Beyond Supply and Demand

Entropy and Information in Economic Science

www.profitandentropy.com

E T Jaynes, from *How Should We Use Entropy in Economics?* 1991)

> [That] an economic system is in some ways like a mechanism… is recognized in all theories. But it is really more like a thermodynamic system than [like] a mechanism - an analogy also recognized by others, but not yet developed sufficiently to judge the possibilities…
> … On this analogy, the failure of Keynesian and monetarist mechanisms to account for recent economic behavior would be attributed at least in part to failure to recognize the entropy factors that must ultimately control economic change and equilibrium, just as they do in thermodynamics…

Albert Einstein, quoted in M.J. Klein, *Thermodynamics in Einstein's Universe*, in Science, 157 (1967), p. 509.

> [A law] is more impressive the greater the simplicity of its premises, the more different are the kinds of things it relates, and the more extended its range of applicability. Therefore, the deep impression which classical thermodynamics made on me. It is the only physical theory of universal content, which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown.

Sir Arthur Stanley Eddington, in *The Nature of the Physical World*. Macmillan, New York, 1948, p. 74.

> The law that entropy always increases -- the second law of thermodynamics -- holds I think, the supreme position among the laws of Nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations - then so much the worse for Maxwell equations. If it is found to be contradicted by observation - well these experimentalists do bungle things sometimes. But if your theory is found to be against the Second Law of Thermodynamics, I can give you no hope; there is nothing for it but to collapse in deepest humiliation.

Appreciation

The authors wish to express their appreciation of the work of

Edward Thompson Jaynes, 1922-1998, Wayman Crow Distinguished Professor of Physics at Washington University, St. Louis. We have freely adapted ideas from his remarkable essay, *How Should We Use Entropy in Economics?* We refer the reader to: http://bayes.wustl.edu/

Richard Goldwater rpg@profitandentropy.com Newton Center, Massachusetts
Arthur Jonath aj@profitandentropy.com Portola Valley, California

Our motto: Steve Jobs did not give a damn about supply and demand.
He understood Buyer-Seller temperatures, and built the most valuable corporation in history. AJ

Table of Contents

Beyond Supply and Demand

Entropy and Information in Economic Science[1]

 By Richard Goldwater and Arthur Jonath

"Capitalism is the extraordinary belief that the nastiest of men, for the nastiest of reasons, will somehow work for the benefit of us all." [2]

Part I: Toward Reconciling Economics and Natural Science

Introduction: We Need a Thermo-Economics

Vast resources cannot provide clear, scientific answers to complex economic questions. Internet searches for root causes and mitigating solutions in 2012 to the 2008 financial collapse bring 25 million responses, but no consensus. President Harry Truman wanted a one-armed economist who could not answer, "On the one hand, and on the other".

Early proponents based economics on natural science. Adam Smith in 1776 associated a Law of Supply and Demand with Newton's Laws of Motion.[3] Mid 19th Century economists inserted economic variables into the First Law of Thermodynamics.[4] Both are laws of conservation and balance that cannot account for anything new or unpredictable. Neither can recognize an expanding economy, an expanding universe, or the accumulation of profit.

Many still expect the "genius of the free market" to rein in business behavior. Instant communication, super-sized databases, superfast computation, and mathematical chicanery have by now fostered a brave, new chaos that only a proper science can resolve. A complete economics must account for innumerable Buyers and Sellers, and their individual transactions. Statistical mechanics is accepted theory that quantifies interactions among billions of entities, the results of which reduce to and confirm the Second Law of Thermodynamics.[5]

The Second Law describes the flow of thermal energy from warmer A to cooler B. *We propose a "Thermo-economics" that compares currency flow (in dollars) to heat flow (in joules) from warmer person A (the Buyer) to cooler person* B (the Seller). In a model "economic engine", ignited currency flow (a sales transaction) produces goods, services, and wealth.

Correspondence with Nature: Analogy Presents the Case

Cultures create characteristic analogies from perceptions of nature. Traditional analogy is symbolic. Greek myths organized stars into heroic constellations. Shakespeare's characters saw portents in comets and lightning. People still consult astrologers, and attribute intentionality to nature, as if disease punished sin, or as if it rained to ruin a picnic.

Since the European Enlightenment, perception has become increasingly objective: mathematical and statistical. Physicists still argue by analogy -- according to the "parsimony

---

[1] The authors are grateful to Micah Goldwater, Ted Lehman, Ab Kader, and Richard Kullberg.

[2] Attributed to economist John Maynard Keynes

[3] Copious references, including "Isaac Newton's Influence on Adam Smith's Natural Laws in Economics", Norriss S. Hetherington, Journal of the History of Ideas, Vol. 44, No. 3 (Jul. - Sep., 1983), pp. 497-505, University of Pennsylvania Press

[4] *The Economist Has No Clothes* by Robert Nadeau, **Scientific American**, April, 2008

[5] Thanks to Robert P. Wolf, Prof. Emeritus, Physics, Harvey Mudd College, Claremont, CA.

principle", that there are only a few, fundamentally different phenomena.[6]

"Isomorphism" is especially rigorous analogy, a precise mathematical mapping from A to B, leading to the question: if their math is the same, are they the same? If economic mathematics is the same as Newton's, is economics Newtonian physics? Do dollars act like Newtonian quantities, because they are quantifiable? Economists assume that they do.

Yet no one can be satisfied that economics describes and predicts, as a science ought. Economists blame the problem on not yet quantified "quirks" of human motivation. They refer to consumers more than to businesspeople, financiers, or economists. We shall describe an economy as an engine guided by the Second Law of Thermodynamics. Motivation might describe why someone starts an engine, but an engine works according to its own laws.

"Crises in Physics and Economics" *by ET Jaynes*[7]

"Physics is by far the oldest of the quantitative sciences, so it is hardly surprising that some of the … problems arising in newer sciences have turned out to be almost identical with [those] recognized and solved long ago in physics. As we read in the newspapers, both Keynesian [favoring government intervention] and Monetarist [favoring the unregulated, free market] economic theories have been unsuccessful in accounting for recent economic behavior. …. Of course, this does not mean that all their equations are wrong… It does mean that both systems are incomplete.

"Physics has been in methodological crisis many times. …Eventually we are forced to recognize that .. no amount of computing power, no amount of mathematical skill in manipulating the old variables can help us - only new ideas…. At the turn of the Century, we learned that the real world of physics is not describable merely in terms of particles interacting via central forces in imitation of Newtonian cosmology. This was the methodological crisis that Albert Einstein and Max Planck faced; their conceptual innovations started our present relativity and quantum theories.

"Today, it appears that the real world of economics might not be describable merely in terms of conventional [Newtonian] macroeconomic variables (unemployment rate, GNP, aggregate demand, etc.) If so, then a conceptual innovation is called for. So, what is the missing factor?

"An economic system is in some ways like a mechanism, as is recognized in all theories. But it is really more like a thermodynamic system than a mechanism - an analogy also recognized by others, but not yet developed sufficiently to judge the possibilities"...

Newton's Third Law of Motion versus the Second Law of Thermodynamics

To address Dr. Jaynes' "Crises", we distinguish "Newtonian" from "thermodynamic".

Newton's 17th Century Laws of Motion describe the universe as a frictionless mechanism in eternal equilibrium and perfectly repeating, perpetual motion. Nothing new can happen; the future is redundant. Otherwise, the sun would not rise as predicted! Nothing can accumulate, not even time. There is no point of view. Newtonian time is a universal present moment from which past and future look identical. One can prove this; solving Newton's equations of motion using either negative or positive time yields the same result.

In Newton's universe, any action produces an immediate, equal and opposite reaction, and energy moves around without loss. Newton's Laws are thus zero-sum, or "no net change". Sporting contests are zero-sum: a winning team goes one-up and the losing team

---

[6] Credited to Richard Feynman.

[7] from *How Should We Use Entropy in Economics?* by ET Jaynes 1991

one-down in the standings; +1,-1 add to zero. A child's see-saw is zero-sum; as one side goes up, the other goes down, and vice-versa.

Barter is zero-sum. Barter exchanges objects of intrinsic value, like a horse for a cow. Barter uses no currency, and so generates benefit, but not profit. Each barter exchange occurs in its own present moment. Barter does not lead to a next transaction.

The Second Law of Thermodynamics is not zero-sum; *time accumulates*. Accumulating profit renders economics not zero-sum, and so brings economics toward the purview of the 2nd Law. Profitability implies succession, a potential next transaction. In Thermo-economics, profit is time, time is profit, profit is success, and success is the next transaction.

We may immediately distinguish Newton's Laws from the Second Law as *"action-and-reaction" versus "cause-and-effect"*. Action-reaction are simultaneous, while a cause precedes an effect. A rifle recoils exactly as a bullet flies away. This is simultaneous and symmetrical, action-and-reaction -- even if Newtonians call it cause-and-effect. Gunpowder ignites *before* a bullet flies away. This is sequential, time-asymmetrical "cause producing an effect". Causality releases energy and uses up fuel, in this case, gunpowder.[8]

There was no great need to understand either causality or fuel until the mid-19th Century, when industry sought to harness the horsepower of steam engines. Suddenly fuel mattered. As it became obvious that one could not use the same fuel twice, people realized that time must go one way, and not the other. Progress was born, and its name was the Second Law of Thermodynamics, the Law of Laws that none may contradict.

The Second Law describes a hot cosmos that opens with a Bang, and expands into space and time until all hot-cold differences shall average out in a universal "heat-death". Thermodynamics insists: "Nature abhors a gradient",[9] but adores an equilibrium. Or, nature destroys gradients and creates equilibria. The Law describes heat flow from warmer to cooler temperatures toward equilibrium. Heat may not spontaneously flow from equilibrium to distinct, hot and cold states. The universe seeks thermodynamic equilibrium.

The complex structure of fuel molecules stores energy; ignition releases energy and destroys structure. Engines can extract work from energy as it flows from hot ignition to cooling system, transforming old, storage structure into new structure. No use of fuel can be perfectly efficient, however.[10] There is always a *net loss of structure, of "order"*. Even the most elegant or creative actions waste fuel, and so create overall more disorder than order. A functioning engine keeps itself from equilibrium by exhausting its waste as pollution into its environment, and refreshing its temperature gradient with new, ignited fuel.

The 2nd Law predicts losses of order as engines convert energy into work. Increasing entropy measures disorder as energy no longer available for work. Entropy is maximum at equilibrium. The universe seeks thermodynamic equilibrium and creates entropy en route.

A corollary: because fuel can only burn once, *every fueled event is new*. Releasing energy from storage in atomic or molecular order is a new and unrepeatable event. This newness is

---

[8] It follows that while a "cause" must have at least one discernible effect; any "effect" may have had many causes. Because cause-and-effect do not reverse, no "retrospect-o-scope" can always guarantee which possible cause was a root cause – even the proverbial "smoking gun". The post-facto analysis of many disasters both economic and physical will be incomplete.

[9] *Into the Cool: Energy Flow, Thermodynamics, and Life*; E.Schneider and D.Sagan; Univ. Chicago Press, 2005. See also Swenson, op.cit.

