

## Are There Any Laws and Constants in Economics? – A Brief Comparison to the Sciences

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**Abstract:** Economics is still only a discipline or a craft. Although many economic "laws" have been named, none of them comes close to the empirical reliability, regularity, precision, and consistency that are the hallmarks of laws and constants in the physical sciences. The key attribute of universal laws and constants is that they are background-independent, but such independence is not at all evident in current economic theories and applications. This paper reviews and contrasts some of the most important and famous laws and constants in both economics and the physical sciences and concludes that, in economics, we are yet far from knowing what we need to know.

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### 1. Introduction

Economics has always wanted to be taken seriously as a science. And to this end economists have been largely emulative in adopting much of the language and the mathematical approaches used in neoclassical physics. The economics literature of the past decades is filled with equilibrium-seeking models that optimize, minimize, or maximize variables and apply probabilistic attributes to all sorts of expressions relating to supply and demand features and resource allocations. In many such applications the unspoken underlying assumption is that the economy works linearly and much as a physical machine does.

It may be argued, however, that decades of erudite studies in august peer-reviewed journal articles have still not raised economics to the level of practicality and respect that the "pure" sciences have reached. Physicists and mathematicians, nowadays, have plenty of their own issues, complaints, and concerns, but the one thing they definitely don't have is economics envy.

In fact, the modern sciences have moved well beyond their 19<sup>th</sup>-century neoclassical roots, whereas economics has not to anywhere near the same extent similarly followed. Sure, econometrics, game theory, and quantitative finance have progressed considerably and enormous inexpensive computing power has made it possible to analyze and relate huge amounts of data. But even so, the precision and gravitas accorded in the pure sciences is absent.

Will there be a recession next year? If so, how deep will it be? Can the Fed and other central banks really control interest rates beyond the shortest-term maturities? And, by the way, what is the Wickselian natural rate of interest? Is Minsky's approach correct? How about Austrian economics? Have the recently massive quantitative easing programs of central banks ultimately boosted the

world's economies or restrained them? Which of Keynes, Hayek, or Friedman built the strongest theoretical foundation for prescriptive policies?<sup>1</sup>

Maybe the answer is none of the above when debt as a percent of GDP reaches a certain level. What that level might be has not quite yet been conclusively established. The only thing we vaguely know, thanks in part to Reinhart and Rogoff (2009), is that when people start saying “This Time Is Different” it probably isn't.

Most of the time there's no clear answer and forecasts often seem to go most awry at significant inflection points where and when predictive accuracy is most important and valuable. Economists, it seems, still even cannot all agree on what happened in the past, let alone confidently predict what will happen in the future.<sup>2</sup> It has, moreover, been convincingly shown that the economic role of banking and credit has been misunderstood and misapplied to policy decisions for more than a century.<sup>3</sup>

Of course, predictions and financial market models based on linear extrapolations and Brownian motion/martingale-based approaches provide an aura of mathematical depth and sophistication. And so do those endlessly tweaked and adjusted dynamic stochastic generalized equilibrium (DSGE) models on which central bank macroeconomists rely to form policies that will presumably steer the economy away from inflation or deflation and also towards a self-defined “full employment” rate.

The problem in economics is that macro experiments cannot be readily replicated in a campus lab<sup>4</sup> Economics policy-making is instead a game that in a sense resembles golf – you play the ball from wherever it lies, take a swing with whatever blunt and time-delayed fiscal or monetary club is at hand, and then hope for the best outcome.

Economics deals with human nature and the emotional responses that originate in our brains. Studies by Levy (2006) and others such as LeDoux (2004), for example, suggest that the primal pleasure circuits in the brain (i.e., the nucleus accumbens) often override the seat of reason that resides in the frontal cortex. Cowen (2006) writes that “people are not consistent or fully rational decision makers....brains assess risk and return separately, rather than making a single calculation of what economists call 'expected utility.'”

Thus, rational thinking and risk avoidance are not closely related and instead reflect visceral factors and emotions. As Tuckett (2011, p. x) explains, the traditional economic approaches, including behavioral finance, don't adequately capture the essence of trading in financial markets.

If so, then the machine-like optimization/maximization and equilibrium-seeking modeling approaches that today pervade economics ought to be taken as being largely akin to and extensions of mere armchair thought experiments: Though laced with proofs and corollaries and all sorts of

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<sup>1</sup> See Wapshott (2011).

<sup>2</sup> McGrattan and Prescott (2003, p. 274) write that there was no asset bubble in 1929! Cole and Ohanian (1999) find that neoclassical theory provides an incomplete description of what happened in the Great Depression.

