

Beyond Supply and Demand

Entropy and Information in Economic Science

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Richard Goldwater and Arthur Jonath © 2008-2012

[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...”

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

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/>

Our motto: *This project would never have happened if we had the time to do it.* (AJ)

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Introduction: What is Wrong with Economics?

Let us recount the ways...

With the advent of universal search engines, research necessary to answer scientific problems has never been easier...or harder. Consider for example solving the basic rocket science equations that specify the propellant necessary to place a known payload into a specific orbit. One can quite easily find the necessary information on the web, or even find the problem already solved, once and for all.

On the other hand, the huge amount of information available to solve complex economic problems may simply obscure the fact that there are no good economic answers. With more than 25,000,000 search results for finding the root-cause of and mitigating solutions for the 2008 financial collapse, there is in 2012 no consensus about why it occurred, about what actions would support a recovery from a collapse, nor about what actions would protect against another occurrence.

By 1981, post-Vietnam anxiety had opened a vacuum at the top of American leadership that sucked in gobs of naive ideology -- that its first economist proponent disowned during the recent financial crisis. Ronald Reagan's romantic but implausible, "supply side economics" deregulated business and de-taxed the rich, expecting to liberate economic activity, and thus raise the revenue that would pay for his accelerating arms race with the USSR. The USA, which had been the greatest creditor nation, became the greatest debtor nation on earth. No one noticed.

Arguments rage on about nearly every aspect of economic theory, starting with Adam Smith's 1776 law of supply and demand, and its resemblance to Newton's Law of balanced, action-reaction. Why can't economic science predict the dynamics of economic cycles? Why does nearly every correction to economic imbalance cause unknowable and unintended consequences? How can the Supply-Side idea, demonstrably a dangerous failure, still attract advocates?

Reliance upon the Law of Supply and Demand as an "invisible hand" that keeps economic balance and generates the greatest good for the greatest number is responsible for our growing economic inequality and financial instability.

Most of all: why has economics not publically and successfully incorporated any new natural science into its modeling since its conception during the era of Isaac Newton? Many still believe that the "genius of the free market" is supposed to take care of extreme or ignorant, business behavior. To manage the chaos that instant communication, super-sized databases, superfast computation, and mathematical chicanery all encourage, economics must integrate with more recent science. No physical science is required in economic and business school education, only some advanced mathematics, so it is no wonder that "neoclassical" economics has updated its mathematics, but not its science.

The law of supply and demand at the heart of contemporary, "free market" economics has come down to us unchanged from Adam Smith, who wrote in 1776. This law describes Supply and Demand as opposing economic forces that tend to balance and as they do, stabilize prices. Not by accident, Smith's law resembles Newton's Third Law of Motion -- that every action generates an immediate, equal and opposite reaction.

During the 18th Century scientific Enlightenment, Newton's mathematical laws of conservation or perfect balance seemed to apply universally, so it was only natural to model 18th Century economics on Newtonian science. Newton's Laws perfectly describe the repeating, perfectly predictable, perpetual motion of planets in friction-free orbits. They also describe perfectly the recoil of a rifle firing a bullet. Newton's laws do not however very well describe anything that uses and uses up fuel to keep moving -- such as an automobile engine, or an economy.

No one is satisfied with the ability of economics to describe and predict economic events, as a

science ought. Economists blame the problem on human behavior. They refer mostly to the behavior of consumers, and not to that of business people or of economists. Objective attempts to understand the economic “rational actor” have however led to scant improvement in the ability to predict economic outcomes. Masses of data approximate group buying behavior well enough for marketing purposes, but there is more to economics than buying.

A complete economic science would understand buyer and seller together, as existing on a continuum along which currency flows like thermal energy from buyer to seller. A novel interpretation of 19th Century thermodynamic science enables the necessary revision. Applying the Second Law of Thermodynamics to the social sciences including economics opens discussion to a new universe of possibilities. To explain the novelty and importance of our approach however, we need to address some of the philosophical and historical, “back-story”, as well as rehearse some simplified science.

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Beyond Supply and Demand

*Entropy and Information in Economic Science*¹

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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

Correspondence with Nature: Analogy Presents the Case.

Physicists argue by analogy, adopting the “parsimony principle”, that there are few, fundamentally different phenomena.³

Cultures create characteristic analogies from perceptions of nature. Traditional analogy is metaphorical or symbolic. Greek myths organized stars into heroic constellations. Shakespeare’s characters saw portents of meaning 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 Western Renaissance, cultural perception has become increasingly mathematical and statistical. “Isomorphism” is especially rigorous analogy, a precise mapping from A to B. Social sciences have developed over the centuries as analogies of the science of Isaac Newton’s era. For example, Adam Smith in the 18th Century associated economics with Newton’s Laws of Motion.⁴ Smith in effect compared an economy to a gyroscope, which is an almost perfectly stable, spinning device that classroom teachers use to demonstrate Newton’s laws.

The question is: if their math is the same, are they the same? If the mathematics of economics is the same as applies to Newton’s physics, does this make economics Newtonian physics? Do numbers of dollars behave like Newtonian objects and forces, because forces and objects behave like numbers? Knowingly or not, *economists assume that they do*. Otherwise, economists could claim no power to explain. They blame any unreliability of their explanations on the complexity of a macroeconomic system and the subjective irrationality of individual participants in an economy.

Comparing an economy to a fuel-consuming engine will suggest a novel approach to economic complexity as well as to subjectivity in economics. It will lead to understanding profit as economic individuality in an “information theory” sense. To understand the comparison and to develop these ideas, we shall need an introduction to the 19th Century, Second Law of Thermodynamics.

“Crises in Physics and Economics” (by ET Jaynes)⁵

“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.

¹ The authors are grateful for the invaluable assistance of Micah Goldwater, Ben Lambert, Ted Lehman, Ab Kader, and Richard Kullberg.

² Attributed to economist John Maynard Keynes

³ Credited to Richard Feynman.

⁴ Don’t just take our word for it. “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

⁵ from *How Should We Use Entropy in Economics?* by ET Jaynes 1991

“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 first distinguish “Newtonian” from “thermodynamic”.

Newton’s 17th Century Laws of Motion, and the 19th Century science of Thermodynamics describe the universe differently. Newton describes a symmetrical universe in perfect balance; every action has an immediate, equal and opposite reaction. The Second Law of Thermodynamics describes an asymmetrical, imbalanced universe flying through time and space toward oblivion.

We may most practically distinguish Newtonian from thermodynamic science as “*action-and-reaction*” versus “*cause-and-effect*”. A rifle recoils exactly as a bullet flies away. This is simultaneous and symmetrical, action-and-reaction (even if Newtonians call it “simultaneous” cause-and-effect). Gunpowder ignites before a bullet flies away. This is asymmetrical and sequential, cause producing a *new* effect. Causality releases energy and uses up fuel, in this case, gunpowder.

Newton’s cosmos is a repeating, fuel-free, frictionless mechanism in perfect equilibrium and perpetual motion. Nothing changes or accumulates, not even time. Newton’s laws are *reversible*; ‘t for time’ in his equations may be positive or negative. The Newtonian past predicts a redundant future. Because events repeat, the sun rises exactly on schedule, same as last year.

Newtonian mechanics is thus zero-sum, meaning “no net change”. Sporting events are zero-sum. A winning team goes one-up and the other goes one-down; +1,-1 add to zero. Barter economics is zero-sum; a horse and a cow trade places, but nothing measurable changes overall. A child’s see-saw is also zero-sum; as one side goes up, the other goes down, and vice-versa.

Economics as inherited from Adam Smith considers itself zero-sum. Economists rationalize profit as “inefficiency” in the supply-demand, see-saw. 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. *There is however no such thing as Newtonian inefficiency;* even classroom gyroscopes run down, losing energy to friction. Heat-generating mechanisms like engines and organisms are inefficient. *If economies are not perfectly efficient, they must be thermodynamic.*

Inefficiency is inescapable. Heat energy released from storage in the complex, molecular structures used as fuel can accomplish work. Inefficiency means that thermodynamic systems cannot perfectly recycle heat into the work that might produce new structure. As a result, disorder increases overall. The Second Law of Thermodynamics defines “increasing entropy” to refer to energy in a system not available for work, such as after its release from fuel. *Entropy increases overall any time anything happens that releases energy from any kind of fuel.* This includes the workings of engines, the metabolism of organisms, the brilliance of stars, and the bustling of economies.