[10] Some released energy remains "transformational" forever.

alas not innovation or creativity, but just increasing entropy. Waste happens. Waste is the only thing that can be guaranteed to happen. By waste, we mean the net loss of order into randomness. This is the thermodynamic equivalent of Original Sin. Life pollutes.

Time is non zero-sum experience. There is more time in the universe today than yesterday; the universe is older, and so are we. Time and space expand together; the universe is older *and* bigger today. Entropy accumulates, too.

Entropy increases as energy releases, whether due to the burning of stars, the metabolism of organisms, and the bustling of economies. As the only quantity that increases with time everywhere, the 2nd Law identifies increasing entropy as the "arrow of time".

Just as gravity defines "down", increasing entropy defines the sense of forward time.[11]

We find two distinct ideas of equilibrium, one ideal and the other not. Newtonian equilibrium is serene repetition, like the space station spinning to a Strauss waltz in the film, *2001*, or like rows of identical, praying Buddhist monks. Newtonian equilibrium is other-worldly. Thermodynamic equilibrium is the death of anything that is not average. Perhaps social networks that herd everyone toward "average" are agents of increasing entropy. Is the spread of information since the printing press "increasing entropy"?

The 20th Century, mathematical "information theory" grew out of thermodynamics. In information theory, entropy combines with order to construct individual messages. Information theory broke enemy codes during World War II, and empowers your smart-phone to talk to you today. It is real progress to recognize that *information is* as *fundamental as matter and energy, and that order and chaos are information states*. We shall have more about "information economics" toward the end of this document.

A complete economic science must account for innumerable Buyers and Sellers, and the individual transactions that generate macroeconomics from microeconomics. Statistical mechanics is accepted mathematical theory that quantifies interactions among billions of entities, the results of which reduce to and confirm the Second Law of Thermodynamics.[12]

The Failure of Newtonian Economics

Is economics either a physical or a social science? Economists are divided. Any claims of a basis in physical science rest upon The Law of Supply and Demand, a theory of opposing forces that actively equilibrate toward price stability. Supply-demand compares an economy to a pendulum, or to a cradle guided by an Invisible Hand.

Neither supply nor demand can be tested as a force. Neither has precise causes nor unambiguous, measurable effects. Regardless, unfettered freedom to equilibrate is the kernel of the call for less regulation of business and finance, and for a freer hand for strategy.

Adam Smith's economics mixed religion and science. Supply-demand may resemble Newton's Law, but Smith's law also plays a divine role to keep an unregulated marketplace in balance. Smith combined the objectivity and religiosity so effectively that many assume that the most rapacious behavior fits into god's plan.

---

[11] Attributed to Ludwig Boltzmann

[12] Thanks to Robert P. Wolf, Prof. Emeritus, Physics, Harvey Mudd College, Claremont, CA.

Supply-demand is a theory of price, not profit. Adam Smith's economics considers itself ideally zero-sum. Supply goes down or demand goes up; prices go up. Supply goes up or demand goes down; prices go down – minimizing profits toward a profitless, zero-sum.

Economists rationalize profit as "inefficiency" in the supply-demand mechanism that prevents perfect price equilibrium. In a theoretical state of perfect competition, profits reduce to "normal profits", the minimum necessary to make running a business worthwhile. Profits beyond normal are "economic profits". One infers that good business (maximum profit) is bad (inefficient) economics, a problem best left to the Invisible Hand to solve.

Normal profits are *un-eliminable inefficiency*, like residual friction that slows down a pendulum. In supply-demand price reckonings, normal profits are counted as *cost*. Sneaking in normal profits as cost obscures that *inefficiency is a thermodynamic concept*. Inefficiency requires fuel to overcome, and there is no specific economic fuel in supply-demand.

Supply-demand describes profit as market inefficiency. Thermoeconomics measures profit as a sign of market health. Both are correct.

Physical engines consume fuel, accomplish work, and produce and expel waste. We propose that economic engines use currency as fuel, perform economic work, and accumulate and re-circulate profits. We define economic work as the recovery of value – the recovery of costs-to-market. Proceeds above cost-return are profit. Because of intrinsic energy losses, it requires excess economic fuel to produce profits.

Seeking to update economics from Adam Smith, "neo-classical," mid-19th Century economists tackled the First Law of Thermodynamics, the Conservation of Energy as put forth by Heinrich von Helmholtz. Historian Robert Nadeau writes in *Scientific American*:[13]

> The progenitors of neoclassical economics, all of whom were trained as engineers,[14] developed their theories by substituting…variables derived from classical economics for physical variables in the equations of soon-to-be outmoded, mid-19th century…physics.
>
> … The strategy the economists used was as simple as it was… absurd—they substituted economic for physical variables. Utility (a measure of economic well-being) took the place of energy; the sum of utility and expenditure replaced potential and kinetic energy.

Basing economics on a law of conservation requires ridiculous assumptions:

> …The market system is a closed circular flow between production and consumption, with no inlets or outlets…. The economic value of [natural] resources can be determined only by the dynamics that operate within this [market] system… [and] … There are no biophysical limits to the growth of market systems….[15]
>
> Well-known mathematicians and physicists told the economists that there was absolutely no basis for … these substitutions. The economists ignored criticisms… [claiming] that they had transformed their field of study into a rigorously mathematical scientific discipline.[16]

Perhaps this is the first clear example of the ignorant or deliberate distortion of science to suit the profit motive. Even though they ignored the much more relevant Second Law, they did accept that *economic science must be modeled on thermodynamics*.

---

[13] "Brother, Can You Spare Me a Planet", by Robert Nadeau; **Scientific American**, March 2008

[14] Among them were William Jevons, August Walras, Francis Edgeworth, and Vilfredo Pareto.

[15] The Economist Has No Clothes by Robert Nadeau, **Scientific American**, April, 2008 op.cit.

[16] Ibid

In the 20th Century, John Maynard Keynes also relied on a zero-sum model, as he presented vital new theories of an integrated economy. His macroeconomics addressed huge quantities like aggregate supply/demand and Gross National Product. To balance full employment against inflation or deflation, Keynes argued that government spending must be increased or decreased. In Keynes as well as in Smith, balance (Newtonian equilibrium) is all. Smith and Keynes are, as it were, opposite sides of the same economic coin.

Mainstream economists have believed that their pricing models are 99% correct, and called rare events "outliers", "fat tails", or "black swans". Since no theory pertained to them, economists could reason with confident circularity before 2008 that "outliers" were of no concern.[17] Their reasoning reigned until supercomputer, "High Frequency Trading" (HFT) accelerated and compressed years of financial activity into just a few minutes, making what had been rare, commonplace.

Accepted mathematical formulations are at last suspect. Nouriel Roubini writes, "Laissez-Faire Capitalism Has Failed".[18] Conservative guru Alan Greenspan has publicly lamented the failure of his economic thinking.[19] Notable businesspeople including George Soros call for a new economic model.[20] The *Financial Times* hits "misplaced risks":[21]

> We are surrounded by things that do not work well, but are … widely used, … [including] the Black-Scholes model, according to [mathematical trader] Nassim Taleb. The equation, named after… men who devised it in 1973, is widely seen as the best method for pricing options and the derivatives based on them. It is often argued that Black-Scholes has provided the basis for the explosion of derivatives trading over the past two decades.

Black-Scholes is about price, not profit, and so is Newtonian, not Thermoeconomic.

> Mr. Taleb, … author of *Fooled by Randomness* and *The Black Swan*, thinks that the fundamentals of the equation are plain wrong, that the equation is not used in practice, and that the revered status of its founders, who were given the Nobel Prize, is undeserved.

In 2000, statisticians at JP Morgan Chase led by Dr. David X. Li sought to justify risky investments. They adapted mathematical functions called "Gaussian copulas" to estimate the likelihood of market collapses.[22] Gaussian curves show probabilities and correlations; "copula" refers to "coupling" those correlations. The copula soon entered the world's financial vocabulary, and brokers started quoting prices based on them. "Correlation trading has spread through the psyche of the financial markets like a highly infectious thought virus," wrote "guru" Janet Tavakoli.[23] Cash rolled in, and everyone ignored warnings. The ecstatic reliance of the finance community on Dr. Li's Newtonian equations were extremely important among the causes of the recent crash.[24]

---

[17] "Overreliance on financial software crafted by physics and math PhDs [to estimate risk and confidence] helped to precipitate the Wall Street collapse". After the Crash: How Software Models Doomed the Markets. *Scientific American*, Dec. 2008.

[18] Forbes Magazine, February 19, 2009

[19] Alan Greenspan Oct 23, 2008, op. cit.

[44] George Soros, "The Crisis & What to Do About It", New York Review of Books, Vol. 55, No. 19, December 4, 2008.

[21] "Mispriced Risk Tests Market Faith in a Prized Formula", Anuj Gangahar, *Financial Times*, April 15, 2008.

[22] Mathematical Model and the Mortgage Mess, Dennis Overbye, NYT, March 9, 2009.

[23] Recipe for Disaster, Felix Salmon; WIRED Magazine: 17.03, 12-03-09

[24] "Benoit Mandelbrot, fractal pioneer and longtime critic of mainstream financial theory, wrote in *Scientific American* in 1999: established modeling techniques presume falsely that radically large market shifts are unlikely and that all price changes are statistically independent; ... Here is where reality and rocket science diverge. *Scientific American*, Dec. 2008, op. cit.

Nassim Nicholas Taleb is particularly harsh when it comes to the copula.

> "People got very excited about the Gaussian copula because of its mathematical elegance, but the thing never worked," he says. "Co-association between securities is not measurable using correlation" because past history can never prepare you for the day when everything goes south. "Anything that relies on correlation is charlatanism." [25]

For centuries, economic response times spread across planting seasons and ocean sailings. Stresses grew slowly, and markets responded lazily.[26] The industrial revolution sped things up; Keynesian controls during the 1930s assisted equilibration. Today, super-computed, "High Frequency Trading" (HFT) compresses years of financial activity into a few minutes, making what had been rare, an imminent threat. Note for example the market "glitch" of May 6, 2010 when the market fell 1000 Dow Jones points in a few minutes.[27]

Paul Krugman writes:

> So why were so relatively few economists willing to call the [2008] bubble? I suspect that efficient market [supply and demand] theory, in a loose sense — the belief that markets couldn't possibly be getting things that wrong — played a major role. And in that sense there was a structural flaw in the profession.[28]

The association of fuel and currency, and of physical and economic work may be easy to accept. Associating profit and waste will confuse those who admire profit as fuel, however. Because there is no other non zero-sum, natural law, if an economy accumulates profits, one must compare profit to increasing entropy. If profit is "inefficiency", it cannot be fuel. The alternative is that economics is no science, but a selfish, childish fantasy.

Time for Economics 2.0

Economic behaviorists use the same mathematical rules to predict the future state of an economic system, as do the Black-Scholes devotees to predict the price of options.[29] Both suffer similar predictive limitations because both depend upon algorithms that use normal distributions, or else distributions based on past results. After-the-fact analyses of missed predictions place blame on "Fat Tails" (skewing of actual distribution data differently from that used in the model) and "Black Swans" (appearance of data-points outside the distribution altogether).

While temporal fluctuations in components (microstates) of all distributions may be acknowledged, the argument is that these can be ignored, because the overall distribution (macrostate) fluctuates much more slowly that does any individual microstate. There are at least three huge gaps in this logic.