<sup>3</sup> See Werner (2016) and Akerlof and Snower (2016) on the role narratives play in decision making.

<sup>4</sup> Nobel laureate Vernon Smith might disagree, but the experiments that he pioneered were largely in microeconomics. See for example, his early paper in Smith (1962).

fancy mathematics, such experiments too often seem to actually have few if any connections to reality.<sup>5</sup>

Said another way, people and their societies cannot be analyzed as automatons. At times many people, especially via herding and crowd-following instincts, are boundedly rational. But this can usually only be seen and understood in hindsight – after the erratic and emotionally-driven decision-making urgency of the moment has been dissipated or otherwise neutralized and relative tranquility has been restored. Time available for decision-making may be compressed or extended and markets are fast or slow but how people react and behave when confronted with “events” is a different story that involves definitions of “rationality.”

In the stock market, for example, people are most optimistic at the tops and most pessimistic at the troughs because individuals are at those times most heavily influenced by their emotions and caught up in the zeitgeist. And nominally rational professional asset managers often have little or no choice but to join the crowd as they need to maintain relative performance metrics else suffer a loss of prestige, of assets and fees, and of their employment prospects.

Moreover, it has been cogently argued that trading reactions to changes in supply and demand are different (i.e., inverse) in markets for financial assets (i.e., stocks, bonds, real estate, foreign exchange, and commodities) than in markets for goods and services.<sup>6</sup>

Most economists have great difficulty in wrapping their heads around this notion, although such an inversion in transacting for goods and services versus financial assets has been and is always particularly apparent in bubbles and crashes. For, as extreme conditions unfold, high and rising prices in bubbles attract and encourage more units to be bought and fewer to be supplied while in crashes falling prices dissuade purchases and lead to more units being offered.<sup>7</sup>

In describing such extreme and not so uncommon events, random-walk and efficient market theorists have instead been largely fixated in demonstrating that under a few carefully specified and calibrated theoretical conditions, there could not ever be any bubbles and crashes. The elaborate proofs and corollaries are always impressively rigorous and impeccably-derived – but pray-tell, of what use is any of this except as a display of mathematical dexterity and erudition?

At the most fundamental level, what’s mostly missing in economics, it seems, are any reliable and precise touchstones, benchmarks, or constants to which reference can *always* be made. That however, is not for lack of efforts.

In physics, for example, Albert Einstein’s famous  $E = mc^2$  formula equating mass and energy uses the speed of light,  $c$ , which is 186,282.397 miles (~300,000 km) per second in a vacuum and

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<sup>5</sup> For example, the brilliant Nobel-prize winning work of Professors Arrow and Debreu, who in the early 1950s proved that competitive equilibrium under many assumptions exists. But so what? As reviewed in Fisman and Sullivan (2016, p. 36) Nobelist Joseph Stiglitz “showed that even a little bit of dysfunction was enough to render the deeply abstract general equilibrium models unhelpful in resolving all sorts of puzzles and paradoxes.”

Thaler (2016) reviews the behavioural approach and writes, “we are relying on one theory to accomplish two rather different goals, namely to characterize optimal behavior and to predict actual behavior...All economics will be behavioral as the topic requires.”

Silber (2012, p. 18) quotes Oskar Morgenstern in 1937 in *Limits of Economics* (p. 4) writing that “unless [economics] offers a contribution to the mastering of practical life...it is but an intellectual plaything.” On neurofinance see also Dhami (2016).

<sup>6</sup> Prechter and Parker (2007).

<sup>7</sup> Vogel and Werner (2015) and Vogel (2010).

which holds for all frequencies.. This speed holds with great accuracy for any and all practical purposes and for any nearby universes we might ever in the distant future of humanity have a chance to somehow contact or explore.

Yet nothing in economics comes even close to exhibiting such consistency (and constant-cy), universality, and precision. The discovery of such “hard” economic laws and constants – if they indeed even exist – would likely make it much easier to directly implement, with much greater certitude and accuracy than what can be currently done, a broad spectrum of (macro and micro) fiscal and monetary policies and strategies.

Economists are inherently, deep-down, aware of this comparative vapidty, though some might be reluctant to ever admit it.<sup>8</sup> That said, economic theory does rest on a few generally well-accepted economic phenomena, or stylized facts, which include:

- the existence of macroeconomic cycles, microeconomic propensities to consume, save, and invest<sup>9</sup>
- broad classification of industry structures ranging from pure competition to oligopoly and monopoly
- network effects, meaning that typically (but not always) the more nodes in a network, the more useful and valuable the network becomes with this so-called “Law of Connectivity,” often approximated by an expression of the form,

$$V = aN^2 + bN + c \quad (1)$$

where  $V$  is the value,  $N$  is the number of nodes, and the other terms are constants.<sup>10</sup>

- Scale notions such as diminishing returns concepts linked to expected utility, wherein an extra hundred dollars of income to a billionaire has virtually zero utility but to a homeless person significant utility.
- For individuals, firms, and governments to survive economically and financially, marginal revenues (and returns) ought to be at or in excess of marginal costs (including the cost of capital). That is, benefits must exceed costs.