The law of increasing entropy is the only natural law of necessary increase, rather than of perfect conservation. Increasing entropy means inherent inefficiency; increasing entropy is waste. To remain func-

tional, a thermodynamic system must exhaust, export or “dissipate” its increasing entropy production into its environment. This is the thermodynamic equivalent of Original Sin.

There is more time (the universe is older) and there is more entropy (disorder) today than yesterday. *Increasing entropy thus represents the arrow of time.* Just as gravity determines the sense of “down”, increasing entropy determines the sense of forward time.⁶

Because the 2nd Law is the only law of necessary increase, if an economy must produce profits and expand, then one must compare profit to increasing entropy, which is waste born of inefficiency. Many in business and finance assume that profit “fuels” investment, even though “Adam Smith economics” considers profit as inefficiency. Profit as inefficiency cannot be financial fuel.

Let’s Review

Here we summarize and illustrate what we have presented so far about thermodynamics, entropy, and asymmetry. These are steps toward reconciling economics with natural science.

- Molecules above absolute zero in temperature perform a random, heat driven motion.
- Heat is thermal energy, which can be measured in joules. Hotter molecules contain more joules of thermal energy, and so move faster and more randomly than do colder molecules.
- Heat energy flows across a hot-to-cold temperature gradient, reducing it. Flow stops at equilibrium.
- There can be no spontaneous return from temperature equilibrium to distinct, hot and cold states. Otherwise, one might burn the same fuel twice.
- The Second Law may thus be cited as, “Nature abhors a gradient,⁷ but adores an equilibrium”.
- Fuels store joules of “free energy” in the structure 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 molecular structure than work can recreate.
- As a result, using fuel for work creates more disorder overall than order - disorder that is described as “increasing entropy”.
- Joules of released energy = joules of work + joules lost to entropy.
- Increasing entropy measures the necessary, universal loss of order with time, and establishes real time as irreversible. Increasing entropy is the “*arrow of time*”, pointing toward the future.
- Maximum entropy may be defined as:⁸ “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...”
- Profit has no central place in supply-and-demand economics, which amazingly enough defines profit as “economic inefficiency”. Supply-demand economics is about price, not profit. A thermodynamic economics looks at profit directly, as it is related to the *sine qua non* of thermodynamics, increasing entropy.

Now we are prepared to discuss in Part II the Second Law and increasing entropy in more detail. Discussing thermodynamics a bit more closely in Part II will prepare us for discussing thermoeconomics in Part III.

⁶ Attributed to Ludwig Boltzmann

⁷ *Into the Cool: Energy Flow, Thermodynamics, and Life*; E.Schneider and D.Sagan; Univ. Chicago Press, 2005. See also Swenson, op.cit.

⁸ “entropy.” *Webster’s Third New International Dictionary, Unabridged*. Merriam-Webster, 2002.

Part II: *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.

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 therefore to what is in no formation at all – to what is “in-formation-less”.⁹ 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 individual molecules that forever 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 and their joules of energy reach equilibrium at an average value, but entropy increases overall, rather than “averages out”.

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. 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; they 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*.¹⁰ Entropy is maximum at thermodynamic equilibrium. *Entropy is not conserved*.

At maximum entropy, individual molecules in Room A+B may roam in twice the space as before. That is, at equilibrium any individual molecule may be anywhere in the two rooms. *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 loss of information – of *location information*.¹¹

The Room A-B example represents diffusion across any thermal gradient in the universe. Diffusing heat cannot accomplish work, however. An engine accomplishes work. In Part III, we consider engines, including economic engines.

Another point. Neither joules of heat nor degrees of temperature are units of increasing entropy, because neither changes overall as heat spreads. 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*.¹²

We shall also return to discuss in later sections the meaning of the Second Law as it may apply to social sciences such as economics. To do so, we need to learn two special words: “macrostate” and “microstate”. The condition of a dynamic system as a whole is its “macrostate”. At equilibrium, its

⁹ When Star Trek characters “beam up” from a planet to their ship, but their forms do not rematerialize, they remain “transformational”.

¹⁰ See equations at www.profitandentropy.com/needswork

¹¹ “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

¹² 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.

state of maximum entropy, a macrostate is most uniformly average, so that (for example) temperatures measured anywhere within it are the same.

Each possible molecular location in a macrostate is a “*microstate*”. At equilibrium, the maximum number of microstates make up a macrostate. So, maximum entropy identifies average, *macroscopic uniformity* at the same time as it represents maximally individualized, *microscopic chaos* – at least from the perspective of a scientific observer of the macrostate. Applying this version of reality to economics, we note that while macroeconomic variables like average earnings may be calculated precisely, what any microeconomic individual earns or buys is 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 however to infer the nature of a micro- or macro-system from the other, whether we compare the behavior of a few gas molecules to balloon full of gas, or of economic individuals to a national economy. The accepted, economic propaganda that equates the behavior of a macro-economy with that of a household denotes the failure of public education in America.

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

From Casino Statistics to Statistical Mechanics

Puzzling the relation of microstates and macrostates brings us to statistical mechanics.

Amid great scientific drama, Ludwig Boltzmann (1844-1906) sought to reconcile Clausius’ cause-and-effect asymmetry and Newton’s action-and-reaction symmetry.¹³ He reasoned that while the Entropy Law applies to heat-flow on the macroscale, individual molecules that carry heat must function as tiny billiard balls, and so be subject to Newtonian reversibility. Such “micro-reversibility” means it must be possible for heated molecules spontaneously to return to their original state, even if such is not likely to occur within the age of the universe.¹⁴ In this “statistical interpretation of thermodynamics”, perfect knowledge is quantitatively unlikely, not qualitatively impossible.¹⁵

Flashback. At the same time as Newton described simultaneous, action-and-reaction, gamblers who wished to calculate their odds at dice found it necessary to consider non-simultaneous, cause-and-effect; after all, throwing dice *causes* them to move. This was the birth of what we know today as the statistical representation of individually caused events, such as according to the famous “bell-shaped curve” of normal distribution.

“Casino” statistics may *correlate events*, but cannot *discern causes*, because distributed, individually caused events are presumed to occur all at the same instant.¹⁶ A bell-shaped curve is just a snapshot. Such pictures cannot represent past-to-future (asymmetrical), cause-and-effect, which occurs (as it were) orthogonally to the dimensions of a normal distribution. As a result, one can calculate one’s odds at any given instant, but one throw of the dice cannot affect the next. *There is no irreversible, cause-effect interval in casino statistics.* Even lines drawn to connect “data points in time” cannot reveal how any one point may “cause” the next.

Boltzmann’s work led to a new branch of physics called “statistical mechanics”.¹⁷ This is the

¹³ Boltzmann opened the door to the future spirits of the Atomic Age, of the Information Age, and of our Age of Entropy.

¹⁴ Readers of Douglas Adam’s *Hitchhikers Guide to the Galaxy* will have come across this idea as the “infinite improbability drive”.

¹⁵ 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*.

¹⁶ Attested to as the caveat, “Past performance is no indication of future earnings” that appears on financial prospectuses.

¹⁷ The story of “Maxwell’s demon” explains how it is that Newtonian observation cannot reveal statistical mechanics.

study of macroscopic properties as they emerge from the interactions of independent, constituent micro-particles. (Individual air molecules have no temperature or pressure, but a balloon of air does.) If cause-and-effect asymmetry applies to macrostates but not to microstates, then one approaches the problem mathematically as, “How can macroscopic asymmetry arise from microscopic symmetry?” Perhaps statistical mechanics will someday describe how macroeconomics arises from microeconomics, as well as solve the problem of causality in mathematics.

Puzzling about symmetry versus asymmetry led Erwin Schrödinger in 1944 to write the book credited with beginning the science of molecular biology, *What Is Life?*. He pointed out that physicists perceive a natural, “order-from-disorder principle”. That is, the laws that describe regular behavior on the macroscale somehow arise from chaos on the microscale. He reasoned that biological cells could not work this way, and still 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.