First, the effect fluctuations have on Fat-Tail distributions is not equal across the distribution. Think of it this way: a daily +/-10% fluctuation in problem-solving capability among individuals (micro-states) near the norm will not shift the overall ability of a com-

---

[25] WIRED Magazine, op.cit.

[26] Elasticity is recovery from stress to a previous state. Beyond its range, there is no return. Demand-supply elasticity requires that there are no fatal perturbations like famine, war, or huge profit bubbles. One cannot reliably predict when resilience yields to bursting.

[27] "Algorithms Take Control of Wall Street" by Felix Salmon and Jon Stokes, *Wired Magazine*, January 2011.

[28] Presidential Address: *Profession and Crisis* Eastern Economic Journal 2011 **37**, pp.307-312.

[29] See for example, Ian Stewart, "The mathematical equation that caused the banks to crash", The Observer, Feb. 11, 2012, http://www.guardian.co.uk/science/2012/feb/12/black-scholes-equation-credit-crunch .

pany (macro-state) to perform, but a +/- 10% fluctuation in decision-making capability of the CEO (one micro-state at the extreme of the company population) can cause huge variation in overall company performance.

Second, "Black Swans" might be ignored when their appearance is rare. This might have been true of the "100 year flood" in computing insurance costs, or in the extensive risk analyses made on nuclear power plants before all the design flaws were exposed, or for economic depressions before the age of supercomputers, data mining and high frequency trading sped everything up.

As life speeds up and world complexity, population, and energy use per person increase, *we can no longer depend upon rarity as a buffer against cataclysm*.

Third are the destabilizing effects of positive feedback loops.[30] Economists do not recognize positive feedback loops as destructive, as engineers often do. Familiar physical examples include sound expanding into a squeal when an active microphone stands in front of the loudspeaker that returns sound to the mike. We are however all familiar with financial bubbles that expand as profits grow impossibly by feeding on each other, creating profits from profits without creating value until they pop the bubble.

A more troubling, system-wide example is the runaway trend toward inequitable wealth distribution. The concentration of wealth in fewer hands that circulate money extracted from the commonweal among themselves represents a positive feedback loop of unknown impact. The last time wealth inequality in the U.S. was as pronounced as now was just before the Great Depression. Government regulations and taxes are mechanisms to provide necessary counterbalancing negative feedback corrections. But, nobody likes negative feedback.

We need an approach that takes seriously the warning we find in our investment portfolios .... "Past performance is no guarantee of future returns".

Epilogue I: A Most Cynical View

Financial bubbles are simply the quickest and best means to distribute wealth upward. When bubbles burst, the efflux lands in the bath water of the wealthy and powerful. We may have survived, but we are all a lot poorer, economically and politically, which is more important.

Getting rid of the excess population is being executed properly. The top few percent do not need the riff raff demanding resources and polluting the environment. Robotics can replace the sweating masses and deliver the pleasures of life to the few remaining. A 20% population reduction can do wonders for one's portfolio. (N.F.) (private letter.)

[30] Thanks again to Robert P. Wolf, Prof. Emeritus, Physics, Harvey Mudd College, Claremont, CA.

Part II: The War Between Symmetry and Asymmetry

A Quick Lesson: Symmetry and Asymmetry in Business Planning

American auto companies traditionally relied on symmetrical, demand-supply factors like economies of scale to keep manufacturing costs low and ensure market dominance. They ignored that before a sale and after a sale are asymmetrical, past-and-future times, and so ignored product quality and reliability. Buyers became involuntary, unpaid quality control agents making money for dealers, seeking warranty repairs upon discovery of flaws. The repair punch list became an ice-breaker at parties, while at the same time American car Buyer temperatures froze.

The Japanese quality model in the 1970s was asymmetrical. It aimed to reduce error and waste – product entropy – before a sale rather than enlist a customer in quality control. Superior, in-line quality control delivered defect-free products to happy customers.

Alas. Stories of the 2011 nuclear power plant failure in Fukushima, Japan suggest that traditional thinking in the new century has trumped the insights of the 1970s.

Civil War Story: Government Regulation versus Maximum Profit

We are all aware of the war between businesspeople and "government regulation". This war is an unfortunate consequence of both sides using a Newtonian economic model.

We have discussed how contemporary economics explains profit as "inefficiency" in the economic mechanism. The supply-demand view is that *the unfettered pursuit of self-interest in a perfectly competitive economy leads to maximum economic efficiency*.[31] That is, the pursuit of profits produces efficiency because competition minimizes profits. The model projects responsibility for ethical behavior and efficient economics onto a supernatural mechanism, the "invisible hand", which is the "genius" of the free market.

Supply-demand interactions may tend toward zero-sum, price equilibrium, but they cannot break even. A business must make at least a minimal, "normal profit"; otherwise, owners would spend their time doing something else. Economists consider "normal profit" as an *inherent cost*; normal profits are "irreducible inefficiency".[32] Profits greater than "normal profits" are "economic profits".[33]

Informal conversations suggest to us that many in business and finance are unaware that efficient economics implies minimum profit. They believe that profit is an absolute good that fuels investment, and equate business success with maximum profit.

As it works to protect business competition from conspiracy and monopoly, government regulation interferes with the free pursuit of profits. Thus, government unwittingly assumes the role of protecting economic efficiency. The result is the familiar sociopathic socio-psychodrama of antagonism between business and government.[34]

Free marketeers bristle at the implication of immorality that a need for rule en-

---

[31] http://www.answers.com/topic/economic-efficiency#ixzz1L8ubcdZu

[32] See also http://economistsview.typepad.com/economistsview/2007/06/profit_theory_i.html "Profit and Loss" by Daniel Davies.

[33] Profits above "normal" are desirable, "economic" profits. Albrecht, William P. (1983). *Economics*. Englewood Cliffs, NJ: Prentice-Hall.

[34] Psychanalysts might perceive the "invisible hand" as the "Ego-Ideal" (mother), and government as the "Super-Ego" (father).

forcement implies. They either ignorantly or cynically cite the free market as justification. The most orthodox (Chicago School) zero-sum free marketeers insist that monopolies ought to form freely, because they will eventually fall apart of their own weight. Might not failing monopolies take down an entire economy with them? Might not unregulated Darwinian economics lead to Communist Revolution? Marx would expect so.

Zero-sum logic extends beyond economics proper to finance. Financial "market efficiency" is distinct from "economic efficiency". Market efficiency does not refer to price or profits, but to the state of all traders having the same information, and therefore of all making the same predictions and realizing the same, average profits. *Superior information makes a financial market inefficient, and rewards insider knowledge*. What a miserable business!

Opponents of regulation justly complain that government rules may cause unintended harm, such as inhibiting initiative. Of course! Government regulators use the same Newtonian model as businesspeople, leading regulators to wish to predict economics like the sunrise. Misunderstanding leads to over-regulation. Worse, the perception of government micro-management inspires resistance; complex regulations encourage people to "game the system". Some government strategies aim to keep regulations vague not to prevent gaming, but to play, "Gotcha". The result is a cops-and-robbers contest familiar to parents who seek excessive control over their obstreperous adolescents.

Thermoeconomics cannot prevent "gaming the system"; humans like games, starting with peek-a-boo. Unless some god has declared profits a Promised Land open to pillage, there can be no scientific, moral, or historical reason to wish for a free market *without umpires or referees*. At present, we play a dishonest and dysfunctional economic game.[35]

The profits of productivity are not the problem. Relevant mathematics[36] suggests that using profit-generating instruments (e.g. financial derivatives like "credit default swaps") that are several steps away from value creation and that produce windfall, financial profits threaten the democratic, economic, and natural environments.

Those who advise protecting investors because they "provide jobs" reveal that they are like feudal lords who tolerate their serfs rather than like either economic scientists or democratic leaders. The free market does not operate in the interest of consumers.

---

[35] See also, "Foolproofing Cap-and-Tirade" by David. R. Baker; San Francisco Chronicle, Jan. 17, 2011

[36] (www.profitandentropy.com/needswork) We update the practice that Robert Nadeau describes, op. cit.

Part III: The Natural, Unbalanced Universe

In the beginning, a Big Bang blasted existence into expanding space and forward time; the universe began asymmetrically. Matter and anti-matter came into being together, but these obliterate each other. Anything exists at all only because anti-matter has asymmetrically vanished.

Here are thermodynamic facts to keep in mind as we proceed.

- Heat is thermal energy, which may be measured in units called *joules*.
- Hotter molecules have a higher temperature and contain more joules of thermal energy than do colder molecules.
- Molecules above absolute zero in temperature perform a random, heat energy driven motion that increases with temperature. Because hotter molecules move faster,
- Heat energy flows across a hot-to-cold temperature gradient, reducing the gradient.
- Flow slows and stops as the gradient flattens toward temperature equilibrium.
- Fuel must feed a fire to maintain its temperature gradient against equilibrium.
- There can be no spontaneous return from temperature equilibrium to distinct, hot and cold states. Otherwise, one might burn the same fuel twice.

.

- Fuels store joules of "free energy" in the structure formed of their molecular bonds.
- Heat released from fuel may accomplish work, *which is also measureable in joules*.
- Joules of thermal energy cannot convert with perfect efficiency into joules of work.
- Releasing fuel energy destroys more structure than work can re-create.
- This inescapable disorder is measured as "increasing entropy".
- Joules of released energy = joules of work + joules lost to entropy.
- Increasing entropy is maximum at temperature equilibrium.
- Increasing entropy measures the necessary, universal loss of order with time. Increasing entropy is the *"arrow of time"*, pointing one-way toward the dismal future.
- Maximum entropy may be defined as: "the ultimate state [of] the degradation of the matter and energy of the universe**:** state of inert uniformity…**:** absence of form, pattern, hierarchy, or differentiation…"[37]

Increasing Entropy Up Close and Impersonal

In 1865, Rudolf Clausius used "entropy" to refer to spent energy as *transformation contents*. Trans-formation means "across from form", and refers to what is changing, and so is "information-less" -- in no formation at all.[38] Entropy was well coined; a "trope" is a turn. In literature, a trope is a turn of phrase. In biology, a phototropism is a turn toward light. Increasing entropy refers to molecules that turn, spin, and fly away from each other.

Because hotter molecules move about more randomly than cooler, a warmer room contains a greater entropy than a comparable cooler room. As heat flows across an opening between two such rooms, their temperatures equilibrate at an average value. *Their entropy increases overall however, rather than "averages out"*.

---

[37] "entropy." *Webster's Third New International Dictionary, Unabridged*. Merriam-Webster, 2002.

[38] When Star Trek characters "beam up" from a planet to their ship, but their forms do not rematerialize, they remain "transformational".

In more detail: A and B are adjacent, equivalent rooms; A is hotter, at 60°; B is cooler at 20°. The door between them opens; heat energy measured in joules flows from A to B, cooling A and warming B. No joules are lost or gained overall. Temperatures meet at 40°, so no degrees of temperature are gained or lost, either. Degrees of temperature and joules of energy are conserved; these are zero-sum quantities.

