by the supreme and ultimate test of private gain.” (2nd Edition, 1925, Vol. III, p. 382). But in the last course he taught – at Columbia University in the summer of 1928 – he gave the top academic grade, A+, to a student from India whose arguments in class against this precept (on the grounds that “man is not merely a wealth-producing agent but essentially a member of society with political, social, moral, and spiritual responsibilities”) had made him (Davenport) red in the face. The younger man co-founded with Gandhi in 1934 the All-India Village Industries Association (*See my J.C. Kumarappa: Mahatma Gandhi’s Economist*, Mumbai, 2007, pp. 14 and 30).

7. *See* http://en.wikipedia.org/wiki/Louis_Fieser and <http://www2.vcdh.virginia.edu/PVCC/mbase/docs/napalm.html>. 7)

8. According to a sophisticated observer writing in the late 1990s, “Nobody who has read a business magazine in the last few years can be unaware that these days there are really investors who not only move money in anticipation of a currency crisis, but actually do their best to trigger that crisis for fun and profit. These new actors on the scene do not yet have a standard name; my proposed term is ‘Soro!’” (Paul Krugman, *The Accidental Theorist: And Other Dispatches from the Dismal Science*, Norton, 1999, p. 160).

9. *See* http://en.wikipedia.org/wiki/Ivan_Boesky.

correctly (I believe) argued by several expert observers of 20th-century market-economic theory¹⁰ that normative precepts lurk in the concepts of Economic Man (often postulated to have insatiable needs¹¹), the wealth of the nation, and efficiency of production.¹²

It is incorrect to infer from the fact that physics uses certain kinds of mathematics to make reliable predictions (and is a “positive” science) the conclusion that since market-economic theory (which history shows to have been normative throughout the 20th century) uses some similar kinds of mathematics to make notoriously unreliable predictions, it is a science like physics. However, valuable mathematical formulations may be in some parts of scientific discourse, a proper regard for the difference between empirically valid and invalid predictions (generated by a given theory) is a more essential hallmark of science.¹³

Economic *vis à vis* Medical Science

It is common sense that economists are, like doctors, to be consulted when something goes wrong. I believe there is much more than this to the relationship between medical science and what economic theory must be like if it is to become genuinely scientific. The main purpose of this essay is to offer accordingly a new definition of scientific economic theory by characterizing it in relation to scientific medical theory. The characterization will make use of the terms “endosomatic”, meaning “within individual (human) bodies”, and

10. See for instance the passages referred to in the index under the heading “Economics” in Stephen Marglin, *The Dismal Science: How Thinking Like an Economist Undermines Community* (Harvard University Press, 2008).

11. A 19th-century hint of this 20th-century postulate is William Stanley Jevons’s statement that “To the desire for articles of [aesthetic] taste, science or curiosity, when once excited, there is hardly a limit” (*Theory of Political Economy*, 1871, p. 63).

12. The concept of efficiency of production is salient (along with that of the “creative destruction” whereby more efficient methods become normal) in Joseph Schumpeter’s *Capitalism, Socialism, and Democracy* (1942).

An example of normative thinking by a politically influential late-20th-century market economist is in a memorandum sent on 12 December 1991 from the World Bank’s chief economist, Lawrence Summers, to the staff: “Just between you and me, shouldn’t the World Bank be encouraging MORE migration of the dirty industries to the LDCs [Less Developed Countries]? ...The measurement of the costs of health-impairing pollution depends on the foregone earnings from increased morbidity and mortality. From this point of view a given amount of health-impairing pollution should be done in the country with the lowest cost, which will be the country with the lowest wages.... The problem with the arguments against ... proposals for more pollution in LDCs ... is that those arguments could be turned around and used more or less effectively against every Bank proposal for liberalization....”.

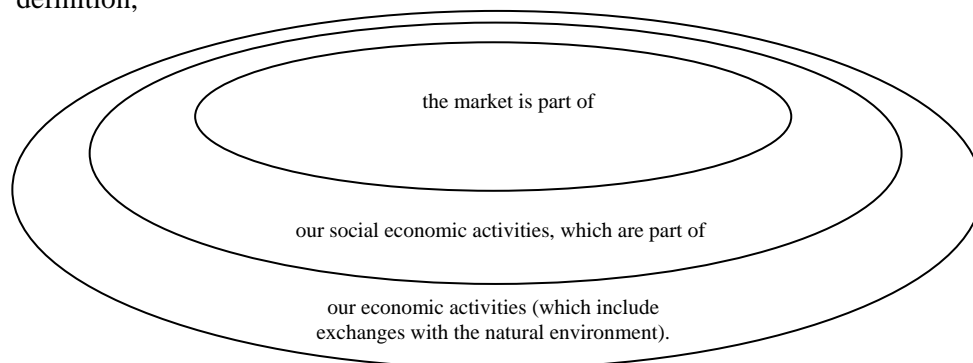
13. There is nothing very original about the points made in this introductory part of the article. Daniel M. Hausman, *The Inexact and Separate Science of Economics* (Cambridge University Press, 1992) and Steve Keen, *Debunking Economics – Revised and Expanded Edition: The Naked Emperor Dethroned?* (London; Zed 2011) are book-length treatments of the theme.

“exosomatic”, meaning outside them:¹⁴ Whereas modern Western medical science studies the endosomatic material aspects of the human organism (this is why X-ray-type internal scans, chemical blood-tests, microscopic views of tissue etc. are often important for diagnosis,¹⁵ and then the treatments often include the use of pharmaceutical substances), economic science, including ecological economics, will have to study the exosomatic material aspects of society and of its exchanges with the environment in order to be adequate to some of the most vital 21st-century economic issues.

Concerns for hygiene and public health have to be shared by these two normative-scientific fields of study. There is a lot of overlap between what economists mean by “polluted” and what medical scientists mean by “unhygienic”, and, various kinds of pollution directly or indirectly damage public health and hence the economy.

Three Implications of this Concept of Economics

According to the concept of economic science implied by the proposed definition,



However, no vision of ecological context underlay the main 19th- and early-20th-century British definitions of economics or “political economy”. The preëminent mid-19th-century British philosopher and economist, John Stuart Mill, defined the study of political economy as a branch of “moral philosophy”

14. These terms were introduced in 1945 by a biophysicist, Alfred J. Lotka (in “The Law of Evolution as a Maximal Principle”, *Human Biology*, XVII), to distinguish between endosomatic and exosomatic “instruments” (A hammer is exosomatic, a fist endosomatic). See www.eoht.info/page/Exosomatic+energy.

In E.C. Graham (Ed.), *The Basic Dictionary of Science*,^[1] Edited in Basic English for The Orthological Institute (New York 1965), the definition of “economics” is “Science of ways by which the material needs of man are taken care of, that is, of the conditions and laws of the producing, distribution and use of goods.”