Section 2 provides additional perspective and an overview of some of the most important laws and constants in the sciences. Section 3 does the same for economics and shows why the non-existence or not-as-yet discovered hard laws and constants remains an important problem and challenge. Section 4 then summarizes.

## **2. Sciences – Laws and Constants**

A science must be able to explain, predict, and prescribe.<sup>11</sup> And laws of science describe or predict the behavior of natural phenomena. The term “law” has diverse uses which often might only

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<sup>8</sup> Derman (2011) is the exception.

<sup>9</sup> Akerlof (2002) covers the recent development of macroeconomic thought, which requires that bargains between firms, workers, and other participants be consistent with maximizing behavior.

<sup>10</sup> The *Law of Connectivity*, also called Metcalfe’s Law, is named after Robert Metcalfe, one of the Internet and Ethernet engineering pioneers. This “law” finds application in airline hubs, phone networks, and financial trading and banking, for examples. See also Mayer and Sinai (2003) and Shy (2001).

suggest approximations related to the expected outcomes from applications of sometimes broad or sometimes narrow theories. In all cases, though, to be called a "law," there needs to be support from repeatedly verified empirical evidence – and with the law never falsified.

There is also a difference between laws and hypotheses, which are proposals and postulates set up for eventual validation by a scientific process. In science, the most significant and forever unalterable laws are those describing conservation of energy, momentum, and mass. Hypotheses, on the other hand, often come and go; permanence is not their strong suit

“God does not play dice with the universe,” is another one of Einstein’s famous, pithy assertions.<sup>12</sup> Einstein wanted to know “whether the dimensionless constants of Nature could have been given different numerical values without changing the laws of physics or whether there is only one possible choice for them. Going further he might wonder whether different choices in their values are possible for different laws of Nature. We still don’t know.”<sup>13</sup>

Yes, we still don’t know. But for all practical purposes, including the sustenance of life on Earth, we know vastly more about the nature of Nature than we do about the nature of economics.

Perhaps the simplest and most easily grasped and important example of Nature’s constants involves the freezing point (i.e., temperature) at which a liquid changes into a solid. In searching for the possibility of life on other planets, extra-terrestrialists will always first have the most intense interest in whether there’s any evidence of water, or H<sub>2</sub>O, as a chemist would say. If the water does not contain any impurities and is at earth’s sea level- air pressure, the constant is 0°C or 32°F, which is of course only dependent on which scale is used and not on which planet or galaxy is being observed.

Other examples appear in mathematics, where the most elementary and stable relationships start with the constants *e* and *pi* ( $\pi$ ).

$$e = 1 + \frac{1}{1} + \frac{1}{1*2} + \frac{1}{1*2*3} + \frac{1}{1*2*3*4} \dots \sim 2.71828\dots \quad (2)$$

and  $\pi = \pi \sim 3.141592\dots$ , which is the ratio of a circle’s circumference to its diameter. Both *e* and  $\pi$ , whose properties have been studied and calculated for centuries, are derivable from basic arithmetic. And *e* in particular has the unique property that it is its own derivative.

Seventeenth century Isaac Newton’s gravitational constant, *G*, although difficult to measure with high accuracy is also an important feature of life on our little globe. According to Newton’s law of universal gravitation, the attractive force *F*, between two bodies is proportional to the product of their masses (*m*<sub>1</sub> and *m*<sub>2</sub>) and inversely proportional to the square of the distance, *r*, between them. This is expressed as:

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<sup>11</sup> See Naim (2009).

<sup>12</sup> Einstein also said, “things must be made as simple as possible, but not simpler (Medio 1992, p. 3). A sign in Einstein’s office at Princeton said: “Not everything that counts can be counted, and not everything that can be counted counts.”