We might wonder why the reversibility we associate with *balance and certainty* on the Newtonian macroscale appears as *statistical uncertainty* on the microscale. Our wonderment suggests a thermoeconomic view of free market psychology. Economic libertarians seek to protect their microstates as expressions of individual liberty. “Don’t tread on my microstate!” We know that microstates appear as chaos to the macroscopic observer, but that on the reversible microscale (where we microeconomic, individual humans exist), cause-and-effect vanishes and Newtonian certainty reigns. Free marketeers protect their microstate status by imagining that the economic macrostate is their microstate writ large. It is no wonder then why free marketeers insist that the government balance its budget as though it were a household.

Social scientists including economists (and physicists dabbling in finance) have not yet sought properly to adapt statistical mechanics into their fields; as a result, financiers seem much more like gamblers than like physical scientists. An aleatory (dice-throwing) world-view is comforting. There are only a few different ways dice can land; landing on an edge or a point is quite rare!

Toward the end of this duo-graph, we shall briefly discuss the evolution of entropy as a concept in the 20th Century, mathematical theory of information. Mathematical information theory grew out of efforts to decode enemy messages during World War II. Since then, information theory has revolutionized biological science, and produced the computer age. Information theory may help economics to advance, as well.

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.

<p>Heat disperses, space expands, entropy increases, information is lost, and time travels. Entropy is the famous “waste” that “happens”. And, thereby hangs the tail.¹⁸</p>

¹⁸ – which is sometimes a statistical, “fat tail”. See also www.profitandentropy.com/needswork.

Part III: From Thermodynamics to Thermoconomics

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 and Demand. We explain briefly the scientific justification for this revision, and consider some of the implications.

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*. Flow continues until a gradient “evens out”; for example, hot water mixes in a cool tub until all the water is lukewarm. Because flow across a gradient is toward equilibrium, *flow is irreversible*. Rivers will not spontaneously flow uphill, and heat will not spontaneously flow back from a lukewarm equilibrium to previously distinct, hotter and colder temperature zones.

Money in circulation is *currency*. When a Buyer pays more for an object (or a service) than it cost a Seller to bring to market, currency flows across a Buyer to Seller gradient. Flow across the gradient drives micro (personal) and macro (international) economics.

Free Market economists recognize no driving, irreversible 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. (Nothing in nature works this way.) Because supply-demand flow is reversible, a free market might either be Supply-side driven (fueled by Federal Reserve policy and tax cuts to investors) or Buyer-side driven (fueled by graduated taxation and consumer spending).

During the crisis of mid-2008, the fulcrum vanished, and seesawing ceased, which revealed that economic equilibrium is a state of paralysis, and no ideal at all. If two people of equal weight on a playground seesaw pause at equilibrium, their play ceases until an outside force (like a stimulus package) can tip the balance, and start them moving again.

Idealizing equilibrium generates dysfunctional economic ideas, such as balancing the federal budget at all costs. In their zeal to balance the budget, some want to tax the rich, while others want to cut spending. These are equally plausible, in supply-and-demand terms. Those who want to protect investors because they “provide jobs”, reveal themselves as hierarchical rather than as freedom-loving and egalitarian at heart; the free market is in their sly interest, not in that of consumers.

Balancing the federal budget when an economy is running well reduces debt interest payments, putting that money to work creating everyday value. It is counterproductive to balance the budget through spending reduction when an economy is near equilibrium. We need to protect and enhance the Buyer-Seller gradient, even if it means borrowing more and taxing the rich. 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

Economic currency (such as dollars) flows like heat, and represents a capacity for economic work.

Economists at last accept as inadequate the view of sentient participants in an economy as “rational actors” motivated to survive. There is more to Buyer economics than survival; one buys things because one wants things. Interesting studies of brain, cognition, and behavior do not however describe emotional, “whole beings”. Many in the quantitative sciences find it awkward to relate emotions to physical science constructs. We hope to overcome this awkwardness by describing Buyer

and Seller, psycho-economic temperature scales and an *economic temperature* gradient between them. We expect our heuristics to present a more functional view of human nature than underlies the libertarian, free market.

We do not need to measure economic temperature precisely. Any temperature scale that rises from absolute zero, including one that we imagine and estimate is valid in thermodynamics. Because relativity to absolute zero is all that is required, 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 interactions objectively. We just need to know that one side of a gradient is hotter than the other. We therefore propose a psycho-economic temperature scale of economic desire or libido that is the microeconomic equivalent of the well-known, macroeconomic measure: Consumer Confidence.

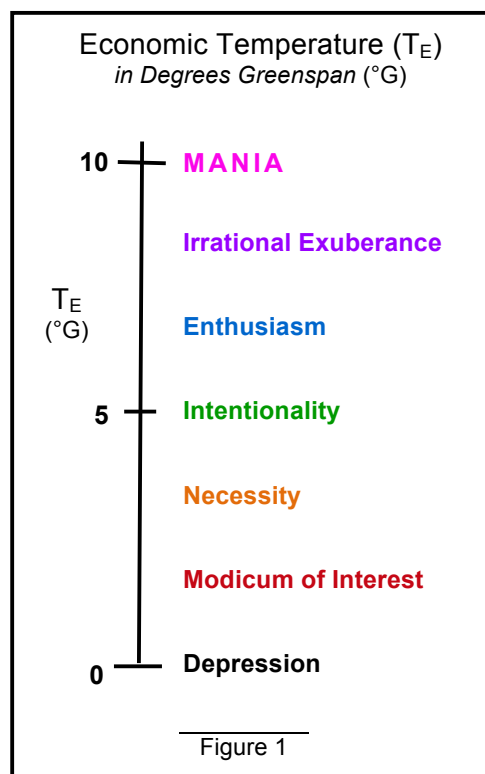
Heat excites molecules, increasing pressure upon a container from within. If we may say that desire or "libido" heats up people, then we may also say that libido puts pressure from within upon contained, human behavior. We understand libido here as emotional tension or pressure *apart from any behavior* (such as Buying) that might relieve it; literature across the ages describes passion without relief as torture.

Because there is no actual, subjective energy – libido is not energy -- we say that *information* affects subjective, Buyer temperature. Buyers gather information about products from ads or in-store displays. Advertising was not vital during Adam Smith's era (when survival or Necessity drove most Buying), but is necessary today to maximize the Buy-Sell gradient in a consumer economy.¹⁹

Joules are units of heat; we compare dollars as units of currency to joules as units of heat. We think of cash as a fuel that releases its energy when it is ignited at a point of sale. When Buyer-Seller temperatures meet at a sale price, dollars of "hot cash"²⁰ flow across the desire gradient, heating the Seller, and releasing the object to the Buyer.²¹ 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.

Figure 1 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.

Intentionality or rational choice is at center. Necessity implies less choice. Modicum of Interest needs a hard sell; Depression means staying in bed. Above Intentionality, rationality melts into Enthusiasm for fads and fashions. Higher temperatures lift the Buyer from Enthusiasm to Irrational Exuberance,²² where price is almost no object. Further above, Exuberance yields to Mania. Gambling on real estate and assuming wild credit card debt qualify here.



¹⁹ See also: Study: Your Brain Thinks Money Is A Drug by David Kestenbaum. Nat'l Public Radio August 7, 2009.

²⁰ A Buyer of a horse brings "hot cash", and is literally "hot to trot", eager to "consume".

²¹ 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.

²² Alan Greenspan, Fed Chairman during the Dotcom era, popularized Yale Professor Robert J. Shiller's *Irrational Exuberance*.

The well-known Consumer Confidence Index (CCI) represents average Buyer Temperatures macroeconomically. Figure 2 shows its flow over the past 12-year period. For comparison, we estimate our micro-economic equivalent temperatures in °G on the right-hand scale.

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, Intentionality 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.

To discuss the Buyer-Seller temperature gradient, we refer back briefly to increasing entropy. Recall that a physical system generates increasing entropy as it approaches equilibrium. A system far from thermal equilibrium (in which there are distinct, hot and cold areas) generates more entropy en route to equilibrium than a system that is already close to equilibrium. Similarly, an economic transaction across a wide Buyer-Seller, economic temperature gradient will generate more profit than will a transaction across a small Buyer-Seller gradient.

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

Steve Job's 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, which produces high profits. New product presentations build excitement as though Apple were Santa Claus bringing Christmas 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 loving homes. He could imagine and positively identify with the states of mind of Apple's customers.

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 "Intentionality" 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 recent 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.

Our third example is the worldwide financial near-Collapse of 2008. Unpoliced finance endangered the world economy, but citing greed as the root cause has not led to prosecutions of malefactors, 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, 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 market believers, 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.