15. In medical terminology, “disease” refers to abnormalities of the structure and/or function of body organs and/or systems, whereas “illness” refers to the patient’s experience of ill-health and the meaning [s] he gives to that experience. See www.ncbi.nlm.nih.gov/pmc/articles/PMC1972172/pdf/jroyalcgprac00105-0038.pdf. A diagnosis names the disease.

which “does not treat the whole of man’s nature as modified by the social state, nor of the whole conduct of man in society”, but instead

*“is concerned with him solely as a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means for obtaining that end.... [It presupposes] an arbitrary definition of man, as a being who inevitably does that by which he may obtain the greatest amount of necessities, conveniences, and luxuries, with the smallest quantity of labour and physical self-denial with which they can be obtained.”*¹⁶

The preëminent British economist of the early 20th century, Alfred Marshall, removed the academic study of economics from moral philosophy in order to make it an independent discipline (at Cambridge University). His fudged description of the subject matter – “men as they live and move and think in the ordinary business of life”; “man’s conduct in the business part of his life” – tended to preclude for the time being a re-assessment of Mill’s arbitrary definition of man.¹⁷

Many recent textbooks of economics rely, when defining the subject, upon Lionel Robbins’s opportunity-costs precept that it is the aspects of human behaviour which are “guided by objectives” and “deal with scarce means which have alternative [possible] uses”.¹⁸ My proposed definition, compatible with this precept, would nudge the balance of interest toward the “sustainability” aspect of the basic (in my opinion) normative macroeconomic “trilemma” represented in Figure 1.¹⁹

16. John Stuart Mill, “On the Definition of Political Economy, and on the Method of Investigation Proper to It” (1836), Paragraphs 38 and 46; see www.econlib.org/library/Mill/mlUQP5.html (derived from a subsequent publication of the essay). William Stanley Jevons boiled down this idea to “the mechanics of utility and self-interest” (*op. cit.* in Note 11, 1888 edition, Chapter 1, Paragraph 26; see www.econlib.org/library/YPDBooks/Jevons/jvnPE1.html#Chapter%201).

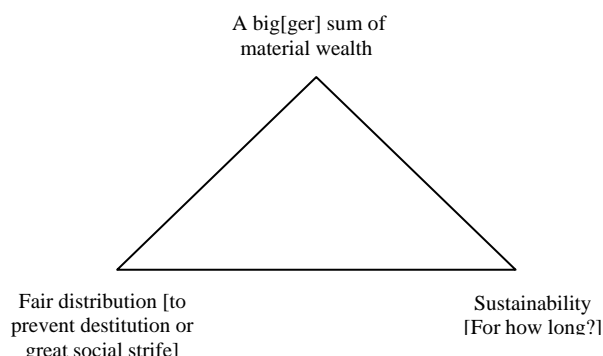
Jevons also presented in *The Coal Question* (1865) a salient concept of fossil-fuel depletion, which late 19th- and early-to-mid-20th-century economists tended to ignore. He said (in the last chapter): “[B]y our [British] plantation of new states, by our guardianship of the seas, by our penetrating commerce, by the example of our just laws and firm constitution, and above all by the dissemination of our new arts, we stimulate the progress of mankind in a degree not to be measured. If we lavishly and boldly push forward in the creation and distribution of our riches, it is hard to overestimate the pitch of beneficial influence to which we may attain in the present. But the maintenance of such a position is physically impossible. We have to make the momentous choice between brief greatness and longer continued mediocrity.”

17. Alfred Marshall, *Principles of Economics* (1890), Book I, Chapter II, Section 1, “The Substance of Economics”; see <http://www.econlib.org/library/Marshall/marP.html>. Marshall envisaged hopefully the possibility that Mill’s arbitrary definition of man might be an incomplete account of human nature. The main work of his chosen successor as professor of economics at Cambridge University, A.C. Pigou, is entitled *The Economics of Welfare*.

18. Lionel Robbins, *An Essay on the Nature and Significance of Economic Science* (London 1932; second edition, 1948), p. 16. A 19th-century presentation (1850) of the idea of opportunity costs (but without the term) is in the first chapter of a book by Frédéric Bastiat entitled “*Ce qu’on voit et ce qu’on ne voit pas*” (“What is Seen and What is Unseen”).

19. This diagram is adapted from a similar one devised about ten years ago by Jan Otto Andersson; see www.lucsus.lu.se/Jan_Otto_Andersson_Paper.pdf, p.1.

Figure 1:



A great deal could and should be said, and done, about this trilemma.²⁰ I will focus here on the 21st-century opportunity-cost crunch between (a) greater GNP's and (b) avoiding or mitigating “natural” catastrophes due to human agency. It seems to me that technological innovations and – who can predict? – political wisdom²¹ may mitigate, but not eliminate, this crunch.

(2) Since it has become clear that the market pays too little heed to ecological sustainability, I would favour, in regard to big-factory industrial production such as has flourished under capitalism, a revisiting of the 20th century “Socialist Calculation Debate”. It seems to me that the theory of “market socialism” – whereby the distribution and hence production of consumer goods would be determined by freely fluctuating market prices while a central planning board makes decisions about “intermediate” goods²² produced by a small number of firms – never got a fair trial in the country, Poland, where it was mainly

20. Amartya Sen has studied production and distribution (including some non-material aspects of distribution) but has expressed little concern about ecological sustainability. The Gandhians express concern about sustainability as well as fair distribution, but have never called for increases in production. Some of the affluent among us are concerned about ecological sustainability without having any real concern about humane distribution.

21. See www.eafit.edu.co/minisitios/ambientesurbanos/documents/peterhead.pdf. Attitudes are evolving so fast that by the time this essay is published, new statements by political leaders will have superseded any that might be cited here. Let me note, however, that Manmohan Singh, a leading architect of reducing Indian government controls of the economy, has in recent years paid lip service to the concept of sustainability. On 5th April 2013, for instance, he expressed regret that “economic policies designed to promote growth have been implemented without considering their full environmental consequences” and declared that “It has become clear today that economic development must be environmentally sustainable.” Barack Obama during his campaign for re-election in 2012 to the presidency of the USA said (on September 6th), “And yes, my plan will continue to reduce the carbon pollution that is heating our planet, because climate change is not a hoax. More droughts and floods and wildfires are not a joke. They’re a threat to our children’s future. And in this election, you can do something about it.” It is uncertain to what extent he can keep his promise.

22. “Intermediate goods” means goods that are neither produced directly (like crops) from Nature nor sold directly (like clothes) to consumers. A factory is an intermediate good.

propounded,²³ as that country was exploited economically by the bigger country, the USSR, whose troops were occupying it.

(3) Market economists reckon normally in terms of a single – monetary – kind of measure;²⁴ but money is a medium of social exchange, not of exchange between humankind and its environment. In medical practice it is regarded as scientifically obligatory to assess the patient’s health in terms of various kinds of measure: for age, size, endosomatic temperature, pulse rate, blood pressure, cell counts, chemical analysis, etc.²⁵ Scientific ecological economists would do something analogous. They would have various specialized kinds of *resource literacy*²⁶ (somewhat as many physicians in their post-doctoral professional “residencies” are specially trained in regard to this or that aspect of the human organism) and yet would all be familiar with certain standard kinds of units of

23. Oskar Lange, a leading Polish economist, said, in a letter of 1945 to Friedrich von Hayek, that he would favour in practice the determination of prices by markets wherever this was feasible – which for him meant wherever there were sufficiently large numbers of both purchasers and sellers – but that prices should be set by public agencies in those sectors of the economy where the numbers of sellers or purchasers are low. He held that something analogous happens under capitalism, except that *there* it is monopolies which do the price-fixing rather than agencies acting in behalf of public interest. In 1967 Lange argued, in an essay entitled “The Computer and the Market,” that recent technological developments made it possible to solve in relatively short periods of time the large sets of equations theoretically involved in certain aspects of rational central planning. This did not, however, change his basic view that planners would always have to correct their plans by trial and error. He felt that while computers could be used for making prognostications, it would be unwise to try to replace markets altogether in regard to short-term decisions (economic planners could instead use sophisticated computer models to make forecasts which would then be verified against market data), but that markets are not very useful for long-term economic planning since they work by treating the accounting problem as a static issue. He was alert to the fact that market prices reflect recent conditions but do not provide systematic information as to the possible effects of investment changes, of changes in technical conditions for production, and of the creation of new wants. See Tadeusz Kowalik, Ed., *Economic Theory and Market Socialism: Selected Essays of Oskar Lange* (Aldershot, UK and Brookfield, USA; Edward Elgar; 1994), pp. 298-299 and 361-364. Hayek (who died in 1992) never replied to this latter argument, which thus terminated the “Socialist Calculation Debate”.