As the rooms approach thermal equilibrium, molecules in Room B bounce more energetically as they warm. Molecules in Room A bounce less energetically as they cool. *Here's the rub*. Simple math shows that molecules in Room B move more energetically (as they warm) *more than* molecules in Room A move less energetically (as they cool). (Got that?) As a result, at equilibrium temperature, overall random, energetic motion measured as entropy has *increased*.[39] "Chaos" has increased. *Entropy is not conserved*. Entropy maximizes at thermodynamic equilibrium. Because igniting fuel in an engine releases heat energy to flow from combustion (A) to cooling system (B), fuel cannot be perfectly recycled.

The A-B example represents diffusion across any thermal gradient in the universe.

Heat diffusion cannot accomplish work, however. An engine accomplishes work. In Part III, we consider engines, including economic engines.

The distinction of Rooms A and B is a simple state of order. Merging A+B loses that order. At equilibrium any individual molecule may be anywhere in the merged rooms. Molecules in Room A+B may roam in twice the space as before. *Increasing entropy thus represents expanding space as well as advancing time*. Because expanding space increases the uncertainty of any individual molecule's location, increasing entropy is a also loss of information – specifically, of *location information*.[40]

NB: Neither joules of heat nor degrees of temperature are units of increasing entropy, because neither changes overall as heat spreads; these are zero-sum quantities. Entropy is not zero-sum. We note here and shall discuss elsewhere that entropy may be said to change over a *range* of temperatures in units of *joules-per-degree*.[41]

To discuss the Second Law as it applies to information and social sciences, we shall employ two special words: ***macrostate*** and ***microstate***. The condition of a dynamic system as a whole is its *macrostate*. At equilibrium (maximum entropy), macrostates are most uniformly average, so that (for example) temperatures measured anywhere are most likely the same.

Each possible molecular location in a macrostate is a *microstate*. At equilibrium, the greatest number of microstates makes up a macrostate. So, maximum entropy means maximum, *macroscopic uniformity* as well as a capacity for maximally individualized, *microscopic chaos* – at least from the perspective of anyone trying to measure a microstate (except as an average), or even better from the perspective of a mythical being "in" such a microstate.

Applying this version of reality to economics, we note that while macroeconomic variables like average earnings may be calculated precisely, microeconomic, individual

---

[39] See equations at www.profitandentropy.com/needswork

[40] "Thermodynamics, Evolution, and Behavior" by Rod Swenson, Center for Ecological Study of Perception and Action, Univ. of Conn.; from Encyclopedia of Comparative Psychology, Greenberg and Haraway (eds.) New York: Garland Publishers 1997

[41] Arithmetic equations illustrating these ideas may be found at www.profitandentropy.com/needswork. Apologies to thermodynamics mavens for the simplification that substitutes long division and averages for integral calculus.

earnings may not. Maximum entropy in a social science thus describes *both average, social uniformity and the micro-ambiguity necessary to imagine a capacity for individual freedom*.

There is no direct way to infer the nature of a micro- or macro-system from the other, whether we compare a few gas molecules to a full balloon, or of individuals with a national economy. The propaganda that equates the behavior of a macro-economy with that of a household deserves vigorous rebuttal.

Neither matter nor energy can be created or destroyed, only transformed into each other. Information can be created *and* destroyed. Burning a unique document loses its information. More entropy is created every instant as molecules release heat, and cannot be destroyed.

From Casino Statistics (Newton) to Statistical Mechanics (Thermodynamics)

Pondering microstates and macrostates brings us to statistical mechanics.

Amid great kerfuffle, Ludwig Boltzmann (1844-1906) sought to reconcile Newton's action-and-reaction symmetry with Clausius' cause-and-effect asymmetry.[42] He reasoned that while the Entropy Law applies to heat-flow on the macroscale, individual molecules that carry heat must be like tiny billiard balls, and so be subject to Newtonian reversibility. "Micro-reversibility" means it must be possible for heated molecules all to reverse at the same time, even if such is not likely to occur within the age of the universe.[43] In this "statistical mechanics" interpretation of thermodynamics, perfect knowledge is quantitatively unlikely, not qualitatively impossible.[44] Ironically, it seems that protecting the perception of universal, Newtonian certainty depends upon perceiving micro-molecular chaos.

Flashback. At the same time as Newton wrote, gamblers wishing to figure their odds at dice realized that throwing dice *causes* them to move. Of course, there are relatively few ways dice can land, and one throw cannot affect the next. But, this was the birth of what we rely upon today as the statistical representation of individually caused events, such as according to the famous "bell-shaped curve" of normal distribution.

Such casino statistics cannot *discern causes*. A bell-shaped curve is just a snapshot of individual events presumed all to occur at the same instant.[45] One may infer from correlations the possibility of common causality, but nothing more. Even lines that connect "data points in time" cannot reveal how any point might cause the next.

Boltzmann's work opened a new branch of mathematical physics called statistical mechanics,[46] the study of macro properties as they emerge from interactions among independent micro-particles. (Individual air molecules have no temperature or pressure, but a balloon containing them does.) If cause-and-effect applies to macrostates but not to microstates one asks, "How can macroscopic asymmetry arise from microscopic symmetry?"

---

[42] Boltzmann opened the door to the future spirits of the Atomic Age, of the Information Age, and of our Age of Entropy.

[43] Readers of Douglas Adam's *Hitchhikers Guide to the Galaxy* will have come across this idea as the "infinite improbability drive".

[44] Making things more murky is that observation on the microscale introduces objective uncertainty into what can be measured, a version of time asymmetry on the microscale known as the Uncertainty Principle. The "non-equilibrium thermodynamics" of Ilya Prigogine argues that irreversibility is absolute. See his, *The End of Certainty*.

[45] Attested to as the caveat, "Past performance is no indication of future earnings" that appears on financial prospectuses.

[46] The story of "Maxwell's demon" explains how it is that Newtonian observation cannot reveal statistical mechanics.

Puzzling about asymmetry in 1944 led Erwin Schrödinger to write the amazing book, *What Is Life?* that founded the science of molecular biology. He stated that physicists perceive an "order-from-disorder principle": the laws that describe regular, predictable behavior on the macroscale arise somehow from chaos on the microscale. He reasoned that biological cells could not work this way, and reproduce themselves perfectly (as they must) molecule by molecule. He identified biology as working according to an "order-from-order" principle that he called "negative entropy", and that we know today as stored information. If there is "order" at the microscale, it is biological. It is stored information.

Our culture however remains quite Newtonian, which means among other things that people tend not to distinguish micro from macroscale; everything top-to-bottom is Newtonian. Each of us lives (so to speak) in our own, private microscale.

At the same time, many believe that we can infer an orderly macroscale from our randomly micro position. They may even see the world as a planned Newtonian community, a theme park in which every event is meaningful, even if the meaning is not yet revealed. Anything unusual might be a miracle, or a sign of god's wrath.

Libertarian economists and free marketeers (as it were) proclaim, "Don't tread on my microstate!". They perceive that they are free (the random view from a micro state), but also divinely determined (Newtonian view of macro and micro order). These people are certain that a macrostate is a Newtonian microstate writ large. No wonder free marketeers insist that government balances its budget as though it were a big household.

Economists know better. They may either be micro- or macro-economists, but not likely both, because no one knows how one feathers into the other. To believe that we live in either a Newtonian micro- or macrostate ignores the novelty of life and the finality of death. We believe that the Buy-Sell, microeconomic gradient is ample evidence that life is time-asymmetric at the micro-scale.[47]

There is today no application of statistical mechanics such as might unify micro- and macroeconomics, and render economics more predictable. There cannot be any such consummation as long as economics is concerned with price, not profits, and as long as finance is concerned with profits, not value.

Heat disperses, space expands, entropy increases, information is lost, and time travels.
Entropy is the famous "waste" that "happens".
And, thereby hangs the tail.[48]

[47] Professor G. Ellis argues convincingly that the microscale is asymmetrical from the get-go. See *The arrow of time, the nature of space-time, and quantum measurement*, George F R Ellis, Mathematics Department, University of Cape Town, October 7, 2011

[48] – which is sometimes a statistical, "fat tail". See also www.profitandentropy.com/needswork .

Part IV: From Thermodynamics to Thermoeconomics

Introducing Economic Temperature

A warmer Buyer to cooler Seller economic temperature gradient is a better fundamental, economic model of the behavior of currency than is the Law of Supply&Demand.

Current is flow across a gradient. Rivers are currents of water that flow downhill. Currents of electricity flow from one pole to another. Heat is a current of thermal energy that flows across a warmer to cooler, temperature gradient.

Currents flow across gradients *toward equilibrium*; hot water mixes in a cool tub until all the water is lukewarm. Flow toward equilibrium is irreversible. Heat will not spontaneously flow back from equilibrium toward distinct, hotter and colder temperature zones.

Money in circulation is *currency*. It flows. When a Buyer pays more for an object or service than it cost to bring to market, currency flows from Buyer to Seller, producing a profit. Buy-Sell flow drives micro (personal) and macro (national/world) economics.

Free Market economics recognizes no driving, Buy-Sell flow. Instead, a law of Supply-and-Demand balances opposing economic forces that seesaw around a fulcrum, as though guided by an "invisible hand" toward an ideal, price equilibrium.

During the crisis of mid-2008, seesawing ceased, which revealed that economic equilibrium is paralysis. If two people of equal weight on a playground seesaw stall at equilibrium, their play ceases until an outside force (like a stimulus package) can tip the balance.

Idealizing equilibrium generates dysfunctional ideas, such as balancing the federal budget at all costs. Balancing the budget when an economy is doing well reduces debt interest payments, putting money to work creating value. It is wrong to reduce spending to balance a budget when an economy is near equilibrium. We need to protect and enhance the Buyer-Seller gradient, even if we must borrow more and raise some taxes. Running out of gas with no cash in Death Valley, one must call for help and use a credit card.

The Subjective, Psycho-Economic Temperature Gradient

Computer programmers write code as binary strings of ones and zeros (1,0). Mathematicians and scientists tend to think of objectivity as "one", and subjectivity as "zero". In other words, objectively speaking, subjectivity doesn't exist.

There is by definition no objective way to understand subjectivity, no objective model of each of us as a unique person, or "***I***". Objective results must be reproducible, and uniqueness is not reproducible. The relegation of subjectivity to invalidity is thus circular logic. Scientists may study behavioral or neurological data and gather "reproducible results", but these need never apply to any actual, subjective person.

We think of the subject-object relation not as binary (1,0), but as like that between the numbers one and the square root of minus one (1, $\sqrt{-1}$). The square root of minus one is the imaginary number, "***i***". No real number squared yields a negative number, but ***i*** is the imaginary unit in the complex number a + b***i*** (where a and b are real numbers) that is needed in many mathematical and engineering expressions that will include thermoeconomics. The number ***i*** represents an intimation to us "flatlanders" of another dimension.

Economists at last accept as inadequate the view of participants in an economy as "rational actors" motivated to survive. Studies of brain, cognition, and behavior cannot describe recognizable, "whole beings", however. We hope to introduce the economic ***I*** as we describe Buyer and Seller, psycho-economic temperature scales and an *economic temperature* gradient between them. We shall find that complex numbers are useful here.