<sup>13</sup> Barrow (2002, p. 40 and p. xiii) writes, “we have identified a collection of mysterious numbers which lie at the root of the consistency of experience. These are the constants of Nature. They give the Universe its distinctive character and distinguish it from others we might imagine. They capture at once our greatest knowledge and greatest ignorance about the Universe...[but] we cannot explain their values.”

$$F = G \frac{m_1 m_2}{r^2} \quad (3)$$

an expression in which the gravitational constant (Big G) has a precise definition written in terms of meters cubed per kilogram per second squared. The more familiar and considerably less complicated local gravitational field, small  $g$ , is then equivalent to the free-fall acceleration at the Earth's surface. Here, the earth's mass,  $m_1$ , is in kilograms and the Earth's radius,  $r$ , is in meters. At sea level, this little  $g$  approximates a free-fall acceleration constant of around 32 feet per second squared.<sup>14</sup>

Planck's constant,  $h$ , is another remarkable example of genius-work. This fundamental physical constant lies at the heart of quantum mechanics and describes the behavior of waves and particles on an atomic scale. German physicist Max Planck introduced the constant in 1900 via calculations of the distribution of radiation emitted by a perfect absorber of radiant energy (i.e., a blackbody). The constant's value in meter-kilogram-second units is  $6.62606957 \times 10^{-34}$  joule-second, with a standard uncertainty of  $0.00000029 \times 10^{-34}$  joule-second. Without  $h$ , there would not be laser beams, smart phones, and all of the other technological wonders of our era.

Mention of Einstein and Planck further brings to mind the immense contribution of James Clerk Maxwell, circa 1861. Maxwell's set of partial differential equations provide the foundation of classical electrodynamics, optics, and electrical circuits and that thus lie at the base of all modern communications technologies. Maxwell's equations, along with Faraday's law of induction describing how magnetic fields will interact with electric circuits, are in a form – worthy of appreciation by any mathematical economist – of the integral equation written as:

$$\oint_{\partial\Sigma} \mathbf{E} \cdot d\boldsymbol{\ell} = - \int_{\Sigma} \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{A} \quad (4)$$

Then there's Avogadro's number and law, a building block of chemistry that can be traced back to around 1811, nearly a century prior to Planck. This dimensionless quantity, which describes the number of elementary elements (atoms, molecules, electrons, or ions) contained in a substance (and known as a mole), is  $6.0221415 \times 10^{23}$ . Avogadro's Law states that equal volumes of any two gases at the same pressures and temperatures must hold an equal number of particles.

While browsing in the chemistry department, it is also impossible to leave unmentioned Boyle's Law, dating from 1662. This law states that at a constant temperature for a fixed mass, the absolute pressure ( $P$ ) and the volume ( $V$ ) of the gas are inversely proportional, i.e.,  $PV = k$ , with  $k$  representing a constant as long as the temperature holds steady. Although Boyle's does not have the practical significance that the similar-looking Ohm's Law has in electrical engineering and physics, it nonetheless provides a useful description of what happens to an experimental gas in a closed system.<sup>15</sup>

Biology has also evolved through empirical testing of several key laws, most notably begun with the laws of inheritance as derived by Gregor Mendel and detailed in a published article in

<sup>14</sup> Barrow and Webb (2014).

<sup>15</sup> Ohm's law states that the current ( $I$ ) in amperes coursing between two points on a conducting material is directly proportional to the potential – i.e., the voltage ( $V$ ) between the two points. This is expressed as  $I = V/R$ , where  $R$  is the resistance of the conductor in units of ohms and  $R$  is taken as a constant and as independent of the current.

1866. Mendel found a Law of Segregation (the first law), the Law of Independent Assortment (the second law), and the Law of Dominance (the third law).<sup>16</sup>

Many more such physical, chemical, and biological (e.g., DNA and genes) laws and numbers have been discovered and they are all importantly related to the functioning of life as we know it. For instance, the ratio of the rest mass of the proton divided by that of the electron is,  $\mu = m_p/m_e = 1836.15$  (with the value known to about 0.4 parts per billion).<sup>17</sup> Here, the mass of the electron,  $m_e$ , in the international system of units (SI units), is  $9.10938188 \times 10^{-31}$ . And in the strange world of quantum mechanics there is what's known as the (Sommerfield) fine-structure constant,  $\alpha = 137.035\dots$ . It characterizes the strength of electromagnetic interaction between elementary charged particles.