24. The “Socialist Calculation Debate” began with a criticism by Ludwig von Mises in 1920 of some ideas expressed by Otto Neurath, who was a Socialist and who while serving in Vienna as a government economist during the World War, I had observed that “As a result of the war, in-kind calculus (*Naturrechnung*) was applied more often and more systematically than before.... It was all too apparent that war was fought with ammunition and with the supply of food, not with money.” (Otto Neurath, Ed. T. Uebel and R. S. Cohen, *Economic Writings 1904-1945* (Kluwer Academic Publishers, 2004), p. 304) Neurath thus came believe in the feasibility of an economic system with planning done in terms of quantitative amounts of specified goods and services, and with no use at all for monetary currency (Oskar Lange opposed such “complete socialization” (*Vollsozialisierung*) in the foreseeable future). See apropos John O’Neill, “Socialist Calculation and Environmental Valuation: Money, Markets and Ecology”, *Science & Society*, LXVI/1 (Spring 2002).

25. The clinical report of a pre-diagnostic “work-up” will also routinely specify, at the outset, gender and (in an interracial society) race along with age.

26. Prof. H.M. Desarda coined this expression. I think the concept is pedagogically valuable. Please note that natural resources include “sinks” as well as “sources”.

physical measure such as for temperature, carbon footprint, groundwater levels, characteristics of soils, Body Mass Index,²⁷ nutrient analysis,²⁸ and presence of various noxious chemicals, dangerous micro-organisms and forms of radiation.

The market economists' one-dimensional estimates of utility²⁹ and per capita "cost of living"³⁰ influenced latently the late 20th- and early 21st-century economists' uses of similarly reductive estimates of such things as "poverty",³¹

27. Body Mass Index (BMI) is a standard kind of measure in medical science, devised in the first half of the 19th century as a tool for use in "social physics." (See http://en.wikipedia.org/wiki/Body_mass_index.) It is reckoned by dividing the person's weight (in kilograms) by the square of his or her height (in metres). (According to the World Health Organization, the normal (healthy) range is from 18½ to 25. The BMI for too many of India's people is lower than 18½; *see* apropos <http://country-bmi.findthedata.org/d/g/India>.)

28. *See* for instance C.P. Timmer, W.P. Falcon and S.R. Pearson, *Food Policy Analysis* (Johns Hopkins University Press, 1983), p. 62. Ecological economists in the 20th century, influenced by the market economists' use of a single kind of unit of measure, would habitually reduce estimates of nutrition to calories. (A one-page description of our elaborate nutritional needs is available at www.academia.edu/3409697/Some_types_of_nutrients.) J.C. Kumarappa knowingly did so when he drew up, in *An Overall Plan for Rural Development* (1946), a table showing how 77,000 acres of land – 66,600 in crops, the rest for "seed and waste" – could provide 100,000 people with a "balanced diet" of *ca.*2850 calories per day (i.e., for people engaged in robust physical work) and enough cotton for their clothing. The Table was an exercise in the use of non-monetary units of measure. Its rows were for various kinds of produce (cereals, beans & peas, molasses, nuts, edible oils, butter, milk, vegetables, potatoes & tubers, fruits and cotton); its columns were for *per capita* weights (ounces daily, pounds annually), surfaces (acres cultivated) and daily calories (except of course in regard to cotton). I note in passing that 100,000 people on 77,000 acres is tantamount to 320 per km², whereas the population density of India now-a-days is some 370 per km².

29. Nicholas Georgescu-Roegen argued well, in an essay entitled "Utility and Value in Economic Thought" in Vol. IV of Philip Wiener's *Dictionary of the History of Ideas: Studies of Selected Pivotal Ideas* (New York 1973), that the neoclassical economists' "assumption that utility, too [i.e., like money], is cardinally measurable" is "truly vulnerable." *See* <http://homepages.rpi.edu/~gowdyj/mypapers/RSE1998.pdf>, p.142.

30. It was during World War I that the federal government of the USA began to compile a comprehensive "consumer price index". *See* www.bls.gov/opub/hom/pdf/homch17.pdf, pp.7-8.

31. Some criteria besides income and assets are used in the "multidimensional poverty index":

Aspects	Indicators	Criteria
Education	Past schooling	No household member has completed five years of schooling
	Current schooling	Any school aged child is not attending school up to class 8.
Health	Child Mortality	Any child has died in family
	Nutrition	Any child or adult has been found to be malnourished
Living Standard	Electricity	The household has no electricity
	Flooring	The household has a dirt, stand or dung floor
	Cooking fuel	The household cooks with dung, wood or charcoal
	Sanitation	The facility is not improved,* or is shared with other households
	Drinking water	The household does not have access to improved* drinking water; or safe drinking water is more than a half hour walk away (roundtrip)

*This term is defined by a technical slandered.

(*See* <http://www.ophi.org.uk/policy/multidimensional-poverty-index/>). But then the index itself is one-dimensional. The details seem to me more informative than the final number.

“happiness”³² and “ecological footprint”.³³ The ecological-footprint numbers and the associated numbers for “ecologically productive surface” are revealing but are in my opinion likely to be superceded in the course of the 21st century by direct estimates of what is happening to the environment.³⁴ I would offer a similar assessment of the more recent concept of “social metabolism”.³⁵

Ecological Degradation

Sustainability is threatened by the cumulative effect of various forms of ecological degradation, including depletions and pollution. Depletion is a matter

32. Happiness theory was developed initially by an American professor of economics, Richard Easterlin, who around 1970 began to entertain doubts that more money always brings more happiness. Having become aware of some surveys asking people how happy they were, he gathered data from various countries and found that in each one, the rich people reported more happiness than the poor but that the happiness-levels for poor countries were often nearly as high as for richer ones. Data from the USA covering from 1947 to 1970 led him to the so-called “Easterlin paradox”: Even though the average family money-wise in the USA became more than 60 per cent richer between 1947 and 1970, this did not make Americans significantly happier. In 1947, about 42 per cent of them surveyed by one pollster said that they were “very happy,” whereas a similar poll found that 43 per cent did so in 1970 (There were some ups and downs in between). His explanation for the paradox is that (a) the more a nation has, the more its people think they are entitled to, and (b) the fact that others whom they know or know about are just as well-off materially as they are detracts from their happiness. A good retrospective anthology, edited by Easterlin, of fifteen articles (by various authors) published originally between 1974 and 2001 is *Happiness in Economics* (Edward Elgar, 2002). “Happiness economics” is now-a-days flourishing as an academic discipline even more in Western Europe than in the USA. The most eminent British researcher in this field has been Professor Richard Layard of the London School of Economics.