We do not need to measure economic temperature precisely. Any temperature scale rising from absolute zero is valid in thermodynamics, even one that we imagine and estimate. We just need to know which side of a gradient is hotter. Because relativity to absolute zero is all we require, *we can move readily between subjectivity and objectivity*. We can imagine a subjective, "psycho"-thermo-economic temperature scale of Buyer desire, and yet treat Buyer-Seller financial interactions objectively.

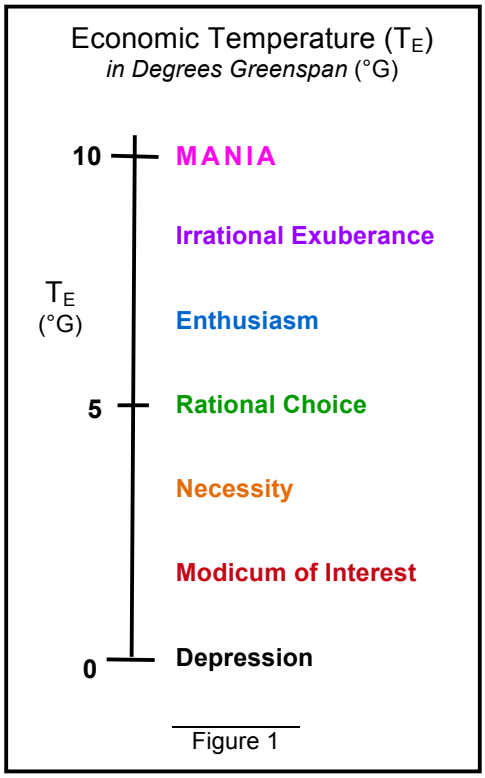

Figure 1

Joules are units of heat; we compare dollars as units of currency to joules as units of heat. We think of cash as fuel that releases its energy when ignited at a point of sale. When Buyer-Seller temperatures meet at a price point, dollars of "hot cash"[49] flow across the desire gradient, heating the Seller, and releasing the object to the Buyer.[50] If the price of a horse is $200, and its cost-to-market is $150, then $150 covers costs. The $50 profit alerts us to wonder about increasing entropy.

We propose a *psycho-economic* temperature scale of economic desire or *"libido"*. We understand libido as *passion* apart from any behavior (such as Buying) that might relieve it; literature across the ages describes unrelieved passion as *torture*. Heat excites gas molecules, increasing pressure from within upon a container. Heated libido puts pressure from within upon contained behavior.

Figure 1 above estimates grades of *Buyer Economic Temperature* as T_E. Just as 100° Celsius span freezing to boiling water, we posit that 10° Greenspan span economic liquidity. Temperatures range from frozen Depression near absolute zero, to vaporizing Mania at 10°G. Alan Greenspan is a former Chairman of the US Federal Reserve Bank.

Rational choice is central. Necessity implies less choice. Modicum of Interest needs a hard sell; Depression means staying in bed. Above Rational Choice, rationality melts into Enthusiasm for fads and fashions. Higher temperatures lift the Buyer from Enthusiasm to Irrational Exuberance,[51] where price is almost no object. Further above, Exuberance yields to Mania. Gambling on real estate and assuming wild credit card debt qualify here.

---

[49] A Buyer of a horse brings "hot cash", and is literally "hot to trot", eager to "consume".

[50] Transforming "analog" horse into "digital" cash is the original "analog to digital" conversion. A philosophical adept might add that an economic transaction transforms quality into quantity, Being into Becoming, and Essence into Physics.

[51] Alan Greenspan, Fed Chairman during the Dotcom era, popularized Yale Professor Robert J. Shiller's *Irrational Exuberance*.

Libido is not energy; "subjective energy" is an oxymoron. *Libido interprets information*, and information affects subjective, Buyer temperature. Buyers input stimulating information about products from such as ads or in-store displays. Advertising was not vital during Adam Smith's era, when Necessity (survival) drove much Buying, but is necessary today in a consumer economy to maximize the profitable, Buy-Sell gradient.[52]

When we describe libido as "heating up" a Buyer, we analogize physical and mental temperatures, and we analogize entropies as well. Physical microstates increase with temperature and therefore with entropy, and we propose that "mental microstates" do as well. We equate increasing, subjective entropy with sensed, inner chaos, and increasing mental microstates with anxious tension. The relief of tension or anxiety is pleasure.

Buyer economic temperature is the microeconomic equivalent of the well-known, macroeconomic measure: Consumer Confidence Index. The CCI represents average Buyer Temperatures macroeconomically. Figure 2 shows its flow over the past 12-year period. Our estimates of comparable micro-economic temperatures in °G are on the right. Our micro-economic temperature scale correlates with the CCI.

Starting from the end of dotcom, Irrational Exuberance in Q-1 2000, average Buyer temperatures fell until they bottomed out at 3°G, Necessity, in 2003. During the subsequent 4 years, average Buyer temperatures recovered to hover around 5.5°G, Rational Choice to Enthusiasm, but never reached the high temperatures of the dotcom days.

Figure 2. U.S. Consumer Confidence Index (2000 - 2011)

Since mid-2008, we have seen both the lowest and the longest low CCI on record. We estimate the fluctuation as from 1°G to 3°G -- between Depression and Necessity. Consumers are barely able to meet their needs, regardless of Sellers' price reductions.

The Temperature Gradient, Increasing Entropy, and Profit

We noted that a non zero-sum return – a profit – alerts us to think about profit as entropy. A physical system generates increasing entropy as it approaches equilibrium. A system far from thermal equilibrium (distinct very hot and cold areas) generates more entropy en route to equilibrium than a system that is already close to equilibrium. Similarly,

[52] See also: Study: Your Brain Thinks Money Is A Drug by David Kestenbaum. Nat'l Public Radio August 7, 2009.

if profit and entropy are (as we suspect) intimately related, then an economic transaction across a wide Buyer-Seller, economic temperature difference will generate more profit than will a transaction across a smaller difference.

Here are examples of how we might apply the notion of economic temperature.

Apple Corporation exemplifies the successful marketing of low Seller temperature, which is partly why customers think Apple products are "cool". Apple does not segment markets by offering "hot" new products at every price point. Apple never appears in a hurry to sell anything. Apple product development secrecy enhances the "cool".

At the same time, Apple keeps customer temperature in a high Enthusiasm range, maintaining a steep, economic temperature gradient between warm Buyer and cool Seller. New product presentations build excitement as though Apple were Santa Claus bringing gifts to good boys and girls. Perhaps part of Steve Jobs' success was related to his life as an adopted child. He wanted Apple products to be lovable, and to find adoptive homes. He could imagine and identify positively with the states of mind of Apple's customers. In 2012, Apple is the most profitable and valuable business corporation in history.

Here is an example of the problems of flatter gradient. Consider an inventor of a new method to ascertain municipal water quality. He needs to sell his product, which might have enormous implications for public safety. Unfortunately, the inventor finds it necessary to sell his product into customer Necessity, which is below "Rational Choice" on the temperature scale. None of his municipal customers intends to buy his device. Few of his customers are aware of any Necessity; most assume that things are fine as they are, and would not want to admit it if they were not. With such a small Necessity-to-Necessity, Buyer-Seller gradient, our inventor is for now, dead in the water.

This story and those of the safety compromises that led to the New Orleans inundation and the Gulf of Mexico oilrig disaster testify that safety is not sexy. Unfortunately, unsexy safety is as much an issue in finance as in physical situations.

A third example is the worldwide financial near-Collapse of 2008. Unpoliced finance endangered the world, but citing greed as a root cause has not led to prosecutions, or to broad agreements on remedies. Risky, lucrative financial vehicles without obvious economic value still proliferate, especially those driven by High Frequency Trading (HFT).

We identify the problem not as greed *per se*, but as high Seller temperatures. By 2008, hot trading in financial vehicles such as "credit default swaps" had wiped out the Buy-Sell gradient; everyone was a Seller. A flat gradient means equilibrium, which means maxed-out financial entropy, which means no more flow and no more profits. To the chagrin of free marketeers, government infused borrowed cash to prevent a crash. Unfortunately, the infusion went more to support financial institutions than to support employment and consumption. As a result, recovery overall remains tepid, and financial risk has become "socialized" – foisted upon the hapless, underemployed public.

Part V: Inside the Thermoeconomic Engine

"Work, Work, Work, Work"[53]

Currency flows like heat, and represents a capacity for economic work.

To compare heat diffusion and an economic transaction, variables must correspond and identical functions must operate. Recovery of cost-to-market releases the horse in our example to pass "upstream" from Seller to Buyer, which constitutes economic work. *Nothing diffuses from B to A in the room heat-diffusion example,* however. Heat diffusion can do no work, and neither can diffusion thermo-economics. Engines accomplish work.

But first, what is work? It takes no work to roll downhill or to make a mess. That is simply the direction of increasing entropy and forward time. It does take work to drive uphill or to clean up a kitchen, which in effect slows, stops, or "turns back" time.

In physics, work is *force* in action over a *distance*. Weight is a force, and height is a distance; to lift the weight of a bucket of water to a height is work. Like heat energy transfers, work is measured in joules, which are zero-sum units. Work would thus seem not directly related to increasing entropy. It makes sense therefore that *engines work in cycles*.

An end of a cycle is a return. There are orbital cycles, seasonal cycles, and economic cycles. An automobile engine cycle returns a piston to its origin. As a concept then, a work cycle is not so different from a planetary orbit. Ignoring fuel, an engine cycle is zero-sum. *Engine work cycles are* not *Newtonian* only in that *new fuel ignites to drive the next cycle*. Therefore, we may distinguish between a gasoline engine's work cycle and its fuel consumption. A thermo-economic engine must be similar.

No matter how efficient is an engine, or how beautiful or useful is its output, burning fuel increases entropy overall, of course. It remains to imagine how an economic engine might produce economic work and also generate byproducts that safely dissipate whatever we mean by increasing economic entropy.

Entropy increases, and time passes. So it goes.

Economic Work Recovers Value, and Dissipates Profit.[54]

Fuel molecules imprison joules of free energy in bonds that determine molecular structure.[55] Nature worked hard to imprison all that free energy! In internal combustion engines, ignition frees the energy, destroys the prison structure and creates a temperature difference between an ignition chamber and the exhaust system. Expansion in the chamber forces the piston to deliver power; ignition of new fuel restores the temperature difference for another cycle. We know that each cycle generates increasing entropy as well as power.

We compare economic work in dollars to physical work in joules. Products and services store the dollar cost of bringing them to market (labor and materials, etc.) as what we call "value", referring to dollars of "production-cost-energy" or of *economic free energy*.

At a point of sale, the aptly named "consumer" sparks the release of value dollars to

---

[53] Spoken by Governor WJ LePetomane (Mel Brooks) in *Blazing Saddles,* as his head poked out from between closed curtains.

[54] The last systematic theory of profit may have been "Risk, Uncertainty, and Profit" by Frank H. Knight, published in 1921.

[55] In *What Is Life* (1943), because of its storage in molecular structure, Erwin Schrödinger equated free energy and "negative entropy".

do economic work, which is the repayment of those costs. Cost recovery completes a production cycle, delivers the product, and restores conditions for another cycle. We have not yet left the world of zero-sum barter, however.