To prepare us to discuss the economic Pleasure Principle, we address *work, value, worth, and profit*.

“Work, Work, Work, Work”²³

To compare heat diffusion and 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.* Heat diffusion does no work. We need a better idea.

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 transfers of heat energy, work is measured in joules, which are units of *energy* (not *entropy*). Work would thus seem to be zero-sum and so not related to increasing entropy. It makes sense therefore that *engines work in cycles*.

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

No matter how efficient an engine is 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 on the one hand, and on the other generate byproducts that dissipate whatever we will come to mean by increasing economic entropy.

Entropy increases, and time passes. So it goes.

²³ Spoken by Governor WJ LePetomane (Mel Brooks) in *Blazing Saddles*, as his head poked out from between closed curtains.

Economic Work Recovers Value, and Dissipates Profit.²⁴

Fuel molecules store joules of “free energy” in structure determined by molecular bonds.²⁵ Nature worked hard to store all that energy! In internal combustion engines, fuel ignition frees the energy, and creates a temperature gradient between the ignition chamber and the cooling system. Expansion in the chamber forces the piston to deliver power; ignition of new fuel restores the gradient for another cycle. We know that each cycle generates increasing entropy (waste heat, which is energy that cannot be used to do work) as well as power.

We draw an analogy between physical work in joules and economic work in dollars. Products and services store the work-energy (labor and materials) of bringing them to market as dollars of *economic free energy* that we call “production-cost-energy” or “value”. At a point of sale, the aptly named “consumer” sparks the release of these dollars to 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. Proceeds in excess of cost are profits.

We define production-cost-energy as **value**, and the cyclic recovery of value as economic **work**.

A barter exchange of objects of intrinsic value, like many rabbits for a cow, uses no economic fuel – no currency – and so generates no measureable profit. There is no future and no planning in such a hare-and-cow, barter system. Each barter exchange takes place in its own present moment; there is no implied, next transaction. A barter exchange is to a cash transaction, as a perpetual motion machine is to a fuel engine.

Currency transforms intrinsic value into abstract value exchangeable for anything of like price, and invents finance. A price that just recovers costs mimics the zero-sum balance of barter; cash that pays creditors and employees has *intrinsic value* for the seller, and so completes a production cycle. Breaking even can buy nothing new, however.

Because an economic engine burns fuel, successful economic transactions cannot be zero-sum. They will produce something like increasing entropy: profit, which signifies that new things are happening, and that the engine needs more fuel.

Acting as increasing entropy, each profitable transaction prints new currency, expands economic space, and invents the economic future. Circulating, accumulating profits inflate money supply, and ensure that there is more money in a system than can be in use at any given moment; banks store and distribute excess cash. Currency fixed to a standard like gold restrains advance from a break-even, barter economy. So far, profit seems more wonderful than inevitable. But, entropy is waste! (Not to worry; there is a clean, happy ending.)

Because virtually everything that happens uses up fuel, overall virtually everything increases entropy. It won't hurt to repeat that increasing entropy represents the irreversible “arrow of time”. Just as gravity accounts for the sense of down, increasing entropy accounts for the sense of *forward time*. Our time on earth exists because we can harness and expend energy. The alternative is a universe of perpetual motion. Planets in perpetually repeating orbits require no fuel because they move without friction and accomplish no work. Perpetual motion machines can do nothing new. *Doing anything new requires fuel, which increases entropy.*

Introducing profits as “irreversible time” identifies a profitable transaction as “successful”, which means that another transaction can succeed it – can follow it in time. Profit thus invents the future, and with it the hope of civilized progress. There can be no measureable profit however until

²⁴ The last systematic theory of profit may have been “Risk, Uncertainty, and Profit” by Frank H. Knight, published in 1921.

²⁵ In *What Is Life* (1943), because of its storage in molecular structure, Erwin Schrödinger equated free energy and “negative entropy”.

somebody buys something using currency. Barter is two-way Buying or maybe two-way Selling; either way, nobody pays a measurable, profitable price.

Systems in industry and nature develop functions that dissipate increasing entropy; there are automobile radiators and biological excretions. The analogy is inescapable that profits carry away waste economic "heat". This is neither shameful nor catastrophic! It just means that an economy functions more like an engine or like the body of an animal than like a solar system or a gyroscope.

Consider biology. A body is a food-burning furnace; exporting its high-entropy waste products keeps it in working order. 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.*

Maximum profit was never a rational, overall *goal* of economic activity. Even the most committed free marketeers rationalize that the goal of economics is the well-being of civilization; they (naively or cynically) claim that individuals earning maximum profits (Greed is good!) is the best means to that end. Identifying profits as entropy would mean that transforming profits directly into value resembles spinning straw into gold – possible only magically, in the imagination.

We may not need the magic that would spin straw into gold, but we have nevertheless created an imaginary friend (like a golem) to turn profits into value. A business corporation is a fictitious, "legal person" with rights and responsibilities (but like a monster, with no conscience). Corporations return profits to the ground to mix with sunlight (either downloaded every day for free, or released from storage in fossil-fuels), which creates new product and service value.

In Part II we noted that joules cannot designate both energy and entropy; we calculate increasing entropy in "*joules-per-degree*". Likewise, cash cannot refer both to price and to profit-as-entropy. Elsewhere, we discuss "*transaction profit*" as "*dollars-per-degree Greenspan*".²⁶

Since cash profit is not the same as *transaction profit-as-entropy*, some economic "free energy" must remain in cash profit, just as some free energy remains in natural fertilizer. Nevertheless, recognizing that profits are less like refined fuel than like waste products suggests that we ought not to think we invest profits so much as recycle or even sequester them. Gasoline engines can recycle some waste heat in a turbo device. Farmers can return manure to the ground to mix with sunlight and earth to fertilize new crops, useful as long as we protect the water supply. Some industrial waste like nuclear fuel must be sequestered, however; any energy it retains is dangerous. Any other view of profits seems quite unsanitary.²⁷

To leverage profits purely financially from profits fails either to recycle or to sequester them. Recent events (since 2008) demonstrate that compounding profits purely financially (such as from bogus mortgages) leads inevitably to a trading frenzy of "value-less profits" that inflates profit bubbles, leading to events like our most recent meltdown. We suggest our solution here.

Many nations use value added taxation or VAT. We would use a simple, Non-Value Added Tax or NVAT to address the lack of financial profit sequestration. Many financial products will score a high NVA and be commensurately taxable. Cogent application of NVAT will reduce chaos-forming pressures in financial markets. A significant side benefit will be the elimination of many arcane and value-crushing regulations. Any NVAT collections would create a financial disaster recovery fund.

We do not call for revolution - just for a rotation in our thinking to comprehend that we do not create value to make *new* profits; we create value to recycle or sequester *previous* profits. Without

²⁶ www.profitandentropy.com/needswork. We do not yet know how to calculate the free energy remaining in cash profits.

²⁷ "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)

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 by itself reverse entropy, of course. New value production must also sell at a profit. We create value to slow increasing entropy, not to stop or reverse it.

Value versus Worth

Selling that recovers costs-to-market has *value*. Bartering parties exchange objects of perceived, intrinsic utility, but nobody buys anything. There can be no profit until somebody buys something for currency. Profit accrues in excess of intrinsic, exchange value because of *worth* to a Buyer.

Worth (*as distinct from value*) exists as an *expectation of product gratification* sufficient to motivate buying at a profitable price (rather than for example waiting for a “better deal”). A well-heated, “mind of profit”²⁸ can blithely ignore workers’ rights, environmental impact, and responsible, personal finance.

Two orthogonal elements define worth as *utility*. One is *objective* or intrinsic utility; a Buyer wants a horse to work the farm. A horse might also have *subjective*, social utility: to impress a woman a man wants to marry. 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, and perhaps relief from social status anxiety. Advertising subtly blends these two expectations into a heady and hearty ambrosia.

The utility of warm coats in a cold climate might seem to matter. Not many coats may be 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.²⁹ Ponzi-schemer Bernie Madoff could steal billions because he aroused social-status lust among his prospects, convincing them of favored, “insider treatment”.

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

Value, Worth, Pleasure, and Profit

We turn to address what motivates economic behavior, a concern of so much economist research. 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 such as spending on desirable items is pleasurable. The classical, economic “rational actor” would associate pleasure with physical or social survival, sometimes as simply as, “I am going to die if I cannot buy that new iPad.”