33. The main initial publications on ecological footprint were Mathis Wackernagel and William Rees, *Our Ecological Footprint: Reducing Human Impact on the Earth* (New Society Publishers, 1996) and Mathis Wackernagel *et al.*, “National Natural Capital Accounting with the Ecological Footprint Concept”, *Ecological Economics*, XXIX (1999), pp. 375-390. The ecological footprint of a given population (from which a per-capita estimate is obtained by dividing by the number of people in the population) is defined as the total area of ecologically productive land and water – cropland, pasture, forest, marsh, river, sea, etc. – that would with prevailing technologies be required in order to provide on a continuous basis the energy and materials consumed by that population, and to absorb its wastes. Since the reckoning is in terms of two-dimensional surface area, it is inapplicable to aspects of depletion (e.g., of fossil fuels) or pollution (e.g., of air) which call for reckoning in terms of weight or three-dimensional volume. A clever thing about it, however, is that for each national population it can be derived from data which have already been gathered for market economics; the pasture component, for instance, of a given country’s ecological footprint can be estimated from the totals of how much money is being spent in that country for dairy products and from estimating, for that complex of dairy products, how much pasture, not necessarily in the same country, is needed to produce those goods.

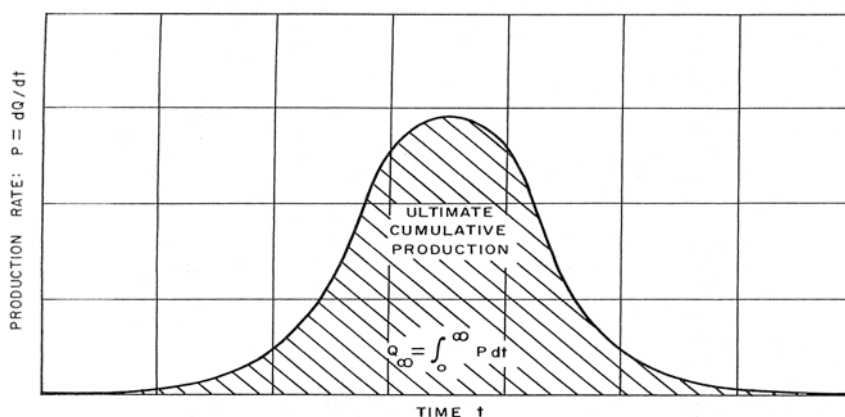
34. Estimates of “general health status” exist (*see* for instance www.healthypeople.gov/2020/about/genhealthabout.aspx) but do not occupy a prominent place in medical science since (a) clinical health care providers usually don’t have time to administer to elaborate questionnaires, and (b) short comprehensive questionnaires are less informative than a bit of physical examination and personal interaction with the patient.

35. *See* www.slideshare.net/environmentalconflicts/an-introduction-to-social-metabolism-and-its-operational-tool-material-and-energy-flow-analysis.

of natural sources running out, pollution a matter of sinks getting overloaded. Depletion includes: (a) exhausting non-renewable *stocks* of mineral resources; (b) drawing upon *flows* of naturally renewable resources faster than they are renewed, and (c) causing the extinctions of too many biological species.

(a) Hubbert Curves are used to make predictions in regard to non-renewable stocks (which are of great interest to market economists). M. King Hubbert, a geophysicist in Texas, devised a model, shown in Figure 2, of how such a stock is likely to be depleted.

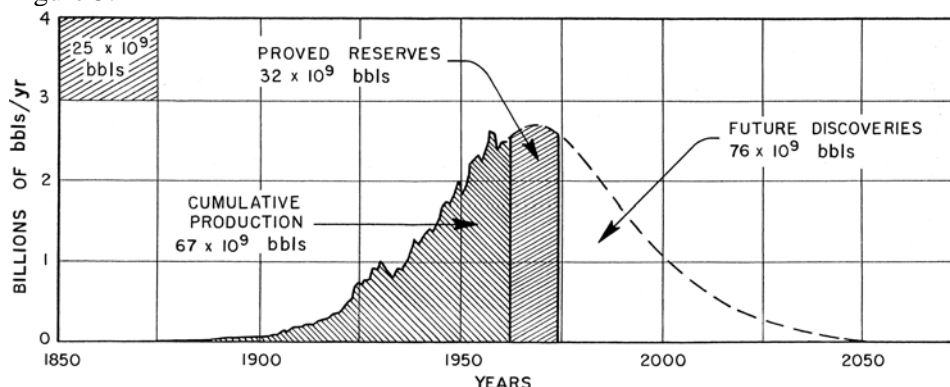
Figure 2:



The area under the curve represents the stock. The height of the curve at any given moment (time is plotted from left to right) represents the rate of its extraction at that moment. The left half of the curve represents an historical progression from slow start-up to a kind of feeding frenzy at the “peak production” moment halfway along the curve. For any given real stock, data is likely to be available for some of the left half of the curve; the method of making a prediction involves using on the one hand an estimate of the total stock and on the other hand a presumption that after half of it has been used, the rate of extraction will slow down pretty much in reverse to the way it had sped up. Hubbert thus predicted in the mid-1950s that peak production from oil wells in the USA would occur sometime between about 1963 and 1973, depending on whether the total stock might be 150 or 200 billion barrels. In 1962 he refined the prediction as shown in Figure 3, using an estimate of $67+32+76 = 175$ billion barrels.³⁶

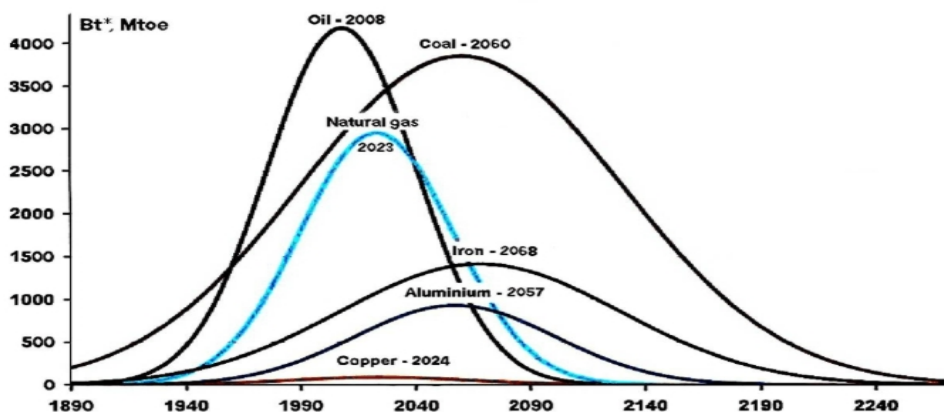
36. M. King Hubbert, *Nuclear Energy and the Fossil Fuels* (Houston 1956), pp. 10 and 22, and *Energy Resources: A Report to the Committee on Natural Resources of the National Academy of Sciences - National Research Council* (Washington 1962), p. 73.

Figure 3:



This prediction of peak production was so accurate (it occurred in 1970) that Hubbert curves are taken seriously by corporations and governments. Figure 4 shows a set of competent recent estimates in regard to worldwide extraction of three kinds of fossil fuels and three kinds of metal (The fuels can be used only once; large amounts of the metals can be recycled, but at a considerable cost in fuels). The number over each curve tells the estimated year of peak production.