Barter is exchange based on intrinsic value, most famously perhaps as "my kingdom for a horse". Barter is two way Selling. There are no consumers. Nobody Buys anything; nobody pays a price. Barter may generate benefit, but not profit. There can be no measureable profit until somebody uses currency to pay a price. Furthermore, each barter exchange is unique. Each takes place in its own present moment; there is no implied, next transaction. There is no future in a barter system, no implied succession of events.

Currency transforms intrinsic value into abstract exchange value, which invents the capacity for finance and debt. A price that just recovers costs just mimics barter, however. Cash pre-assigned to creditors and employees has *intrinsic use value* for the seller.

Proceeds in excess of cost are profits. Profits identify a transaction as "*successful*", which means that another transaction can *succeed* it – can follow it in time. Profit signifies that new things are happening, and that the economic engine needs more fuel. Acting as increasing entropy, each profitable transaction prints new currency and expands economic space. Profit invents the future, and with it the hope for civilized progress.

Accumulating profits ensure that there is more money in a system than is in use; banks store and distribute excess cash, adding interest to profit (a mixed, inflationary blessing). Currency fixed to a standard like gold restrains advance from a break-even economy.

Profit so far seems more wonderful than just nasty or inevitable. But, entropy is waste! Systems in industry and nature dissipate increasing entropy; there are heat radiators and biological excreta. The analogy is inescapable that *profits are products that carry away waste economic heat*. This is not shameful or catastrophic! It just means that an economy functions more like an engine or like the body of an animal than like a solar system.

Consider biology. A body is a food-burning furnace; exporting its high-entropy waste products. Compare a business taking a bite out of an economy and generating profits, to a baby feeding and then "doing its business". Profits signify a healthy economy much as a loaded diaper signifies a healthy baby. *Both signify healthy metabolism*.

In Part II we noted that joules cannot refer to both energy and entropy; we calculate increasing entropy in *"joules-per-degree"*. Likewise, cash cannot refer both to price and to profit-as-entropy. We shall discuss "*transaction profit*" as "*dollars-per-degree Greenspan*".

Since cash profit is not the same as *transaction profit-as-entropy*, we infer that some economic "free energy" remains in cash profit, just as free energy remains in natural fertilizer.[56] So, gasoline engines may recycle waste heat in a turbo device, at some stress to the cooling system. Farmers may return animal waste to the ground to mix with sunlight and earth to fertilize new crops, useful as long as we protect the water supply. Industrial waste like nuclear fuel must be sequestered, however; any remaining energy is dangerous.

Maximum profit was never a rational, overall *goal*, anyway. Even the most committed free marketeers agree that the goal is the well-being of civilization; they (naively or cynically) claim that individuals earning maximum profits (Greed is good!) is the best means

[56] www.profitandentropy.com/needswork. We do not yet know how to calculate the free energy remaining in cash profits.

to that end. Identifying profits as entropy means that transforming profits directly into value resembles spinning straw into gold – possible only in the magical imagination.

We may not believe that we use magic to spin straw into gold, but we have created an imaginary friend (like a golem or Superhero) that operates as a hierarchical social system (like a religion or magic cult) in a zero-sum, free market mythology to turn accumulating profit into value. A business corporation is a fictitious, "legal person" with rights and responsibilities (but like a monster, without conscience). Corporations return profits to the ground to mix with sunlight (downloaded every day for free, or released from storage in fossil-fuels) to create new product and service value.

Recognizing that profits are less like refined fuel than like waste products suggests thinking that we do not invest profits so much as we recycle or even sequester them.

We don't call for revolution – just for enough rotation to see that we do not create value to make *new* profits; we create value to recycle or capture *previous* profits. Without profit sequestration in the ground of value, we can expect global, economic warming just as the products of engine combustion contribute to global, atmospheric warming.

A new crop of value cannot reverse entropy, of course. New value production also sells at a profit. We create value to regulate, not to stop or reverse increasing entropy. Can or should we restrain output to the limits of daily downloaded, free energy? Any other view of profits seems unsanitary,[57] even if wholesome restraint seems impossible.

Value and Worth: The Expectation *to* Profit versus The Mind *of* Profit

We associate *worth* with Buying, just as we associate *value* with Selling.

Why is a Buyer willing to pay a retail price, rather than drive the hardest bargain?

Profit accrues in excess of intrinsic value to a Seller because of *worth* to a Buyer. Worth exists as a wish for *product gratification* sufficient to motivate buying at a profitable price, rather than waiting for a better deal. A well-heated, "mind of profit"[58] can blithely ignore workers' rights, environmental impact, and responsible, personal finance.

We distinguish a consumer's "mind *of* profit" from a seller's "expectation *to* profit". The former does not expect to turn a profit. The mind of profit *pays* a profit, knowing that a purchase may depreciate in value even before it is consumed. Consuming takes a product or service out of the economic flow, leaving its abstract equivalent to circulate. The expectation not to consume, but to sell at a profit identifies a buyer as a seller, economically.

Two orthogonal elements define worth as *utility*. One is *objective* or even intrinsic; a man buys a horse to work the farm. A horse might also have *subjective*, social utility: to enhance his marital eligibility. Drinking a glass of water when thirsty brings objective, *physical* pleasure. Drinking the same water from a branded bottle in a restaurant and feeling "hip" or "cool" may also afford subjective, *social status* pleasure as relief from social status anxiety. Advertising subtly blends these two hopes into a heady and hearty ambrosia.

The utility of warm coats in cold climates would seem important. Not many may be

---

[57] Thieves broke into a gas station, and stole all the bathroom fixtures. The police were baffled. "We have nothing to go on", they said. (NPR's *Car Talk*: Tom and Ray Magliozzi, July 3, 2010)

[58] Adapted from Wallace Stevens' poem, *The Snow Man*: "One must have a mind of winter…"

sold, however, without attention to coats as status-symbol, fashion-statements. Sellers like Apple excel at inciting "minds of profit"; a "cool" social status factor heats sales beyond logic. Hucksters as well as advertisers know that the "mind of profit" is easily blinded by status flattery.[59] Ponzi-schemer Bernie Madoff could steal billions because he aroused social-status lust among his prospects, convincing them of favored, "insider treatment".

Pleasure and Entropy

We propose that economic motivation works according to a "pleasure principle" that operates along a gradient of mental stress or tension between unpleasure and pleasure. Behavior that lessens tension (like spending on desirable items) is pleasurable. The classical, economic "rational actor" would associate pleasure with physical or social survival, sometimes for a Buyer as simply as, "I am going to die if I cannot buy that new iPad."

We distinguish subjective, economic temperature from subjective tension so that we may identify tension -– unpleasure – from desire as the subjective equivalent of entropy.

With rising temperature, molecules move about more energetically and randomly. Their entropy increases, and there are more possible molecular locations, or microstates. One measures temperature precisely, but increasing microstates means more uncertainty about any molecule's location. Higher entropy means (location) *information loss*.

Incoming information (such as scent or advertising) stimulates. Libido raises mental temperature. Rising libido also means more "mental microstates" and therefore information loss. What is going on inside of me? Am I flying apart?

We associate increasing "mental microstates" with anxiety or tension, appearing as accelerated thinking and a loss of impulse control. Heated subjectivity means poor objective judgment, which result effective marketing encourages.

It is easy to imagine that Buying is a pleasure; it replaces the inner chaos of anxiety with action. ("When the going gets tough, the tough go shopping.") Buyer tension does not vanish, however; it crosses the gradient to the Seller along with joules of cash. To explain what this means to participants in an economy, we return to our horse example.

A Seller receives $200 for a horse that cost $150 to bring to market. The Buyer enjoys a horse's worth of tension-reducing, subjective entropy-reducing pleasure at the purchase. The Seller enjoys a horse's worth of pleasure at Selling the horse – but also receives entropy-tension from the Buyer. The Seller receives a *horse-plus* of tension, the cost of the horse, plus profit. Seller tension therefore rises *more than* Buyer tension falls (recall rooms A and B). Tension-wise, the Seller appears worse off than before. This is not the whole story.

A Seller is not in an isolated system. Seller proceeds to reduces his/her tension by spending proceeds to recover costs, and then to save, invest, and enjoy. A Seller thus experiences *more overall tension reduction* after a sale – by inventing the economic future -- than the Buyer did at the sale. *We infer that Selling is overall, a greater pleasure than Buying*. The profit motive increases overall entropy, in grand accord with thermodynamic nature.

The implications are more macroeconomic than personal. If Seller spending satisfies more than Buyer spending gratifies, then *macroeconomically, the Seller profit motive is a*

[59] "You cannot cheat an honest man."

stronger pleasure motive than Buyer desire is. Promotion may be necessary to incite the impulse to purchase specific goods, especially if one might not really need them. (But, they were on sale!) It would therefore make sense that advertising is necessary to encourage buying, but that anyone might sell anything (or anyone) for the right price; hence, the slave, drugs, and arms trades. One might even consider Selling one's children for the right price; we have today "gestational carriers" and "surrogate mothers".

If psychology enters economics as Buyer demand, it exits as the Seller profit motive.

Does this mean supply-side thinking is a basic economic principle, because selling more than consuming drives economic expansion? No. Business yields high profits only when an economy functions far from equilibrium. The unrestrained profit motive drives an economy toward equilibrium, such as we see in bubble-bursting, unregulated finance, as well as in the destabilizing drugs trade.

One invests for the same reason that one Sells: for profit. Selling that recovers production costs-to-market has value. There are only tiny investing finance production costs-to-market to recover. Besides, investing benefits an economy not immediately, only subsequently when new value can be consumed. Finance of yore could add some value because it provided rapid, local business liquidity. But rescuing profit-laden finance in 2009 had even less benefit than it might have had because banking used its bail-out funds for cosmetic, balance sheet adjustment. Nothing here helped the consumer, and instead inhibited improvement of the larger, Buy-Sell gradient.

Employing consumers is good economics, because Buying, not Selling drives the economy. Consumers purchase goods and services of necessity, like food; gaudy branding and salt and sugar content can raise Buyer temperature into enthusiasm. Macroeconomically, middle class earners spend and re-spend rapidly, putting money to work creating jobs. If present unemployment rates continue, middle class earning and consuming capacity may decline permanently, and cause structural, economic damage.

Once upon a time, a Seller might think, "find a demand, and fulfill it." The hot update is, "*create* a demand, and fulfill it". Addiction keeps the demand for drugs far from equilibrium, which motivates the most ferocious profit-seeking behavior.

Successful marketing is empathic, however; it respects subjectivity. Despite the overheated forces of neuro-advertising, a Buyer is not reliably a passive extension of the Seller. It may be that only an intuitive magician like Steve Jobs can think "beyond the gradient". Everybody else uses focus groups.

Accepting that currency flows across an irreversible, Buy-Sell gradient invalidates supply-side theories as primary once and for all. Once one understands and accepts what it means that consuming drives economics, really new thinking may be possible.

All About Your Mother: Baby is the Original Seller

Unpleasure for a screaming, panicked, early infant is annihilation that the rooting (sucking) reflex relieves. By six months of age, a baby has grown to recognize that the source of all safety and comfort is not oneself. We surmise that this recognition of separateness from the Mother Ship sets up an unpleasure-pleasure gradient from vulnerable

"self" to the ideal "other". Developing an ability to comfort oneself in her absence internalizes the mother-baby gradient. Thumb-sucking is early behavior that pleasurably reduces the internalized anxiety gradient toward equilibrium, replacing terror with more manageable separation anxiety. Discovery of one's thumb is a milestone on the path to autonomy.