We must distinguish reducing economic temperature from relieving subjective tension so that we may associate relieving tension with reducing “subjective entropy”.

As heating raises temperature, molecules of a fluid move about more energetically and randomly, which means that their entropy also increases. Heating precisely affects pressure and volume, but greater randomness raises uncertainty about any molecule’s location. Higher temperatures and higher entropy thus mean location *information loss*. The subjective equivalent is anxiety: What is going on inside of me? Am I flying apart?

We draw upon the physical description of microstates to analogize mental microstates. When we de-

²⁸ Adapted from Wallace Stevens’ poem, *The Snow Man*: “One must have a mind of winter...”

²⁹ “You cannot cheat an honest man.”

scribed Buyer tension as subject to information (not energy), we prepared to associate microstates, entropy, and anxiety. We associate mental microstates with anxiety or tension manifesting as scattered thinking, a loss of focus among too many choices, or unchecked impulses. Heated subjectivity means poor judgment – which is just what many marketers want to encourage.

In Section VI, we shall relate how the physical description of microstates became the conceptual basis of information theory.

It is easy to imagine that Buying is a pleasure because it replaces the inner chaos of anxiety with purpose. (“When the going gets tough, the tough go shopping.”) Buyer tension does not vanish; it crosses the gradient to the seller. To explain what this means to participants in an economy, we present a bit more about physical, increasing entropy.

Let us suppose that a Seller receives \$200 for a horse that cost \$150 to bring to market. The Buyer enjoys a horse’s worth of tension-reducing pleasure at the purchase. The Seller enjoys a horse’s worth of pleasure at losing the horse – but also receives entropy-tension from the Buyer. The Seller receives a *horse-plus* of tension, which is the cost of the horse, plus profit. Seller tension therefore rises *more than* Buyer tension falls. Entropy-wise, the Seller appears worse off than before. This is not the whole story, however.

A Seller is not an isolated system. Seller proceeds to reduce his/her tension by spending proceeds first 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 conclude that Selling is overall, a greater pleasure than Buying.* The profit motive increases 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 stronger than Buyer desire.* Promotion may be necessary to incite the purchase of 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 however consider Selling one’s children for the right price. So, we have today “gestational carriers” and “surrogate mothers”, etc. It is no wonder that there is still a sex-slave trade, and an illegal drugs industry. If psychology enters economics as Buyer demand, it exits as the Seller profit motive.

Does this mean supply-side thinking is the right economic principle to follow, because selling more than consumption 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. The continuous, high demand for drugs keeps the drugs market far from equilibrium, and motivates the most ferocious profit-seeking behavior.

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 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”. Despite the over-heated forces of neuro-advertising, a Buyer is not reliably a passive extension of the Seller. Successful marketing is empathic; it respects subjectivity. It may be however 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 once and for all. Once one understands what it means that consuming drives economics, really new thinking is possible. We may even wonder: can there be true, economic democracy?

All About Your Mother

Unpleasure for a screaming, panicked infant is felt “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 (aka the mothering parent) is not oneself. It is as though this recognition of separateness sets up an unpleasure-pleasure gradient from vulnerable “self” to external, ideal “other”. Developing an ability to comfort oneself in her absence by remembering her internalizes the gradient. Thumb-sucking is early behavior that pleasurably reduces the internalized anxiety gradient toward equilibrium, replacing terror with 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), 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.

Part IV: *The Necessity of the NVAT*

A Quick Lesson: Symmetry and Asymmetry in Business Planning

American auto companies long 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 could ignore product quality and reliability. They expected a buyer to seek warranty repairs upon discovery of flaws.

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 an unpaid, quality control function. Superior, in-line quality control delivered defect-free products to happy customers.

Alas. The stories of the Deepwater Horizon well blowout in the Gulf of Mexico (2010) and of the nuclear power plant failure in Fukushima, Japan (2011) reveal that supply-and-demand, market forces in the new century have trumped the lessons of the 1970s, both here and abroad.

Supply-and-Demand, Cause-and-Effect, and Psychology

Economists often complain that psychology confounds economics. If so, why treat Adam Smith as a psychologist? His free market theory trusts an “invisible hand” to rock the supply-demand cradle just gently enough. Its “genius” was supposed to prevent the recent world crash. It seems more reasonable to compare the “invisible hand” to a religious statue on the dashboard of an auto that occupants wish would protect them from the laws of physics. Now, that’s psychology.

Anyone can safely enjoy movie special-effects that ignore cause-and-effect. Planets in unperturbed orbits can also ignore cause-and-effect sans ill effect, because there are no new, interplanetary causes or effects. Ignoring cause-and-effect in economics however suppresses interest in the consequences of one’s actions (“It was an accident!”). The free market turns economics into a brutal sport of which we non-financiers are either spectators or losers or both.³⁰

The “supply side economics” foisted on America in the 1980s was particularly destructive, wishful thinking. Supply-siders could conquer common sense because no one could refute that if supply-and-demand are symmetrical and balanced, then they are logically interchangeable. In our asymmetric, thermoeconomic model, desire for a horse must come before the cart that carries off the cash. *There is no justification in science or history for supply side economics.* The Soviet economy was strictly “supply side”, of course; its production ignored what Buyers wanted or needed.

Supply-side tax cuts since 1981 have slowed growth and redistributed massive wealth up and away from people in the middle and low income brackets. Can that be good? During the fabulous economic growth of the 1950s, the highest income bracket (3.2 million in 2010 dollars) was taxed at 91%. Unfortunately, no one who knows this history proclaims it to us.

In 1981, the USA was the greatest creditor nation on earth. We entered a race deliberately to outspend the Soviet military, and force the Soviet economy into oblivion. Trying to keep up, the USSR collapsed. We were not far behind. *To pay the bill, we counted on reduced taxation and supply-side deregulation to increase federal revenue.* As a result, the USA became the greatest debtor nation on earth. President Clinton muscled the budget temporarily back into balance, but we have not and may never recover our credit-worthy standing.

David Stockman was Ronald Reagan’s budget director and champion of supply-side economics. He regretted how Republicans responded to his ideas, and left Reagan early in his Presidency.

³⁰ Thanks to Howard Berens MD for these thoughts.

“This debt explosion has resulted not from big spending by the Democrats, but instead the Republican Party’s embrace, about three decades ago, of the insidious doctrine that deficits don’t matter if they result from tax cuts.”³¹

Osama bin Laden in his 2001 attacks on the USA returned Reagan’s favor. Osama publically reasoned that by infuriating Americans we would bankrupt ourselves to get back at him. Two wars with no tax hikes to pay for them later, the USA economy teeters toward bankruptcy.³²

From the Success of Newtonian Mechanics to the Failure of Newtonian Economics

Isaac Newton wrote in the late 1600s. Adam Smith published *Wealth of Nations* in 1776. Smith inferred his zero-sum ideas from Newton’s laws, the only scientific “game in town”.

In the 20th Century, John Maynard Keynes presented vital, new theories of an integrated economy. Keynes also relied on a zero-sum model. 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, perpetually (gyroscopically) spinning, economic coin.

Perhaps seeking to update economics from Newton’s era, “neo-classical” economists in the mid 19th Century tackled the science of energy as put forth by Heinrich von Helmholtz, and his account of the First Law of Thermodynamics, the Law of the Conservation of Energy. Historian Robert Nadeau writes in *Scientific American*:³³

“The progenitors of neoclassical economics, all of whom were trained as engineers,³⁴ 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 the conservation of energy depended upon wildly inapplicable assumptions, including that:

...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....³⁵

...A number of well-known mathematicians and physicists told the economists that there was absolutely no basis for ... these substitutions. But the economists ignored such criticisms and proceeded to claim that they had transformed their field of study into a rigorously mathematical scientific discipline.³⁶

One might wonder if this is the first clear example of the careless or deliberate distortion of science to suit the profit motive.

Mid-19th Century economists accepted and touted the First Law of Thermodynamics as the natural science template for economics. Even though they misconstrued the implications, economists

³¹ David Stockman NYT op-ed, July 31, 2010.

³² The Worst Mistake America Made After 9/11: By Anne Applebaum. Sept. 4, 2011, <http://www.slate.com/id/2302754/>

³³ “Brother, Can You Spare Me a Planet”, by Robert Nadeau; *Scientific American*, March 2008

³⁴ Among them were William Jevons, August Walras, Francis Edgeworth, and Vilfredo Pareto.