Figure 4:



The author of these findings, Alicia Valero, when presenting them at an international economic conference in 2009,³⁷ mentioned that if the stock of a substance is actually twice as big as she has estimated, this would shift the date of its peak extraction only 35 years further into the future. The message is that there will be irreversible declines in this century.

37. See <http://barcelona.degrowth.org>. Prof. Valero's book on this topic (written in collaboration with her father) is *Exergy Evolution of the Mineral Capital on Earth* (World Scientific Publishing Company, 2011).

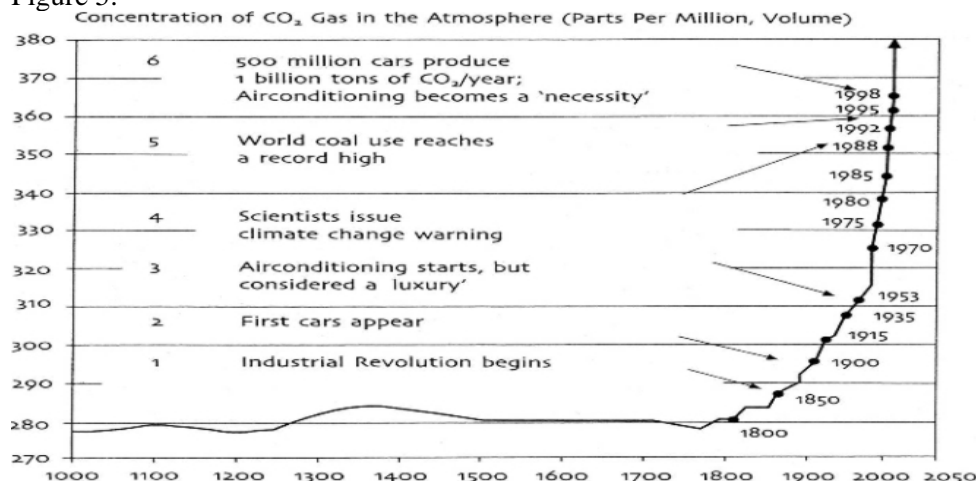
(b) Renewable natural resources which are being used up too fast – i.e., faster than their natural flows are renewed – include the water in several great rivers (no longer flowing into the sea), the wood and greenery in many forests, and various kinds of “micronutrients” in agricultural soils.

(c) I will say something later about extinctions of biological species.

Pollution is, as mentioned above, a matter of natural “sinks” getting “overloaded” (There is always *some* mercury, for instance, in the sea; it is only when the concentration causes some of the fish we eat to become poisonous to us that we say the water is polluted with mercury). There are of course many kinds of pollution, and more and more in modern times. Market economists, regarding them as “external” effects, have not studied them scientifically.

A notable kind of recent overloading of the Earth’s sink-capacities is due to the “greenhouse effect” due in turn to great amounts of fossil fuels having been burnt and the atmospheric concentration of CO₂ having thus increased as indicated in Figure 5.³⁸

Figure 5:



This “carbon footprint” causes the heat produced by our economic activities and wars to be diffused a little more slowly from the atmosphere into outer space. There is now virtually complete scientific consensus that the result is too much heat being retained in the atmosphere and oceans, and hence the climate change which has begun to play havoc with agriculture and economic infrastructure.

38. The most recent data shown in this graph is obsolete. The average concentration in February 2013 exceeded 395 parts per million; see www.esrl.noaa.gov/gmd/ccgg/trends/.

This is but one of many kinds of dangerous pollution which political ecologists³⁹ and responsible governments will have to study and deal with. The ecological degradation includes – in addition to the depletions and the various kinds of pollution – non-polluting dislocations of substances. Two examples are: (a) the dislocation of sand from riverbanks (where it stores water and conveys it laterally to the soil) to make concrete for buildings, roads and dams, and (b) the dislocation of H₂O from glaciers to the ocean, e.g., along the coast of Bangladesh.

Distinguishing between ‘Organisms’ and ‘Systems’

It is beyond the scope of this essay to describe in detail the concepts of “system” and “organism”, but I would like to draw upon the distinction between them. All organisms are systems, but not all systems are organisms.

Because individual humans are organisms, when a patient presents a complaint to a doctor the most effective (for the patient) kind of treatment will most often be one which allows the organism to do its own best to overcome the disease – biological evolution having, in effect, provided the organism with devices for doing this in many cases. This is why a relatively unintrusive medical procedure will – other things being more or less equal – normally be preferred to a more intrusive one.

But neither the world market nor even a national one can qualify as an organism. Medical science recognizes, as characteristic of organisms, a phenomenon called “homeostasis”: Organisms maintain a stable, relatively constant condition of certain physiological and/or chemical properties, such as, in regard to blood, its pH (a measure of alkalinity and acidity), its concentration (i.e., how watery it is) and the level of glucose (a kind of sugar) in it. Mammals and birds maintain also a rather constant temperature inside their bodies (and are therefore, classified as “endothermic”). Many other examples could be cited.⁴⁰

Everyone knows, however, that national markets (and the world market) under capitalism are characteristically subject to booms, bubbles and busts – quite the opposite of homeostasis. A brilliant 17th-century economist who was also a doctor extended the idea of blood circulation metaphorically to

39. See Joan Martinez-Alier, “Environmental Justice and Economic Degrowth: An Alliance between Two Movements”, *Capitalism Nature Socialism*, XXIII/1 (March 2012).

40. The phenomenon was first noted by Claude Bernard in his *Introduction à l'étude de la médecine expérimentale* (1865). (The French word “étude” means “study.”) He called it “*la fixité du milieu intérieur*” and explained that “The living body, though it has need of the surrounding [i.e., exosomatic] environment, is nevertheless relatively independent of it. This independence which the organism has of its external environment derives from the fact that in the living being [i.e., the organism], the tissues are in fact withdrawn from direct external influences and are protected by a veritable internal [i.e., endosomatic] environment which is constituted, in particular, by the fluids circulating in the body.” The term “homeostasis” was coined by Walter Bradford Cannon; see his *The Wisdom of the Body* (Harvard University Press, 1932).

economics,⁴¹ but now-a-days we can tell that the analogy between blood and money is superficial: dollars are simpler than blood (Indeed, many kinds of homeostatic regulation are controlled by the release of hormones into the bloodstream. An example familiar to diabetics is the regulation of blood glucose by means of insulin and glucagon).

(*Laissez-faire* ideologues posit a quasi-organic market, but its theoretical features are unreal in too many ways. A few well-known examples⁴² are the postulates that market equilibrium entails full employment,⁴³ that there is a virtually infinite number of agents in the market, none of whom can exert a substantial degree of influence on the price of anything;⁴⁴ that they all have perfect knowledge of the relevant aspects of what is happening in the market;⁴⁵ and that there are no barriers to firms entering any market and so productive inputs are perfectly mobile to migrate to their most productive use.)

Nor is the Earth an organism. Let me mention here not only that kidneys perform (in mammals) a vital role in homeostatic regulation by removing excess water, salt, and urea from the blood, but also that the waste is then emitted from the organism. The fashionable “Gaia Hypothesis” – to the effect that the Earth is an organism – ignores the fact that organisms do not retain, as the Earth does, their waste products.⁴⁶ All organisms ingest and emit chemical substances.