In our universe, all such physical world constants are assumed to be the same at all places and times and, indeed, they define its very fabric. The specificity of the science numbers is astounding yet, remarkably, no one has ever successfully predicted or explained any of them. "[P]hysicists have no idea why they take the special numerical values that they do. ...The numbers follow no discernable pattern. The only thread running through this is that if many of them were even slightly different, complex atomic systems such as living beings would not be possible."<sup>18</sup>

Moreover, if these constants do actually change over time – still an open and largely unexplored and perhaps unexplorable question – the time scale for any such changes would likely occur not in our economic lifetimes, but over eons, in tens of thousands or millions of years. The long list of empirically-discovered precise physical constants cannot fail to impress and provides a convincing overview of what physics has to offer.<sup>19</sup>

Nevertheless, as Smolin (2006) abundantly and controversially explains, theoretical and empirical work in the physical sciences is still far from perfect nor settled to anyone's satisfaction. In fact, from Smolin's point of view (p. xxii), physics is increasingly and inevitably slipping. What "is failing is not so much a particular theory but a style of doing science that was well suited to the problems we faced in the middle part of the twentieth century but is ill suited to the kinds of

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<sup>16</sup> McFarland (2016, pp. 31- 40) explains the biological bases of economic behaviour and shows how animals and insects adhere to time and energy-expenditure budgets wherein utility is regarded as the "common currency of decision-making...cost is equivalent to utility, energy is equivalent to money."

<sup>17</sup> Barrow (2002, p. 114 ) also lists the average density of the visible universe as being: 1 atom per cubic meter; 1 earth per  $(10 \text{ light-yr})^3$ , 1 star per  $(10^3 \text{ light-yr})^3$ , and 1 galaxy per  $(10^7 \text{ light-yr})^3$ .

<sup>18</sup> Barrow and Webb (2014) and Barrow (2002, p. 292) explain that "we have begun to see the first tell-tale hints of a change in one of our most revered constants of Nature over billions of years of cosmic history...Will the constants change and destroy the coincidences between their values in the future and leave the tree of life leafless and lifeless in the far-distant future? Are our constants linked to the overall rate of expansion of our Universe or are they truly constant?... Do they evolve and change from cycle to cycle of a Universe in a history that has neither beginning nor end, ranging over all possibilities, spawning a multiverse of possible worlds, each consistent in its own way, but most devoid of life and unconscious of their own existence?"

<sup>19</sup> Wikipedia's compilation of scientific laws named after people stretches to more than 100 entries. See [http://en.wikipedia.org/wiki/List\\_of\\_scientific\\_laws\\_named\\_after\\_people](http://en.wikipedia.org/wiki/List_of_scientific_laws_named_after_people)

According to Barrow and Webb, numbers that define our Universe in chaos/complex systems include Feigenbaum's constant. Also, James Gleick in Kolata (2013, p. 215) describes that the rapidity of a system undergoing period doubling on its way toward chaos = 4.6692016...

fundamental problems we now face.”<sup>20</sup> His plaint is one that ought to readily resonate with all economists.

In physics, such concerns now involve innate foundational issues that are described using quantum mechanics, string theories, and dark matter densities and energies – none of which are even close to being theoretically unified or fully understood.<sup>21</sup> And attempts at unification of the physics of weak and strong forces, gravity, and electromagnetism grapple intensely with the notion of infinity: As a consequence, in so-called super-symmetry approaches, “constants” need to be “adjusted” to make the theories viable.<sup>22</sup>

### **3. Economics – Curves and Conjectures**

The late stock market expert Paul Macrae Montgomery (1942-2014) understood deeply that economic systems are fundamentally different from the physical systems which are manifest in material objects and define and govern their intrinsic characteristic features. He wrote (in Montgomery 2000),

“Value derives exclusively from the human *desire* for certain particular objects at certain particular times. ...*human desires*... do not obey the same Law of Conservation of Momentum that physical states obey... economic values...do *not* remain constant with time...a scientific economic dynamic, and hence consistently accurate economic and capital market prediction, is logically impossible within the framework of classical economic theory and methodology.”

One potentially viable place to start looking for an intersection or bridging of science and economics is in *The Entropy Law and the Economic Process*, published in 1971 by mathematician and economist Nicholas Georgescu-Roegen who posited that the second law of thermodynamics – free energy tends to disperse and become bounded energy – also governs economic processes. The notion of entropy is antecedent yet central to economics theories and relationships.

That is because entropy is a measure of a system’s ability to do work as related to the amount of inaccessible (i.e., bounded) energy in a system. It is also, according to many writers, a measure of randomness and/or disorder. In a closed system it can never decrease.<sup>23</sup>

Although it is never explicitly stated as such and little thought is normally given to it, *all* economic transactions require expenditure of energy. This friction is in the form of a cost of time in

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<sup>20</sup> Smolin (2006, p. 5) continues: “General relativity has a problem with infinities because inside a black hole the density of matter and the strength of the gravitational field quickly become infinite...At the point at which the density becomes infinite, the equations of general relativity break down...Quantum theory, in turn, has its own problems with infinities.”