Think of Baby as the original Seller. A successful baby smiles and cuddles, selling gratifying, "self-esteem" to mother. Mother purchases baby-love with joules of free energy delivered as milk. Baby internalizes mother's serene self-esteem along with the milk as self-love, and outputs evidence of their profitable business relationship in a diaper.

We may begin life as Sellers, but we become Buyers and enter the larger economy as we come to believe by age 3 (as advertisers well know)[60], that acquiring an idealized object (Cocoa Puffs!) can abolish at least briefly the self-other, anxiety gradient. A T-shirt legend says it well, "Whoever has the most toys when he [or she] dies, wins."

Over time, one replaces mothering with whatever "floats your boat". Eating relieves hunger; company reduces loneliness; romance fulfills desire; shopping relieves "the blues". We suspect a powerful link between anxiety and profitability. Advertising coyly insinuates the anxiety that a product promises to relieve; drink beer, feel better, get girls.

Closeness to mother is well-known as the *anlage* of self-esteem based on social status. There is good reason why self-esteem can be nurtured or destroyed while one is matriculated in the arms of one's high school or college "alma mater". "To matriculate", which means to join a group, derives its meaning from "mater", or mother. For many of us, buying a "status symbol" is as close to mother as we will ever again get.

[60] One of us (AJ) systematically asked tiny children what beer they would drink when they grew up. Everyone had an answer.

Part VI: The NVAT Modulates Entropy

An Excerpt from: "How Should We Use Entropy in Economics?" *by ET Jaynes*

[emphases ours]

It may be that a macroeconomic system does not move (at least solely) in response to the "forces" that are supposed to exist in current theories; it may simply move in the direction of increasing entropy…, just as a thermodynamic system …approaches equilibrium in the direction of increasing entropy…. The "economic entropy" to which we refer is a function… of whatever macroeconomic variables our theory recognizes and the ... number of different microeconomic ways the macrostate can be realized. … …Entropy is completely non-ideological, having nothing to do with any social philosophy; and so the idea ought to be equally acceptable to all.

… Even though a neighboring macroeconomic state of higher entropy is available, a system does not necessarily move to it. A pile of sand does not necessarily level itself without an earthquake to shake it up a little. The economic system might just stagnate where it is, unless it is shaken up by what an Englishman might call a "**dither**" of some sort…[61]

In our conjecture…, **the dither…is a kind of turbulence** injected into the macroeconomic variables by fluctuations in the underlying microeconomy by which the macroeconomic state is constantly driven to explore the possibilities of neighboring states. … An economy is always more likely to move toward one of higher than lower entropy, simply because there are more of them.

From Whence and to Whither the Dither?

Jaynes is in our view optimistic to see higher entropy as producing "neighboring states" to explore. We've proposed that the profit motive is stronger macroeconomically than Buyer desire. To consider the implications, we continue with Jaynes,

> In economics, the idea of the dither was anticipated by Keynes, who attributed it to animal spirits,[62] which cause people to behave erratically. We think of dither more generally, [as] the result of many independent individual decisions, not necessarily erratic or irrational...

Animal spirited selling drives a macroeconomy toward higher entropy heedless of the danger of profit bubbles and equilibrium. Because the drive to Sell out-drives the desire to Buy, selling-driven, thermoeconomic equilibrium is an endemic risk. The "pleasure principle" warns us that in its thrilling rush, selling will discard any connection to value.

Stock trading is problematic because frequent traders are not Buyers. Traders care nothing for worth; they buy only to sell "on the floor of the exchange", and so thrive on bubbles. High Frequency Trading (HFT) is the latest product of rabid selling psychopathology. These traders make money only because their super-computers are faster and their algorithms are better than someone else's. *HFT represents corrupt, insider trading in the age of*

---

[61] "Dither" refers to using randomization to "even out" errorss. In the creation of digital audio, dither is noise added to a signal to hide low level "quantization" problems that would otherwise cause harsh sound. "During World War II, airplane bombers used mechanical computers to perform navigation and bomb trajectory calculations. Curiously, these computers (boxes filled with hundreds of gears and cogs) performed more accurately when flying on board the aircraft, and less well on ground. Engineers realized that the vibration from the aircraft reduced the error from sticky moving parts. Instead of moving in short jerks, they moved more continuously. Small vibrating motors were [afterwards] built into the computers, and their vibration was called dither from the Middle English verb 'didderen', meaning 'to tremble'… Ken C. Pohlmann (2005). *Principles of Digital Audio*. McGraw-Hill Professional. ISBN 0071441565.

[62] See also *Animal Sprits*: How Psychology Drives the Economy…" By G.A. Akerlof and R.J. Shiller, Princeton Univ. Press.

supercomputers. The *Wall Street Journal* of August 1, 2009 reports:

> "Many high-frequency traders collect tiny gains… measured in pennies on short-term market gyrations. They [seek] temporary 'inefficiencies' in the market and trade in ways that can make them money before the brief distortions go away."

Market forces cannot restrain the animal spirits of traders who bite the invisible hand that feeds them. High Frequency Trading flattens the Buy-Sell temperature gradient, inflating profit bubbles beyond "irrational exuberance". Sooner or later, Buyer trust fails. Close to thermofinancial equilibrium, panic turns any remaining Buyers into overheated Sellers. Pop goes the bubble.

The resemblance of the pleasure principle and the Second Law are suspect, as though the pleasure-driven pursuit of profit were a dysregulated, heat-death instinct. As if treading blindly toward oblivion, civilization produces physical entropy beyond what is ecologically sustainable, and financial entropy beyond what is economically sustainable.

Trademill to Oblivion[63]

An expert trader wrote to us:[64]

"The price of electricity may be different throughout the country (for various reasons). Let us say it is 12¢/kwhr in Wisconsin and 15¢/kwhr in California. If a trader buys from Wisconsin for 13¢ and sells to California for 14¢, then everybody is better off by 1¢."

Traders rationalize that they make a market more efficient and promote equilibration by chewing up inefficient profits. We don't want economic equilibrium. We want a proper theory of profit. These trades create no value. They do not produce; they manipulate. A computer-controlled grid that distributes power based on need and price (not profit) would better serve sustainable, supply-and-demand economics in the power industry.

This is an exchange that reveals profit production as entropic, because only entropy appears as if *ex nihilo*. Newtonian economics "thinks" that economic equilibrium is the goal – but we know that *equilibrium ends economic activity*. There is no Newtonian "trend" toward equilibrium -- we know that any trend toward equilibrium only increases entropy. Besides, even in Newtonian terms, equilibrium tends to restore the barter system; no businessperson wants that. In thermoeconomic terms, equilibrium is heat death.

Applying Clausius' equations to economics,[65] one finds that high profit margins are wholesome if quickly re-invested – captured – in value production. Cannibalizing profits only hastens the drive toward economic oblivion.

Our Weak Recovery: There is no free economic fuel. There is some cost.

From all accounts, economic officials at high level meetings addressing the global financial collapse of 2008 realized that something fundamental had shifted.[66] The law of

---

[63] Culturally literate word-play on *Treadmill to Oblivion*, autobiography of radio comedian Fred Allen.

[64] Private communication from a former manager of power trading software at EPRI, Electric Power Research Institute. "The aim of this example was to show that a free market is not necessarily Newtonian in the +1, -1 sense you claim. That being said, though, you did put it to excellent use by projecting it onto entropy, the central theme of your work (which I do not dispute)."

[65] see www.profitandentropy.com/needswork

[66] Meetings included Paulsen, Gaertner, and Bernanke See Henry M. Paulson, Jr., "On the Brink", www.HachetteBookGroup.com, 2010.

supply-and-demand and its "invisible hand" had restored nothing. That left no theory to support root cause analysis or to light the path beyond *ad hoc* remedies.

In so many words, these economists identified thermoeconomic equilibrium as they reported that a financial bubble had burst, economic work had ceased, and no one could say where all the money had gone. They even prescribed a thermoeconomic fix. The fastest and biggest money deal in the history of economics came to pass - a fuel injection of massive sums to the banking system ($2.3+ trillion by some estimates). The solution was however very partial – because it was very partial to the financial classes. Allocation of new economic fuel to consumers was much less generous and direct than to the banks.[67]

This top-down stimulus did show immediate, short-term benefits. Unfortunately, the banks used their bailout money not to pump the economy, but to fix their various financial ratios. By 2011, because of its huge stimulus spending on employment, the economy of China was on a fast track to recovery.

Can anything creative replace economic fuel injection as a stimulus? Some imagine the mind as infinitely creative, and extoll the power of the mind to lift us up from any collapse. They cite farmers who rebound from drought by cutting costs and saving seed.[68] In other words, referring to Benjamin Franklin, "a penny saved is a penny earned". This aphorism is credible only in the reversible, Newtonian ethos of Franklin's era. Economic progress requires coining new pennies, not on tax cuts. There is no free fuel. Some combination of tax increases and spending (deficit, if necessary) must fund new value creation.[69]

In the asymmetrical, non-reversible macroeconomic world, *a penny saved is not enough*. A farm is not a perpetual motion machine; farming requires new energy from the sun. Tax cuts and deregulation do not produce sunlight. Any recovery model that supplies no new economic energy can only erode further the economic well-being of the middle class to the cynical pleasure of those who consider themselves Masters of the Universe.

Introducing the NVAT

To produce profits from profits fails either to recycle or to sequester them. Events since 2008 demonstrate that compounding profits purely financially (such as from bogus mortgages) leads to a trading frenzy of "value-less profits" that inflates profit bubbles, and leads to events like our most recent meltdown.

We suggest our solution here. Many nations use value added taxation or VAT. We would use a Non-Value Added Tax or NVAT to address failed profit recycling or sequestration. Many financial products will score a high NVA and be commensurately taxable. Statisticians and econometricians now perform such analyses for applications far more complicated than financial transactions.[70]

---

[67] See http://money.cnn.com/news/storysupplement/economy/bailouttracker/

[68] Brian Wesbury, Chief Economist, First Trust (Personal correspondence.)

[69] The combination of deficit spending necessary for victory in WWII, followed by large increase in marginal tax rates, fueled the economy out of the Great Depression and into the huge, sustained growth of the 1950s and 1960s.

[70] William L. Sanders "Comparisons Among Various Educational Assessment Value-added Models" SAS Institute, Inc. White Paper, October 16, 2006 *Accessed June 25, 2011*

Thermoeconomics would eliminate reams of "gotcha" regulations. Our model is keen only to distinguish profit-with-value from the profit-without-value that drives toward equilibrium. Careful application of NVAT will reduce chaos-forming pressures in financial markets. Any NVAT collections would create a financial disaster recovery fund.

Imagine that such an NVA Tax were in place prior to the blow-up of the housing market. Any profits made from trading in the negligibly value-added, bundled mortgage securities market would have been taxed at the highest rates, say 90+%. This would not outlaw or even regulate such trading vehicles; it would just make the Government (the Public) a partner in their "upside" potential by collecting revenue to ameliorate against any "downside" caused by collapse.