41. François Quesnay, manuscript “*Tableau Économique*” (1659). Quesnay had read William Harvey’s *De Motu Cordis* (1628). (In Book V of Plato’s *The Republic*, an analogy between a well-ordered society and a well-ordered individual human soul is said to be the key to answering correctly the question, “What is justice?”. Gratuitous anthropomorphism is not, however, a hallmark of scientific thinking.)

42. I have taken most of this list of postulates from John M. Gowdy, *Microeconomic Theory Old and New: A Student’s Guide* (Stanford University Press, 2010), pp. 61-62.

43. Keynes, *The General Theory of Employment, Interest and Money* (1936). (It seems to me that “Say’s Law” – according to which “a glut [in the market] can take place only when there are too many means of production applied to one kind of product and not enough to another” (Jean-Baptiste Say, *Traité d’économie politique, ou simple exposition de la manière dont se forment, se distribuent et se consomment les richesses*, 1803; the title means “A Treatise on Political Economy, or, A Simple Exposition of the Way in which Riches are Formed, Distributed and Consumed”; pp. 178-179) – is likely to be valid when a substantial number of people have money and unmet material needs. But what about a situation when people have *either* money *or else* unmet material needs and practically no one has both?)

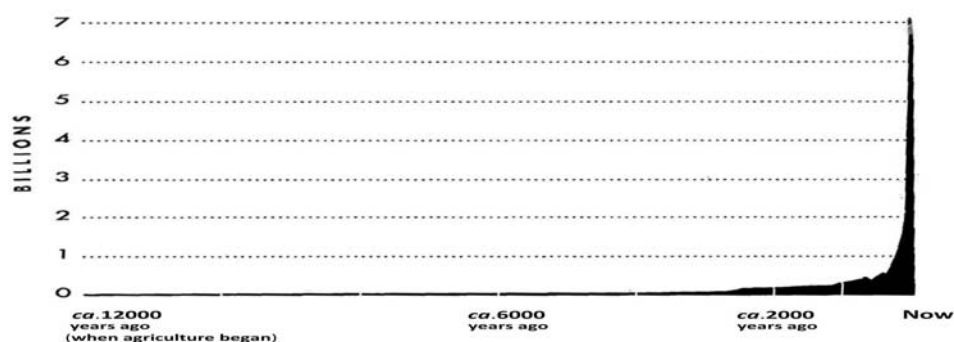
44. Joan Robinson, *The Economics of Imperfect Competition* (1933) and Edward Hastings Chamberlin, *The Theory of Monopolistic Competition* (1933).

45. See http://www.nobelprize.org/nobel_prizes/economics/laureates/2001/popular.html and www.nobelprize.org/nobel_prizes/economics/laureates/2001/advanced-economicsciences2001.pdf.

46. Lynn Margulis, a great microbiologist who studied the Gaia Hypothesis in detail, explained in the 1990s: “The Gaia hypothesis states that the temperature [!] of the planet ... and ... the atmospheric gas composition – the 20 per cent oxygen [etc.] – [are] actively maintained by living matter.... The Gaia hypothesis is a biological idea, but it’s not human-centred. Those who want Gaia to be an Earth Goddess for a cuddly ... human environment ... can buy into the theory only by misinterpreting it.... [James] Lovelock [who invented the Gaia Hypothesis in the 1960s] would say that Earth is an organism ... [but in fact] no organism eats its own waste. ... Lovelock’s position is to let the people believe that Earth is an organism, because if they think it is just a pile of rocks they ... mistreat it [whereas] if they think Earth is an organism, they’ll tend to treat it with

The Earth may in effect have been economically as good as an organism back when humankind numbered less than, say, five million (*see* Figure 6) and agriculture – not to mention industry – was ecologically far less consequential than now. But those days are gone. Preserving wilderness will not suffice to solve the problems caused by modern environmental degradation; radical technological innovations, based on a sophisticated and “resource-literate” grasp of ecological realities and prospects, will also be required.⁴⁷

Figure 6:



It should be noted, however, that when we refer to “co-evolution” and, in particular, to “stability” and/or “resilience” in an ecosystem, we are implying that the system has a degree of quasi-organic virtue, albeit more or less vulnerable to destruction by introducing alien species or by changes in physical circumstance such as temperature. Such virtue of a given ecosystem may be of great economic value, which should be properly appreciated even as we avoid any mystical ideology of primeval ecosystems.⁴⁸

respect. To me, this is a [would-be] helpful cop-out, not science.... This planet’s surface and its atmosphere and environment will continue to evolve long after people and prejudice are gone.” (*See* www.edge.org/documents/ThirdCulture/n-Ch.7.html.)

47. According to Kumarappa, *Economy of Permanence* (1945), Chapter 5: “[M]an ... is endowed with a ‘free will’ and possesses a wide field for its play. By exercising this gift in the proper way he can consciously bring about a much greater coöperation and coördination of Nature’s units than any other living being. Conversely, by using it wrongly he can create quite a disturbance in the economy of Nature, and in the end destroy himself” (On the first page of the book, “permanence” in economics is vaguely but wisely defined as “astronomical” time-spans, i.e., shorter than major cosmic time-spans).

48. Gandhi in the 29/v/1927 issue of his Gujarati periodical *Navajivan* said that Nature (*kudarata*) makes readily available, without entailing misery for anyone, just enough for everyone’s needs food-wise: “If Nature ... has implanted in its creation the instinct for food, it also produces enough food to satisfy that instinct from day to day. But it does not produce a jot more. That is Nature’s way. But man, blinded by his selfish greed, grabs and consumes more than his requirements in defiance of Nature’s principle, in defiance of the elementary and immutable moralities of non-stealing and non-possession of other’s property, and thus brings down no end of misery upon himself and his fellow creatures.” In 1947 he reduced this to a more sensible admonition: that the “Earth [*prithvi*] provides enough to satisfy every man’s need but not for every man’s greed.” This

C.S. Holling explained as follows the difference between “stability” and “resilience” in an ecosystem:

“[T]he behaviour of ecological systems could well be defined by two distinct properties: resilience and stability. Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes ... and still persist.... Stability, on the other hand, is the ability of a system to return to an equilibrium state after a temporary disturbance. The more rapidly it returns, and with the least fluctuation, the more stable it is.... [A] system can be very resilient and still fluctuate greatly, i.e., have low stability.... In ... areas subjected to extreme climatic conditions, the population fluctuate widely but have high capability of absorbing periodic extremes of fluctuation. They [the populations] are ... unstable ... but highly resilient. In more benign, less variable climatic regions, the population are much less able to absorb chance climatic extremes even though the populations tend to be more constant. The balance between resilience and stability is clearly a product of the evolutionary history of these systems in the face of the range of random fluctuations they have experienced.”⁴⁹

‘Full-World’ Uncertainties

In pondering humankind’s prospects, it is useful to draw upon the distinction made in 20th-century market-economic theory between (a) “risk”, which can be calculated inductively from data based on experience if one has reason to believe that the relevant aspects of reality will in the future resemble the way they were in the past, and (b) “uncertainty”, which is our condition if we know that the future will differ substantially from the past and we have no trustworthy basis for predicting how much it will differ.⁵⁰ Our 21st-century macro-ecological prospect

latter statement is reported in Pyarelal, *Mahatma Gandhi - The Last Phase*, Part II (1958 and later editions), in the chapter entitled “Towards New Horizons.”

49. C.S. Holling, “Resilience and Stability of Ecological Systems”, *Annual Review of Ecological Systems*, IV (1973), pp. 17-18.