<sup>21</sup> Dark matter emits light and likely does not interact with electromagnetic fields. Dark energy, discovered in 1998, appears “to differ from all forms of energy and matter previously known, in that it is not associated with any particles or waves. It is just there....It manifests itself as a source of gravitational attraction spread uniformly through space....One thing that dark energy might be is something called the *cosmological constant*.” (Smolin, p. 11 and p. 150). See also Riess and Livio (2016).

<sup>22</sup> Facetiously, in college science and engineering courses, the only constant was Finagler’s – the outcome you get divided by the outcome that you ought to get.

<sup>23</sup> Ben-Naim (2012, p. 234) clarifies the often conflicting notions of entropy, writing they “are at best descriptors of the state of the system.”

terms of alternative opportunities foregone, a cost to acquire the (imperfect) information required for discovery of price and to then accept and execute the bid and ask prices that trace supply and demand schedules. “[E]ntropy,” says Martenson (2011, p. 178), “is the tax the universe places on all energy transformations.”<sup>24</sup> And economic activities certainly qualify as energy transformations.

Ties to energy, work, and economics, however, predate Georgescu-Roegen by at least a century, when what's known as statistical entropy was introduced by Austrian physicist Ludwig Boltzmann. By 1875, Boltzmann had devised a probability measure of entropy  $H$  (also known as Gibbs entropy),

$$H = -k \sum_i p_i \log p_i \quad (5)$$

where  $k$  is Boltzmann's constant and  $p_i$  may represent ordinary, joint, or conditional (marginal) probabilities of selecting one item out of a large sample of similar items. In this situation, the  $p_i$  could also represent stock price returns.

In statistical mechanics this Boltzmann constant =  $1.38065 \times 10^{-23}$  J/K, and the formula illustrates the relationship between entropy and the number of ways the atoms or molecules in a system can be arranged.

The Boltzmann/Gibbs formula fortuitously (and somewhat confusingly) has further importance in that it happens to be the same (with  $k = 1$ ) that the information theory pioneers Shannon and Weaver (1949) had found as a measure of the amount of information that is transmitted. The work of Shannon, Weaver, and Boltzmann provide the theoretical basis for all of today's computer and communications systems.

For the universe taken in its entirety, entropy is always on-balance increasing and, if so, then this effect must be fundamental also to economics. This is indirectly (but not obviously) reflected in the various notions of entropy that appear in the form of power laws, the law of diminishing returns, and Gresham's Law. To a degree, entropy is also inherently embedded in various other economics notions as, for example, expressed by Say's Law, Hotelling's principle (or “Law”) of minimum differentiation, Ricardo's Iron Law of Wages, the Cobb-Douglas production function,  $Y$ , that looks at capital and labor inputs (as  $Y = AL^\beta K^\alpha$ ), and Cournot's duopoly theorem. A brief review of some of the concepts most directly relevant to current policy and political initiatives is illustrative.

### **3.1 Gresham's Law**

If there's one “law” in economics that is not subject to any indecision or debate and that provides a simple example it is Gresham's, which was named in honor of Sir Thomas Gresham in the 19<sup>th</sup> century (even though Gresham himself recognized the effect as early as 1668).

Gresham's Law says that bad money drives good money out of circulation. This means that if coins composed of different metals with different values have the same nominal value as legal tender, the coins of the cheaper metal will be used for payment and those composed of the more expensive metal will be hoarded and exported and thus disappear from circulation.<sup>25</sup> This describes nothing more than fundamental human instinct and intuition and applies over all recorded history, in all societies and nations, and to the rich and the poor.

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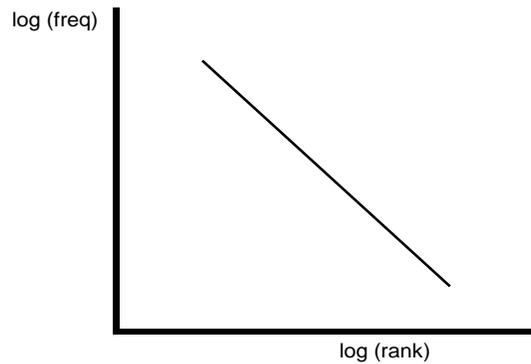
<sup>24</sup> The notion of entropy can also be traced back to Carnot's heat engine and around 1865 to a paper by Rudolf Clausius.

<sup>25</sup> King (2016, chapter 2), in fact provides an opposite; that prior to the 2008 peak of Zimbabwe's hyperinflation, people started using foreign currencies – “an instance of good money driving out the bad.” King also writes, “For over two centuries, economists have struggled to provide a rigorous theoretical basis for the role of money, and have largely failed.”