³⁵ The Economist Has No Clothes by Robert Nadeau, *Scientific American*, April, 2008

³⁶ Ibid

accepted that economic science must be modeled on natural or physical science. Unfortunately, they accepted the First Law, but ignored the much more relevant Second Law of Thermodynamics.

The First Law does not depart from or amend Newtonian principles, so represents no scientific advance from Newton. One must conclude that the economists who adopted Helmholtz did so to dress up Newton in more fashionable garb. It was a case of monkey-see Helmholtz, monkey-do Helmholtz.

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.³⁷ Their mad-cap 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*”.³⁸ Conservative guru Alan Greenspan has publicly lamented the failure of his economic thinking.³⁹ Notable businesspeople including George Soros call for a new economic model.⁴⁰ The *Financial Times* hits “misplaced risks”:⁴¹

We are surrounded by things that do not work well, but are ... widely used. ...[including] according to Nassim Taleb, ...the Black-Scholes model. The equation, named after...the 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.

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

Black-Scholes addresses pricing, not profit, and so is Newtonian, not Thermoeconomic.

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.⁴² 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.⁴³ 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.⁴⁴

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.”⁴⁵

³⁷ “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.

³⁸ Forbes Magazine, February 19, 2009

³⁹ Alan Greenspan Oct 23, 2008, op. cit.

⁴⁰ George Soros, “The Crisis & What to Do About It”, New York Review of Books, Vol. 55, No. 19, December 4, 2008.

⁴¹ “Mispriced Risk Tests Market Faith in a Prized Formula”, Anuj Gangahar, *Financial Times*, April 15, 2008.

⁴² Mathematical Model and the Mortgage Mess, Dennis Overbye, NYT, March 9, 2009.

⁴³ Recipe for Disaster, Felix Salmon; WIRED Magazine: 17.03, 12-03-09

⁴⁴ “As 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.

⁴⁵ WIRED Magazine, op.cit.

For centuries, economic responses spread across planting seasons and ocean sailings. Stresses grew slowly, and markets responded lazily.⁴⁶ Industry sped things up; Keynesian controls during the 1930s helped markets to equilibrate. Today, super-computational, “High Frequency Trading” (HFT) compresses years of financial activity into a few minutes, making what had been rare catastrophes, threateningly imminent. Note for example the market “glitch” of May 6, 2010 when the market fell 1000 Dow Jones points in a few minutes.⁴⁷

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.⁴⁸

Civil War Story: Government Regulation versus Maximum Profit

We are all aware of the endless war between businesspeople and what they despise as “government regulation”. This war is an unfortunate consequence of both sides using a Newtonian economic model. We wish to explain how the war has come to be, and come to be taken for granted.

Contemporary economics explains profit as “inefficiency” that impedes the economic mechanism from gliding toward price equilibrium. The supply-demand view is that *the unfettered pursuit of self-interest in a perfectly competitive economy leads to economic efficiency*.⁴⁹ That is, the pursuit of profits produces efficiency because competition minimizes profits. We have argued that this model in effect projects responsibility for ethical behavior and efficient economics onto what we see as a supernatural mechanism, the “invisible hand”, which is the “genius” of the free market.

Informal conversations suggest to us that many educated in business and finance ignore the basic, economic principle that good economics implies minimum profit. They act as though profit is an absolute good that fuels investment; they equate business success with maximum profit.

Supply-demand interactions may tend toward a 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*; they call normal profit “irreducible inefficiency”.⁵⁰ Profits greater than “normal profits” are “economic profits”.⁵¹

There is no Newtonian inefficiency, however; *inefficiency is a thermodynamic concept*. Normal profit is a “fudge factor” that keeps a supply-and-demand market plausible to those who wish it so. Our thermo-economic model analogizes increasing entropy as representing thermodynamic inefficiency, with profit as representing economic inefficiency.

Because government regulation interferes with the free pursuit of profits, government finds itself very visibly protecting economic efficiency as it protects competition from monopoly. The result is the familiar socio-psychodrama of moral antagonism between business and government.⁵²

Free marketeers bristle at the implication of immorality that a need for rule enforcement implies. They ignorantly or cynically cite the free market as justification. The most orthodox (Chicago School) free marketeers insist that monopolies ought to be allowed to form regulation-free, because

⁴⁶ 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.

⁴⁷ “Algorithms Take Control of Wall Street” by Felix Salmon and Jon Stokes, *Wired Magazine*, January 2011.

⁴⁸ Presidential Address: *Profession and Crisis* Eastern Economic Journal 2011 37, pp.307-312.

⁴⁹ <http://www.answers.com/topic/economic-efficiency#ixzz1L8ubcdZu>

⁵⁰ See also http://economistsview.typepad.com/economistsview/2007/06/profit_theory_i.html “Profit and Loss” by Daniel Davies.

⁵¹ Profits above “normal” are desirable, “economic” profits. Albrecht, William P. (1983). *Economics*. Englewood Cliffs, NJ: Prentice-Hall.

⁵² Psychanalysts might perceive the “invisible hand” as the “Ego-Ideal” (mother), and government as the “Super-Ego” (father).

they will eventually fall apart of their own weight. Might not failing monopolies take down an entire economy with them? Might not unregulated, catastrophic Darwinian economics lead to Communist Revolution? Marx would expect so.

Zero-sum, economic logic often extends to this idea: in an ideally efficient (desirable) economy there is only a fixed amount of money, so that no one can become “better off” without making some one else “worse off”.⁵³ A horrifying, standard definition of economic efficiency is:⁵⁴

... An economic state in which every resource is optimally allocated to serve each person in the best way while minimizing waste and inefficiency. When an economy is economically efficient, any changes made to assist one person would harm another...

In an “ideal” economy therefore, raising the minimum wage deprives richer people of their money.

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 to profits, but to the state of all financiers having the same information, and therefore of all making the same predictions, and therefore of all realizing only 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 rules may cause unintended harm such as by inhibiting initiative. Of course! Government regulators use the same Newtonian model as business-people, 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 preclude “gaming the system”; humans like games, starting with peek-a-boo. Unless some god has identified profits as a promised land open to pillage, there can be no scientific, moral, or historical reason to believe in a free market *without umpires or referees*. At present, we play a dishonest, ignorant, dysfunctional economic game.⁵⁵

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.⁵⁶ 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.

The profits of productivity are not the problem. Relevant mathematics⁵⁷ 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.

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

⁵³ Sullivan, Arthur; Steven M. Sheffrin (2003). *Economics: Principles in action*. Pearson Prentice Hall. pp. 15. cf. “Pareto Equilibrium.”

⁵⁴ http://www.investopedia.com/terms/e/economic_efficiency.asp

⁵⁵ See also, “Foolproofing Cap-and-Tirade” by David. R. Baker; San Francisco Chronicle, Jan. 17, 2011

⁵⁶ Thanks to Ab Kader (op. cit.) for reminding us of this.

⁵⁷ (www.profitandentropy.com/needswork) We update the practice that Robert Nadeau describes, op. cit.

“The Economic-Thermodynamic Analogy”

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. ... Of course, ... it may be that some other unrecognized factor is even more important. But entropy is at least a promising candidate, because it is clearly relevant and is not now being taken into account. (...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, the 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...⁵⁸

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.

There is a close analogy in the mechanism of biological evolution. There the dither is spontaneous random mutation as a result of which every species is constantly exploring the possibilities of slightly different design. Presumably, the human race has thus far explored only a negligibly small portion of all the [neighboring] possibilities in economics.

In economics, the idea of the dither was anticipated by Keynes, who attributed it to animal spirits, which cause people to behave erratically. We think of dither in more general terms, simply the result of many independent individual decisions, not necessarily erratic or irrational...

...With no entropy gradient, a system drifts aimlessly, determined not by any macroeconomic variables, but by unrecorded details of microeconomic variables. When individual citizens become poor or prosperous, pessimistic or confident, cautious or adventuresome, it changes the dither.