50. This distinction dates back to 1921, when Frank Knight’s *Risk, Uncertainty and Profit* and Keynes’s *Treatise on Probability* were published. Here is Knight’s account (p. 233) on the pivotal difference: “The practical difference between the two categories, risk and uncertainty, is that in the former the distribution of the outcome[s] in a group of instances is known (either through calculation *a priori* or from statistics of past experience), while in the case of uncertainty this is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with, is in a high degree unique.” Keynes noted (p. 302) that the issue of uncertainty was at the heart of a famous precept of the 18th century British philosopher, David Hume: “Hume’s skeptical criticisms are usually associated with causality; but argument by induction inference from past particulars to future generalizations was the real object of his attack.”

Rachel Carson was a first-rate marine biologist and writer who in the 1950s and ’60s led some Americans to see the need for ecological economics. Her last book, *Silent Spring* (1962), includes dozens of implicit references to scientific uncertainty: statements like “No one knows whether the same effect will be seen in human beings”, “How lethal these lawns may be for human beings is

is uncertain because of the combined effect of our historically unprecedented levels of (1) various kinds of per-capita pollutions, depletions and ecological dislocations and (2) worldwide population (*see* Figure 6).

There is a marginal status between uncertainty and risk. It occurs when we have a certain basis for predicting the difference between the past and future conditions, but also have reason to believe that the basis is less adequate than we would like. Here is an example related to the topics of biodiversity and the survival and extinction of biological species (of which humankind is one): Scientists in the relevant disciplines estimate that in the last 500 million years the average duration of a species has been between five and ten million years, with an average of some 0.0001 per cent per year becoming extinct, and that the current rate of extinctions is about a thousand times as fast, i.e., something like 0.1 per cent per year.⁵¹ It is uncertain just how dangerous to humankind this latter rate is, but it is certain that if one per cent of the number existing this year were to become extinct each year thereafter, humankind could not survive for another century.

Keep in mind that a modicum of prudence is called for in the face of high-stakes risk or uncertainty. The boy who cried wolf when it wasn't there made a foolish mistake; the villagers made a bigger mistake by disregarding him later.

The economics profession has honoured Robert Solow for dismissing such concerns. He said:

"If it is very easy to substitute other factors for natural resources, then there is, in principle, 'no problem'. The world⁵² can, in effect, get along without natural resources.... If, on the other hand, real output per unit of [natural] resources ... cannot exceed some upper limit of productivity ... then

unknown" and "The whole concept of genetic damage by something in the environment is also relatively new, and is little understood except by the geneticists, whose advice is too seldom sought."

51. *See* http://wwf.panda.org/about_our_earth/biodiversity/biodiversity/ (yes, this last word twice). *See also* www.mysterium.com/extinction.html and Anthony D. Barnosky *et al.*, "Has the Earth's sixth mass extinction already arrived?", in *Nature*, Vol. 471, pp. 51-57, the abstract of which is as follows: "Palaeontologists characterize mass extinctions as times when the Earth loses more than three-quarters of its species in a geologically short interval, as has happened only five times in the past 540 million years or so. Biologists now suggest that a sixth mass extinction may be under way, given the known species losses over the past few centuries and millennia. Here we review how differences between fossil and modern data and the addition of recently available palaeontological information influence our understanding of the current extinction crisis. Our results confirm that current extinction rates are higher than would be expected from the fossil record, highlighting the need for effective conservation measures."

52. Robert Solow, "The Economics of Resources or the Resources of Economics", *The American Economic Review*, Vol. LXIV/2 (1974), pp. 1-14. Solow meant to imply that there is a material human "world" apart from the natural world. If he had said that the natural world could "get along without natural resources" his glibness would have been instantly apparent to everyone. The glibness is evident enough from the following sentence on the first, jocular page of the essay: "The world has been exhausting its exhaustible resources since the first cave-man chipped a flint, and I imagine the process will go on for a long, long time."

catastrophe is unavoidable.... Fortunately, what little evidence there is suggests that there is quite a lot of substitutability between exhaustible resources and renewable or reproducible resources."⁵⁰

All scientists know that photosynthesis is indispensable to humankind; no scientist would leap from "quite a lot of substitutability" to getting along "without natural resources"; and no genuinely scientific institution would, as the Swedish Royal Bank did by awarding Solow its Nobel Memorial Prize in Economic Sciences, honour such obfuscation.

And yet scientific economists may indeed combine the precept of substitutability with a precept of converting waste by-products into useful substances. This latter point can be deduced from two facts mentioned above: (1) that the Earth neither ingests nor emits substances (to any significant degree) and (2) that organisms do ingest and emit substances. Such being the case, it is likely *a priori* that some emitted wastes become organic resources. Twenty-first century civil engineers may devise various new techniques of applying this principle to currently wasted by-products, and governments may, by applying such precepts as "polluter pays" and "extended producers' responsibility", nudge the market toward using those techniques.⁵³

The necessary 21st-century human managing of the environment will, however, involve uncertainties analogous to those which doctors have to accept in some of their relatively insecure prognostications (less secure in regard, say, to certain cancers than to appendicitis). The ecological economists will not be like engineers designing bridges.⁵⁴ Even at their scientific best they may often have to rely on wisdom just as much as the USA Federal Reserve Bank's notoriously

53. Alfred Marshall's chosen successor as professor of economics at Cambridge, A.C. Pigou, envisaged such a role for government in regard to certain kinds of depletion: "Sometimes people use methods that, as against the future, cost much more than they themselves obtain. Fishing operations so conducted as to disregard breeding seasons, thus threatening certain species of fish with extinction, and farming operations so conducted as to exhaust the fertility of the soil, are instances in point.... It is the clear duty of Government, which is the trustee for unborn generations as well for its present citizens, to watch over, and, if need be, by legislative enactment to defend the exhaustible natural resources of the country from rash and reckless spoilation" (Pigou, *The Economics of Welfare*, London 1920, Part I, Ch. 2, Para. 5).

54. In a theoretical discussion of "novelty by combination", Georgescu-Roegen related (a) the fact that the known "laws" of social science – and indeed of biology – have little predictive power to (b) the fact that those of chemistry have less predictive power than those of physics. He said: "The rules that are now used for predicting the qualities of a substance from its chemical formula are spotty. Moreover, most of them have been established by purely empirical procedures and, hence, are less likely [than the known laws of physics] to carry much weight beyond the cases actually observed.... For a chemist the behaviour of a newly obtained compound may display many novelties. Yet, once this chemical compound has been synthesized, the next time the chemist prepares it he will no longer be confronted by another novelty by combination: matter, at the physico-chemical level, is uniform. More often than not, [however] this permanence is absent from the organic and superorganic domain[s] [of reality]. For a glaring yet simple example: in some human societies, the bride is bought, in others she brings a dowry into the new family, and in still others there is no matrimonial transaction of any sort" (*The Entropy Law and the Economic Process*, Harvard University Press, 1971, pp. 115-117).

unscientific market-economists relied on haphazard guesses in 2007 in regard to the approaching financial crisis.

There are nevertheless some significant differences between the market-economists' mistaken claim of practicing a science that is like physics and a correct recognition of the relationship between economics and medical science. The correct view would support a balanced approach to the trilemma described above in Figure 1, whereas recent history has shown (I believe) that the market-economists' mistaken claim of being like physicists tends to support a *laissez-faire* ideology.