But is there a formulaic constant that enables analysis and study of how fast the bad money drives out the good? Is there perhaps a threshold at which this occurs, namely the ratio of the less expensive to the more expensive? Alas, the disappointing answer is no.

### 3.2 Power Laws

Power laws are also a widely observed characteristic of physical, financial, and economic processes.<sup>26</sup> From a practical standpoint, these laws can be used to empirically describe things such as language regularities in the frequencies of words, energy released in earthquakes, lifespan versus heart rate, and size rankings of the number of airport passengers and hotels. Figure 1 displays an idealized version.



**Figure 1.** An idealized power law ranking of size or importance

Power laws are expressed as  $y = ax^k$ , where  $a$  is a constant value that defines the size, scale or magnification of processes and  $k$  is the characteristic negative number that defines the nature of the usually nonlinear relationship between the  $x$  and  $y$  variables. The probability distribution's density function then takes the form,

$$p(x) \propto L(x)x^{-\alpha} \quad (6)$$

where  $\alpha > 1$ , and  $P(x)$  is the probability.

In the physical world there are many such relationships that hold fairly constant over time and space. One, for example, is Kleiber's law, named after biologist Max Kleiber for his work in the 1930s. He showed that for the vast majority of animals, the metabolic rate for different species scales to body mass with a power law exponent,  $k$ , of approximately -0.75 (and in plants an exponent close to 1.0). The relationship apparently holds whether applied to whales or mice.

The problem with all such power "laws," however, is that empirical distributions cannot usually fit all their values and that – especially in economics – the empirical curves are subject to notable shifts over relatively short times (years or decades, not eons) as technologies advance, corporations merge and acquire, countries and regions experience political upheavals, and population components are constantly in flux..

### 3.3 Diminishing and Marginal Returns

This notion, often considered to be a fundamental principal of economics, is rooted in the thinking of the earliest economists, including Adam Smith and David Ricardo. It's also a simple idea because in industrial or agricultural processes, adding one more factor of production while holding all others constant (i.e., *ceteris paribus*), will eventually lead to lower incremental per-unit returns. For instance, at some stage, adding more fertilizer to farmland will not necessarily result in more or better crops; it might actually even reduce the yield. The same effect of diminishing

<sup>26</sup> See Gabaix (2009).

marginal returns is also seen in capital market allocations, in which additional capital injections will lower overall returns.

No doubt, the law of diminishing returns can be readily observed in many different fields and over many different periods of history. But not only are there no specific constants there are also, in a modern data-driven networked economy, instances in which the opposite might be observed. For example, successful Internet businesses (e.g., Amazon, Facebook, and Google) depend on network effects and the addition of factors of production (more network nodes, software programmers, servers) can and will often scale up to increasing marginal returns.

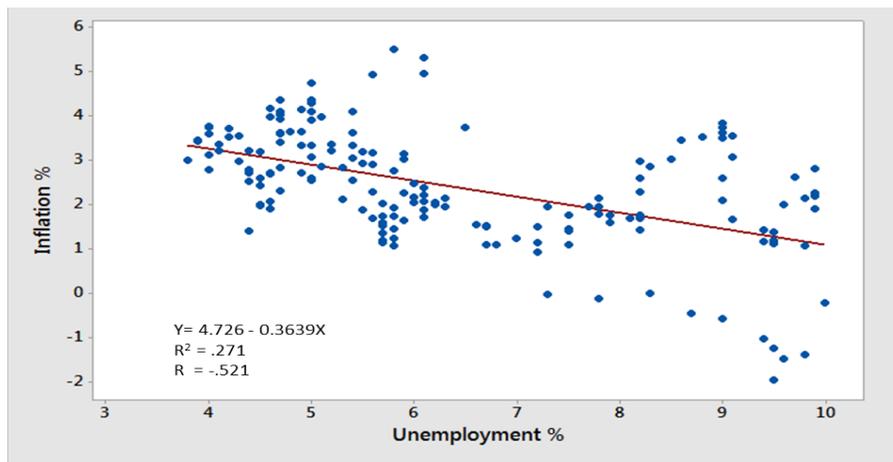
### 3.4 Heckscher-Ohlin

Eli F. Heckscher and Bertil Ohlin (H-O) in 1933 established a theory of international trade that expounds on the observation that different countries are endowed with different natural, human, and capital resources and thus have different patterns of productivity. Under such circumstances, the H-O theorem suggests that different countries have different comparative advantages in goods and services and that, because profitability is determined by input costs, pricing when trading will be different.<sup>27</sup>

Still, even with several important modifications – and notwithstanding the advance of sophisticated econometric methods coupled with enhanced computational technology and big data availability – there is not much evidence that either a law of comparative advantage or a constant of some sort has been discovered.