Dr. Jaynes identifies an “entropy gradient” that is sensitive to macro and microeconomic factors, including “the dither”. He also compares a trend toward higher entropy to biological evolution. We question this comparison. Increasing entropy aims at featureless equilibrium, not at differentiation and complexity. Mutations may improvise on DNA as on a musical score, but even so, most mutations are useless or fatal. Besides, there is no hard core of meaning in economics analogous to biology upon which to improvise. We are quick to associate the dither with “animal spirits”, however. We go on to associate both of these with what most people recognize as the profit motive.

Whither the Dither?

We recall that Jaynes wrote, *“The dither ... is a kind of turbulence injected into macroeconomic variables by fluctuations in the underlying microeconomy. ...An economy is always more likely to move toward [states] of higher than lower entropy, simply because there are more of them. ...Keynes anticipated the idea of the dither, attributing it to animal spirits.”*⁵⁹

We discussed that at a profitable sale, subjective Seller tension increases more than subjective Buyer tension decreases. As a result, we surmised that spending the proceeds of a sale relieves more tension and so affords more pleasure for a Seller than spending wages does for a Buyer. We infer from this that Jaynes’ “unrecorded details of microeconomic variables” are in fact animal spirits selling, selling, and selling. That is, the profit motive and not consumption drives a macroeconomy toward higher economic entropy. Recall our suspicion of Jaynes’ comparison of increasing entropy to

⁵⁸ Please see endnote (after Index p.27) for an interesting, further explanation of “dither”.

⁵⁹ See also *Animal Spirits: How Psychology Drives the Economy...* By G.A. Akerlof and R.J. Shiller, Princeton Univ. Press.

biological evolution, as though increasing entropy were benign.

High Buyer-Seller temperature differences mean high profit margins. All other things being equal, these signify economic health, not economic inefficiency; they are possible when an economy is functioning well, far from equilibrium. Innovative and imaginative, consumer-oriented companies like Apple heat up Buyer temperature nicely. Conventional management for “shareholder value” (stock price) sacrifices innovation to finance.

Because the drive to Sell out-drives the drive to Buy, selling-driven, thermoeconomic equilibrium is an endemic risk. If rising Buyer temperature cannot maintain a Buyer-Seller gradient, the hot drive to sell will flatten the Buyer-Seller gradient, and drive an economy toward chaos. The “pleasure principle” warns us that in its thrilling rush, selling will discard any connection to value.

Stock trading is economically very 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 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 Buyer-Seller temperature gradient, inflating profit bubbles beyond recall. As the bubble expands, it requires “irrational exuberance” to buy. Sooner or later any remaining, Buyer trust in worth fails. Close to thermofinancial equilibrium, panic turns any remaining Buyers into overheated Sellers. Pop goes the bubble.

The pleasure principle and the Second Law bear an uncanny resemblance, as though the pleasure-driven pursuit of maximum profit were a dysregulated, heat-death instinct. As though blindly treading toward oblivion, civilization produces physical entropy beyond what is ecologically sustainable, and financial entropy beyond what is economically sustainable. Traders who claim that “free market economics” justifies their work need to remember that,

“To restrain private people... from receiving in payment the promissory notes of a banker... when they are willing to receive them; or, to restrain a banker from issuing such notes..... may, no doubt, be considered ... a violation of natural liberty. But ...exercising the natural liberty of a few individuals, which might endanger the security of the whole society, are, and ought to be, restrained by the laws of all governments; of the most free, as well as of the most despotical”...⁶⁰

Trademill to Oblivion⁶¹

An expert trader wrote:⁶² “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 like pilot fish, they make the market more efficient and promote market equilibration by chewing up “inefficient” profits. Here we see what it means that contemporary eco-

⁶⁰ Smith, Adam; *The Wealth of Nations*, 1776 Book 2, Chapter 2 pp. 351-352

⁶¹ Culturally literate word-play on *Treadmill to Oblivion*, autobiography of radio comedian Fred Allen.

⁶² 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).”

nomics has no proper theory of profit. These trades create no value because they do no economic work; no new actual product exists. All is manipulation. Economic equilibrium is the last thing that one wants! A computer-controlled grid that distributes power based on need and price but not profit would better serve sustainable, supply-and-demand economics in the power industry.

No example of exchange that is empty of value could better reveal profit production as a symptom of increasing entropy. Only entropy comes 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,⁶³ one finds that high profit margins are wholesome, provided they are re-invested – sequestered – in the production of value. Cannibalizing profits only hastens the drive toward economic oblivion.

Our Weak Recovery: There is no free economic fuel. It must be produced at some cost.

From all accounts, economic officials at the high level meetings addressing the collapse of the global financial system in the fall of 2008 realized that something fundamental had shifted.⁶⁴ The law of supply-and-demand and its “invisible hand” had failed to provide a natural, restoring force. That left no theory to support root cause analysis or to light the path beyond *ad hoc*, partial solutions. Nevertheless, ideology quashed any suggestions of permanent fixes.

These economists were ignorant of thermodynamics. Nevertheless, they identified thermoeconomic equilibrium when they reported that a huge financial bubble had burst, that economic work had ceased, and that no one could say where all the money had gone. No one realized that we had entered the real world of thermodynamics and increasing entropy, in which it takes much more energy to clean up a mess than to make it.⁶⁵ Even so, Paulsen, et al prescribed a thermoeconomic remedy. The fastest and biggest money deal in the history of economics came to pass - a fuel injection of gargantuan sums of money 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 fuel to the lower and the middle classes was much less generous and direct than to the banks.⁶⁶ Even this top-down stimulus did show immediate, short-term benefits, despite the banks remaining on the sidelines, and despite the banks using 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 replace economic fuel injection as a stimulus? Some imagine the mind as a creative soul that inhabits eternity. But when ideas enter the physical world, they must conform to laws of physics: the principles of growth and change in nature. Some extoll the power of the inventive, human mind to get us out of any collapse. They cite farmers who rebound from drought by cutting costs and saving seed.⁶⁷ In other words, a penny saved is a penny earned. This is true only in the reversible, Newtonian universe in which Benjamin Franklin lived, however. Economic progress depends upon coining new pennies, not on tax cuts. Economic recovery models that ignore (and trivialize) the contribution of proper stimulus offer no alternative, realistic way to pull the economy back

⁶³ see www.profitandentropy.com/needswork

⁶⁴ Meetings included Paulsen, Gaertner, and Bernanke See Henry M. Paulson, Jr., "On the Brink", www.HachetteBookGroup.com, 2010.

⁶⁵ In running out of gas in the middle of Death Valley, one reaches thermodynamic equilibrium. The thermodynamic solution is to phone On-Star or AAA to bring you fuel ASAP, regardless of its cost.

⁶⁶ See <http://money.cnn.com/news/storysupplement/economy/bailoutracker/>

⁶⁷ Brian Wesbury, Chief Economist, First Trust (Personal correspondence.)

from equilibrium, and restart it. There is no free economic fuel. Some combination of tax increases and spending (deficit, if necessary) must fund the labor of new value creation.⁶⁸

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 experience with start-up business makes it clear that new ideas die without infusions of new economic fuel – of capital. (“Jesus saves but Moses invests”.) The seed of invention cannot sprout into prosperity without the economic equivalent of Uncle Sol. 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

Thermoeconomics does not suggest new, complex regulations. Rather, it would eliminate reams of dumb, “gotcha” regulations! Our model is keen only to distinguish profit-with-value from the profit-without-value that drives toward equilibrium. We would use a Non-Value Added Tax or NVAT to address failed profit recycling or sequestration. Statisticians and econometricians now perform such analyses for applications far more complicated than financial transactions.⁶⁹

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 tax⁷⁰ or Spahn tax⁷¹, 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).⁷²

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.

⁶⁸ 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.

⁶⁹ William L. Sanders “Comparisons Among Various Educational Assessment Value-added Models” SAS Institute, Inc. White Paper, October 16, 2006 Accessed June 25, 2011

⁷⁰ James Tobin (July/October 1978). “A Proposal for International Monetary Reform”. *Eastern Economic Journal*: 153–159.

⁷¹ 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.

⁷² 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 V: *Conclusions and Recommendations*

We have achieved only a tepid economic recovery because we spent public capital mainly to return Wall Street to profitability. We chose not to enhance Buyer temperature on the macroscale (Consumer Confidence) by supporting job creation. Some would argue that human greed or government meddling brought the crisis of 2008. We argue to reconcile economics with thermodynamics. A thermoeconomic remedy to the collapse of 2008 would include massive spending on employment, aggressive taxation of ill-gotten, financial gains, and the jailing of financial culprits.