There will continue to be some big uncertainties about markets due directly or indirectly to ecological problems.⁵⁵ Even perfectly sensible investors will have more difficulty than in the grand days of capitalism when manufacturing was regarded as more important than agriculture because the adequacy of the latter could be taken for granted; that premise may be invalidated if climate change does its worst.

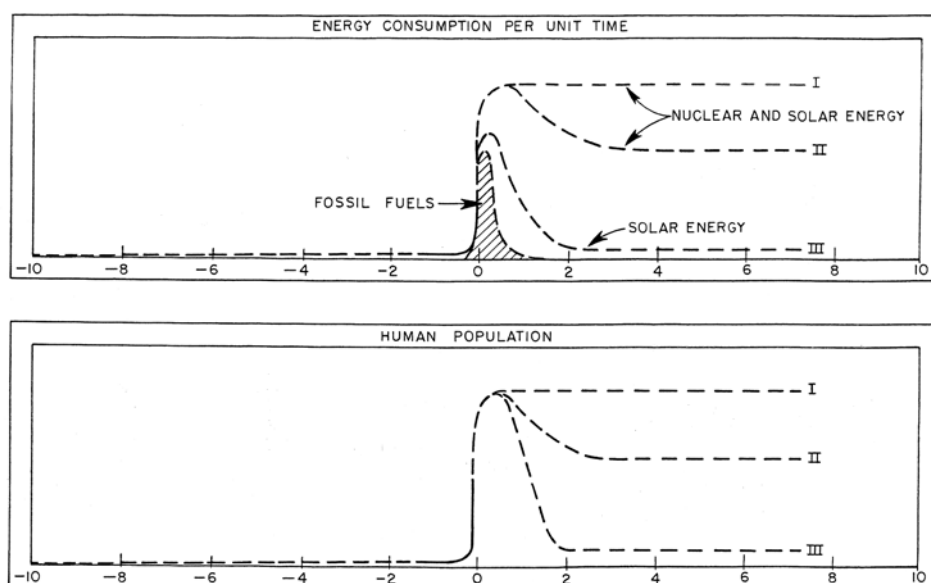
Hubbert envisaged three possible long-term results, labelled "I", "II" and "III" in his relevant graphs, two of which are shown in Figure 7.⁵⁶ The other graph envisaged a similar set of alternatives in regard to per capita consumption of energy. He said that if "foresight can be exercised with respect to the guidance of human affairs" and if "the cultural lag can be sufficiently reduced between [a] the inhibitory sacred-cow behaviour patterns which we have inherited from our recent past, and [b] the action requirements which are necessitated by the socio-industrial complex with which we have to deal," then the long-term outcomes might be somewhat as charted by the lines tagged with the Roman numeral "I" in the graphs, but that a "serious overshooting of the world population above a manageable level" would entail "a temporary state of chaos" (by "temporary" he meant, as the graphs show, *ca.* 2000 years) and one of the other two kinds of long-term outcome (tagged with "II" and "III"), depending in how much wisdom and savvy would be applied during that period. (The term "solar energy" in the first graph covers old-fashioned as well as new-fangled ways of converting the sun's daily radiation into consumable energy. One old-fashioned way is via animals' muscle power). My own opinion is that Option I cannot be realized and, therefore, the wisest course would be to aim for achieving Option II with as few Malthusian disasters as possible.⁵⁷

55. A relevant recent (as of the time this essay is being written) report is accessible on the Web at www.carbontracker.org/wastedcapital.

56. Hubbert, *Energy Resources: A Report to the Committee on Natural Resources of the National Academy of Sciences - National Research Council* (Washington 1962), pp. 134-135.

57. According to Thomas Malthus (*An Essay on the Principle of Population*, London 1798, Chapter VII, next-to-last paragraph), "The power of population is so superior to the power of the earth to produce subsistence for man that premature death must in some shape or other visit the human race. The vices of mankind are active and able ministers of depopulation. ... [If] they fail in this war of extermination, [then] ... epidemics, pestilence, and plague [will do it, or else] famine." (See www.econlib.org/library/Malthus/malPop.html#).

Figure 7:



Conclusions

Keynes's observation, cited near the beginning of this essay, that the material to which economic theorising is applied is "not homogeneous through time" may be complemented with Joseph Schumpeter's concept of fresh doses of "pre-analytical" thought intervening now and then in the history of any science (or, let me add, would-be science). According to Schumpeter,

*"Analytic effort is of necessity preceded by a pre-analytic cognitive act that supplies the raw material for the analytic effort.... It is interesting to note that [pre-analytic] vision of this kind not only must precede historically the emergence of analytic effort in any field but also may re-enter the history of every established science each time somebody teaches us to see things in a light of which the source is not to be found in the facts, methods, and results of the pre-existing state of the science."*⁵⁸

A growing number of insightful people have been teaching us to begin to see economics in a new light. This being so, it seems to me that:

- Economists aspiring now-a-days to become genuinely scientific should, in addition to replacing the traditional Economic-Man premise with an experimentally refined and validated concept of human nature, study enough geology, geography, demography, meteorology, agronomy,

58. Joseph Schumpeter, *History of Economic Analysis* (1952 and later editions), in Chapter 4 ("The Sociology of Economics") the section entitled "The Scientific Process: Vision and Rules of Procedure".

chemistry, biology, biochemistry and ecology to become resource-literate (with due regard for the fact that natural resources include sinks and ecological cycles as well as sources), and should study hygiene, nutrition, demography and epidemiology and to fill out their knowledge about material relations between humankind and its environment.

- Students of economics may find it intellectually worthwhile, in the present context of a certain degree of guild-protectiveness among academic market-economists,⁵⁹ to counter it by accumulating a modicum of knowledge of the history of economic theory even if one's professors are unable or unwilling to teach it. A few appetizing (I hope) slices of that history are in footnotes to this article.
- Anyone who has achieved affluence or upon whom it has been bestowed should – especially if she is inclined to wonder about the economic and hence social conditions under which her infant and unborn descendants are to live – ponder the following implicit analogy between (a) a medical patient with an unhealthy life style, and (b) a society overstocked with dopey consumerists.⁶⁰
- A problematic medical case is most likely to turn out well if the doctor gives the patient good advice about weight, diet, exercise, and narcotics, and if the patient follows it and learns to enjoy life even so.

59. See William N. Parker (Ed.), *Economic History and the Modern Economist* (Oxford University Press, 1986).

60. Rather than to declare that any particular society is like this, I leave it to the reader to surmise whether such a society exists. The following broad historical surmise (from Kenneth Boulding "The Economics of the Coming Spaceship Earth", 1966; see <http://dieoff.org/page160.htm>) is relevant: "Primitive men, and to a large extent also men of the early civilizations, imagined themselves to be living on a virtually illimitable plane. There was almost always somewhere beyond the known limits of human habitation ... some place else to go when things got too difficult either by reason of the deterioration of the natural environment or a deterioration of the social structure in places where people happened to live.... The closed earth of the future requires economic principles which are somewhat different from those of the open earth of the past.... I am tempted to call the open economy the 'cowboy economy,' the cowboy being symbolic of the illimitable plains and also associated with reckless, exploitative, romantic, and violent behaviour, which is characteristic of open societies. The closed economy of the future might similarly be called the 'spaceman' economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy. The difference between the two types of economy becomes most apparent in the attitude towards consumption. In the cowboy economy, consumption is regarded as a good thing and production likewise."