The NVAT is very different from financial transaction taxes based on price, such as the Tobin tax[71] or Spahn tax,[72] suggested during the past several decades to curb excesses in the currency market. NVAT differs from the Bank tax suggested to be levied against balance sheets. It also differs from a Financial Activities Tax (FAT) on the sum of bankers' excessive remuneration and bank profits (without regard to their value-added content).[73]

Common among all such financial taxation ideas other than NVAT is the problem that implementation policies depend jointly on ideology and political will. Only NVAT, with its thermoeconomic basis, brings the clout of science into the discussion.

---

[71] James Tobin (July/October 1978). "A Proposal for International Monetary Reform". *Eastern Economic Journal*: 153–159.

[72] Paul Bernd Spahn (June 16, 1995). "International Financial Flows and Transactions Taxes: Survey and Options". University of Frankfurt/Main; Paper originally published with the IMF as Working Paper WP/95/60.. Retrieved 2010-01-13.

[73] International Monetary Fund (April 16, 2010). "A FAIR AND SUBSTANTIAL CONTRIBUTION BY THE FINANCIAL SECTOR INTERIM REPORT FOR THE G-20". International Monetary Fund; Excerpt and LINK TO FULL REPORT as a PDF - republished online by Global Print Monitor on April 22, 2010. Retrieved 25 June 2011.

Part VII: Information Economics

Redundancy versus Individuality

We know that the Newtonian universe is a friction- and fuel-free mechanism that can do nothing individual, nothing new. We know that the thermodynamic universe of cause-and-effect generates events that are individual and new. We remember however that "individual" and "new" do not mean "creative".

Andy Warhol's famous painting presents identical Campbell Soup cans as exactly *not* thermodynamic individuals. (This was in reaction to the previous decade of super-individuated, Jackson Pollack "action painting", expressionism.) A soup can becomes individual only as it moves off the shelf and is consumed; its individuality is its death.

Events are thermodynamically individual *only* in that they use up fuel and generate waste. This is nothing to turn up one's nose at, of course. The scent of substances that carry away waste identify individual animals to each other, rather like a bar code.

In mid 20th Century, thermodynamics evolved into a mathematical theory of information. In the 21st, we may find that information theory has meaning for economics.

Post World War II Progress

To support proliferating telephone networks after World War II, Claude Shannon presented a mathematical, information theory with "entropy" at its center. At first, he called his a theory of communication, not information. Shannon had worked on coded communications during the War, and later noticed that deciphering messages transmitted over noisy telephone lines resembled decoding scrambled, secret messages.[74]

Shannon defined entropy as "new information" that had "surprise value". He defined redundancy as the *opposite* of information; one could discard redundant letters and words without losing meaning as a codebook would reveal it, or as a person might understand it. High entropy, low redundancy messages were difficult for enemies to decode.

We verbalize language asymmetrically, from the beginning to the end of a sentence. This suggested to Shannon a rule of "left-right" causality. "Shannon entropy" refers to calculating the most likely third word from any two word sequence; this technique has become the basis of speech recognition software everywhere.[75] Databases that include umptillions of sentences make the odds of correct calculation quite good. Of course, today's Shannon entropy calculates the most likely, hence the least surprising word choice.

Entropy as information versus redundancy as its opposite are confusing ideas. Thousands of letters scrambled in a hat have maximum entropy. If whichever letter is next up is equally probable, one cannot infer any message except that letters exist. There must non-random, redundant elements in a message to convey meaning.

Compare the problem of communicating information in language to the function of a library. If all the books are safely stored, all the information is safe. Their order is secure. But the books are useless if they are not in circulation, even at the risk that books taken out

---

[74] *The Information*, James Gleick, p. 214 etc. 2011.

[75] Pointed out by Benjamin Lambert, PhD.

by individual readers will be lost. Libraries thus have opposing, storage (order, redundancy) and circulation (increasing entropy) functions.

Letters and words are the unchanging and therefore redundant elements that store the information in any message.[76] To construct words from letters and sentences from words however, a "dithering" element must jostle letters and words out of alphabetical order, which raises their entropy and risks generating gibberish. Entropy is thus better thought of as a *capacity to convey* information -- to put books into circulation rather than *as* the information in the books.

We infer from all this that entropy as the capacity to communicate and redundancy as the capacity to have something to communicate *work against each other*.[77]

> The capacity to convey meaning through language depends not on an entropy maximum or minimum, but rather on a delicate optimization of the two opposing elements of variety [entropy] and reliability [redundancy]. Carrying either to the extreme, we lose the meaning.[78]

Language somehow puts these distinct, entropic and redundant elements together; grammar organizes word salad into meaningful, communicative coherence.

We return to understand Shannon entropy in a new light. A Shakespeare sonnet would have a very high Shannon entropy (surprise value), because its next word would be hard to predict (unless the database had the sonnet tucked away.) Entropy is a measure of the individuality of a message in language, just as Shannon described.

Redundancy and entropy are complementary elements that pertain almost anywhere that people try to figure things out using language. One of us is a psychiatrist who uses the perception of information (meaning) and entropy as "love" versus "individuality" in his psychotherapy practice, where he may identify them as *Roles and Rules*™.[79]

Biology has been an information science[80] since its earliest classification days. Cellular biology models how to think about language. Every cell combines elements both of "meaning" (information) and "energetic randomness" as distinct structures. The cellular nucleus conserves stored DNA information, so that cells may reproduce. Mitochondria are intra-cellular engines that metabolism supplies with fuel and oxygen to keep each cell working. The nucleus houses information; mitochondria generate increasing entropy. Perhaps verbal language evolves from how genetics puts information and individuality together in cellular structure.

We suggest that "value" exactly as we have used the term is "meaning" in economics. Value refers to the economic work – cost recovery -- that keeps people fed, secure, and employed. Sooner or later however, everything has its price – even medical care – and price implies profits.

Associating profitability with increasing entropy in an information, economic model identifies profit as the capacity for individual enterprise that may be realized when profit

---

[76] Schrödinger called redundancy "negative entropy". Molecular structure containing free energy is also "negative entropy".

[77] *Information and the Living System* by Lila L. Gatlin, Columbia University Press 1972

[78] *Information and the Living System*. Op. cit.

[79] www.rolesandrules.com

[80] *Information and the Living System*. Op. cit., page 51.

marries value, rather than absconds with financial abracadabra. Profit that does not mix with value inflates an economy toward dangerous thermofinancial equilibrium.

Verbal language and cellular biology combine meaning and entropy in creative structure. Viewing profit as a capacity for individuality in economic behavior reminds us that profits must be treated with respect, but not with reverence. *Labor and energy do not mix with and so cannot sequester "non-valued" profits*. Regardless, financiers still invest in the profit-from-profits bubble machine with free-market, religious fervor.

Post Vietnam War Regress

The Glass-Steagall (G-S) Acts of 1932 and 1933 structured American banking for decades. It separated speculative, investment banks from banks that hold depositors' savings. It further divided commercial savings from savings-and-loan banks. Deregulation that eliminated the distinction between commercial and savings-and-loan banks led quickly to the Savings and Loan, home mortgage melt-down of 1982. G-S protections that remained blocked that crisis from bringing down the entire financial system.[81] These protections (alas) were removed in 1999, so that the bubble-burst of 2008 could take down the whole economy. G-S divisions had long protected savings from raids that would turn them into risky mortgage products – risks that newly unleashed brokers tried to insure against before 2008 by building in a credit-default-swap pyramid scheme.

Epilogue II

Supply demand presumes that the universe is zero-sum, which it is not. The more we try to stuff the universe into a zero-sum suitcase, the more the suitcase overflows. That stuff has to accumulate somewhere. In economics, wealth accumulates where very few people can get to it.

This result is pure science, with no necessary relation to virtue, liberty, or talent.

> Financial bubbles don't burst. They simply join all the other bubbles on the champagne glasses of the wealthy and powerful. (NF)

[81] Thanks to Ab Kader (op. cit.) for reminding us of this.

Authors

Richard Goldwater, MD

Richard Goldwater graduated from Columbia College and Boston University School of Medicine. He trained in psychiatry at Harvard Medical School.

Dr. Goldwater's training in medicine and long practice of psychiatry have informed his understanding of motivation and interaction in personal and business life. Rather than the traditional doctrines of adaptation or "meaningful relationships", in his view the center of psychology is the creation and gestation of a self-concept from the elements of experience. Psychotherapy serves to assist the birth and the developing life of a "self", as the sum of the life roles one plays for and with others.

At Columbia College in New York City, Dr. Goldwater was careful to balance pre-med science studies with the liberal arts, leading to the conclusion: The Second Law of Thermodynamics is the Rule of Rules, and Shakespeare's *Hamlet* is the Role of Roles. The present document describes the physical world as a set of rules. His forthcoming, "*Marriage Is for Men and Divorce Is for Women"* presents the psychological world as a set of roles.

There is in the most intimate relationships a potentially creative tension between people becoming like each other, versus developing within the relationship as autonomous individuals. Roles and Rules™ captures the asymmetry that renders intimacy difficult to fathom, as it provides a format for the resolution of conflict.

Dr. Goldwater imbibed increasing entropy at his father's knee. The elder was a distinguished physical chemist who developed market-leading, local entropy-reducing detergent products.

Arthur Jonath, PhD

Arthur Jonath's interest in thermodynamics started with his education in Aeronautics and Astronautics and continued with his graduate work in Materials Sciences. As a sort of vacation from engineering studies while at MIT, he took the Economics Courses 14.01 and 14.02 taught by Paul Samuelson. Not quite the holiday he expected! He learned aircraft control theory from Paul Sandorff and later at Stanford studied thermodynamics under both Dave Stevenson and Walter Harrison. He has used ideas linking these three fields in his technical and management consulting practice.

Dr. Jonath spent the first half of his career in research at the Lockheed Palo Alto Research Laboratories. There he performed R&D on a wide variety of technologies, including solar energy, semiconductors, adhesives and rocket propulsion, and used examples from nature, such as echolocation in whales and compound eyes of dragonflies, in advanced weapons systems designs during the Cold War

Later he was a founder of Visic, a semiconductor start-up, and then VP, Reliability & Quality Assurance for VLSI Technology, Inc. Subsequently he founded Arthur Jonath Associates (AJA) to assist in solving quality, productivity improvement and technology transfer problems. AJA has provided services to a broad range of clients, from start-up to Government Laboratory to Global 500 pharma, electronics and instrument companies.

Dr. Jonath's background also includes grand-scale failure analysis and implementation of customer satisfaction systems. He has served on the board of directors, as CEO or as Technical Advisory board member on several other start-ups. He has taught at the graduate level and was a founding member of the Manufacturing Advisory Board, School of Business, San Jose State University. He currently serves on the Board of Directors of a rapid, reformable tooling company, is New Business Development Director for a high efficiency engine start-up, and is on the School of Engineering Advisory Board, Stanford University.

Acknowledgements

We greatly benefit from the reviews of our work by many people, who subject our writing to points of view we could not have imagined. We await each review, whether criticism or praise, with the anticipation of learning. For this we thank our reviewers sincerely and profoundly.

This project would never have happened if we had the time to do it.

{Names here}

(embryonic) Index