The contest between cap-and-trade and carbon taxation regimes to control pollution is an exemplar of Newtonian versus Thermodynamic debate. Cap-and-trade ignores the cause of pollution effects, and instead uses finance to trade in effects – giving financiers huge profits and many chances to game the system. Carbon taxation, the thermoeconomic solution, addresses the cause of the carbon problem – carbon - before carbon enters the atmosphere to undesirable effect. Government can direct tax proceeds toward mitigation of future environmental disasters.

Non-value profits accelerate the drift toward thermofinancial equilibrium. Working with the profit-value connection in financial products, we can reduce bubble-formation dynamics, and stave off dangerous financial fluctuations from “tipping points”. We expect the proper science to restore the former 100-year interval between financial tsunamis by slowing the rate of increasing entropy.

Many nations use value added taxation or VAT. We would use a Non-Value Added Tax or NVAT to address the lack of financial profit sequestration. Many financial products will score a high NVA and be commensurately taxable. Cogent application of NVAT will reduce chaos-forming pressures in financial markets. Another major benefit of NVAT and thermoeconomics will be the elimination of many value-crushing regulations. Any NVAT collections might create a financial disaster recovery fund.

We call for the political discipline lawfully to restrain financial entropy production to within what we can sequester in new value production. Whatever happens, there is no need for socialist, economic planning. Opponents of government regulation complain with good reason that rules have “unintended effects”. Government over-regulates what it does not understand. If the financial sector is sufficiently, scientifically well regulated however, free market capitalism may yet take care of itself, and of all of us.

A confirmed set of rules makes a game worth playing.⁷³ To paraphrase an old theater song, “Life is a baseball game, Old Sport”. You cannot plan a baseball game, but you can umpire it. The more violent is a sport, the more it needs active, intelligent officiating. *Economics is a blood sport.*

We hope for the further study of such ideas as:

- Comparing economic inefficiency to thermodynamic inefficiency;
- Exploring the relation of profitability to increasing entropy;
- Comparing profitability to Shannon (message) entropy;
- Using an economic temperature gradient to distinguish Buyer desire from Seller profit motive;
- Associating entropy with a pleasure principle that links pleasure with survival and social status;
- Identifying “worth” and “value” as subjective and objective elements of economic transactions;
- Transforming economic “casino statistics” into statistical mechanics;
- Quantifying value as economic work, and economic work as product-cost-energy recovery;
- Distinguishing value-added from non-value-added finance.

⁷³ Thanks to Richard Kullberg

Part VI: *The Next Steps*

Predictability versus Individuality

We know that the Newtonian universe is a fuel-free, repeating perpetual motion mechanism, and that perpetual motion machines can do nothing individual or new. We know that the thermodynamic universe of cause-and-effect generates events that are individual because they are new. The individually different, colored crayons in a box are not thermodynamic individuals. They are all present in the present. Thermodynamic individuality implies the future, and leaves a trail of waste behind to prove it.⁷⁴ *Doing anything new requires fuel, which increases entropy.*

“Individual” and “new” does not mean “creative”. Events are thermodynamically new *only* in that they use up fuel, and generate waste! The smells of the secretions and excretions that carry away the increasing entropy their metabolism produces identify individual animals to each other.⁷⁵

The story does not however end in the 19th Century. By the mid 20th, statistical thermodynamics had evolved into a mathematical theory of information. In the 21st, we may find that entropy, individuality, and profit combine in a surprising new meaning for economics.

Information Economics

In support of telephone networks as they grew after World War II, Claude Shannon presented a mathematical, information theory with “entropy” at its center. At first, Shannon called it a theory of communication, not information. He had worked on coded communications during the War, and later noticed that deciphering messages transmitted over noisy telephone lines resembled decoding scrambled, secret messages.⁷⁶ Shannon equated entropy with “new information” or “surprise value”, and defined redundancy as the opposite of information. High entropy messages were difficult for enemies to decode. Redundant letters and words were those one could discard from a message without losing its meaning as a codebook would reveal it, or as a language-user could understand it.

One writes and speaks 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 a capacity to decipher individual messages by calculating the most likely third word from any two word sequence – which is the basis of speech recognition software even today.⁷⁷ Databases that include gazillions of sentences make the odds of correct calculation quite good.

Entropy as information and redundancy as its opposite are ideas useful in cryptology, but not otherwise. Thousands of letters scrambled in a hat have maximum entropy. Whichever letter one picks next is equally probable. One might infer any or no message from such chaos. There must be some non-random redundancy in a message for Shannon probability to predict anything at all.

Entropy is therefore better thought of as a *capacity to convey* information, rather than *as* information.⁷⁸ Letters and words are the unchanging and therefore redundant elements that actually store the information in any message.⁷⁹

⁷⁴ 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.

⁷⁵ and that some traditions equate individuality with sin.

⁷⁶ *The Information*, James Gleick, p. 214 etc. 2011.

⁷⁷ Pointed out by Benjamin Lambert, PhD.

⁷⁸ *Information and the Living System* by Lila L. Gatlin, Columbia University Press 1972

⁷⁹ Schrödinger called redundancy “negative entropy”. Molecular structure containing free energy is also “negative entropy”.

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*. To construct individual words and sentences, a dithering element must jostle letters and words out of their comfortable, alphabetical order, which raises their entropy and risks generating gibberish. Here, entropy refers to the randomness necessary for individuality of expression, even at the cost of imbedded meaning.

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]. If we carry either to the extreme, we lose the meaning.⁸⁰

Compare the problem of language to the function of a library. If all of its books are safely stored, everyone knows where the information is. Entropy is zero. But the books are useless if not in circulation, even at the risk that individual books taken out by individual readers will be lost.

Biology, an information science⁸¹ since its earliest classification days, models how to think about language better than non-biological science. Every cell combines in distinct structures within it elements both of “meaning” and “energetic randomness”. The nucleus conserves and reproduces stored DNA information so that cells may copy - clone - themselves. Mitochondria are cellular factories that metabolism supplies with fuel and oxygen to keep individual cells alive and growing.

Redundancy and entropy are complementary elements that apply almost anywhere people try to figure things out, especially where language is involved. One of us is a psychiatrist who uses the perception of redundancy and entropy as “love” versus “individuality” in his psychotherapy practice, where he sometimes identifies them as *Roles and Rules*TM.⁸²

Perception of redundancy versus entropy even applies to engines. We were careful as we discussed engine work dynamics to distinguish repeated work-cycling as Newtonian from fuel-burning as thermodynamic. An automobile engine delivers its best combination of mileage, power, and pollution over a range of rpms and transmission gear ratios. An analogous, macroeconomic engine might deliver its best performance at whatever rate of expansion delivers the most consumer value for the least profit.

What would be meaning versus entropy in economics? We suggest that economic meaning is “value” exactly as we have used the term to refer to the economic work (to recover costs) 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 creative, individual enterprise that is realized whenever profit marries value, rather than absconds with financial abracadabra. Profit that does not mix with value inflates an economy toward dangerous thermofinancial equilibrium.

Viewing profit as a capacity for individuality in economic behavior rather than simply as waste reminds us that profits must be treated with respect, but not with reverence. Regardless, many financiers still prefer to invest in the profit-from-profits bubble machine with religious fervor. *Labor and energy do not mix with and so cannot sequester “non-valued” profits*. External mechanisms like the Federal Reserve or the Environmental Protection Agency may help, but competitive, industrial profitability seems to be the only rational way to regulate money supply.

⁸⁰ *Information and the Living System*. Op. cit.

⁸¹ *Information and the Living System*. Op. cit., page 51.

⁸² www.rolesandrules.com

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 tension between people becoming like each other, versus developing within the relationship as autonomous individuals. Roles and Rules™ respects the asymmetry that renders intimacy difficult to fathom, as it provides a format for the creative resolution of tension.

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

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“Dither” refers to the use of randomization to “even out” errors or other characteristics. 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’. Today, when you tap a mechanical meter to increase its accuracy, you are applying dither, and modern dictionaries define dither as a highly nervous, confused, or agitated state. In minute quantities, dither successfully makes a digitization system a little more analog in the good sense of the word.” Ken C. Pohlmann (2005). [*Principles of Digital Audio*](#). McGraw-Hill Professional. [ISBN 0071441565](#).