### 3.5 Phillips Curve

This curve postulates a theoretical inverse relationship between rates of unemployment and rates of inflation. That is, lower unemployment will be associated with higher rates of inflation. The presumed relationship was first described in a 1958 paper by New Zealand economist, William Phillips and is illustrated in Figure 2.



Source Data: FRED Database  
Inflation: CPI for All Urban Consumers

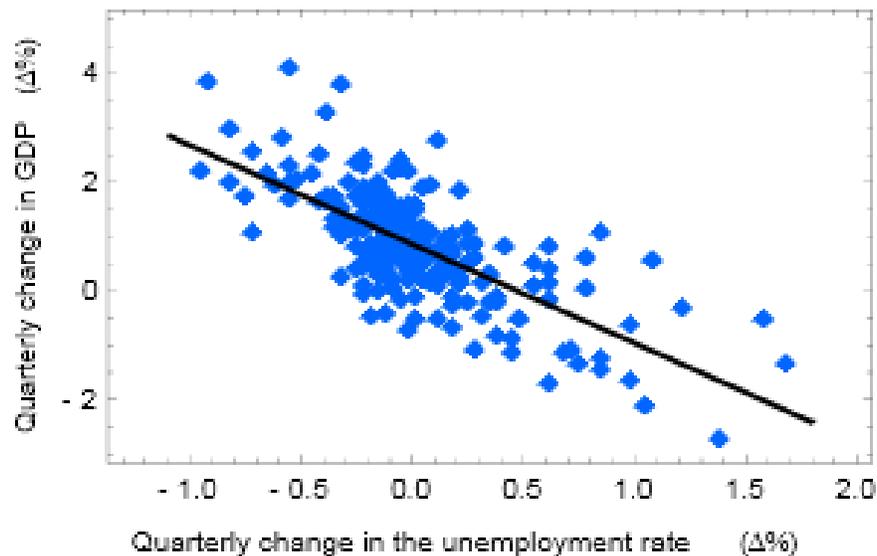
Figure 2. U.S. Phillips Curve: Inflation vs. Unemployment (1/2000 to 8/2014)

<sup>27</sup> This actually is an extension of Ricardo's earlier single-factor of production (labor) model of comparative advantage which focused on productivity aspects. The H-O approach instead removed technological variations but included factors pertaining to the availability and cost of capital. Here, differences in the abundance of both labor and capital account for the comparative advantages that occur.

Although the curve has been extensively studied and may be still influential in current central banking policy formulations, it seems that even in modified forms there is no single curve that consistently fits the data for all episodes. In addition, the relationship might be more reliable for short-run than long-run forecasts. The links are murky and economists just “don’t know how low unemployment can go before it crosses the theoretical threshold when inflation will start to rise, or how soon and fast inflation will respond.”<sup>28</sup>

### 3.6 Okun’s Law

This law, made famous by economist Arthur Okun in the 1960s, provides another seemingly sensible description of the relationship between GDP and unemployment, and it fits well as an adjunct to the Phillips Curve. Okun figured that for every two percentage points that GDP rises above its long-term annual trend, the rate of unemployment will fall by roughly one percent. And when GDP is below trend, every one percent increase in the unemployment rate will pull a country’s GDP approximately two percentage points below its potential. This estimated relationship is shown in Figure 3. Again, as is the case with the Phillips curve, the empirical results are far from being rigorous and precise.



**Figure 3.** Okun’s Law illustrated. "Okuns law quarterly differences" by Stpasha - Own work. (Licensed under Public Domain via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:Okuns\\_law\\_quarterly\\_differences.svg#/media/File:Okuns\\_law\\_quarterly\\_differences.svg](http://commons.wikimedia.org/wiki/File:Okuns_law_quarterly_differences.svg#/media/File:Okuns_law_quarterly_differences.svg))

### 3.7 Engel’s Law

German statistician Ernst Engel was first (circa 1857) to investigate how household expenditures on a particular good or service might vary with household incomes. Such estimates lead to Engel’s curves and law, which supports the idea that poorer families will tend to spend larger shares of their budgets on food and wealthier ones a lesser share of budget on consumer staples even though total food expenditures will rise.

<sup>28</sup> Leubsdorf (2015). Irwin (2015) also writes, "...there are nearly as many versions of the Phillips curve as there are researchers who study it...an ever shifting curve raises more questions than it answers... just knowing the unemployment rate may tell you very little about what inflation will be." See also Meade and Thornton (2012).

Of course, this can be readily verified with modern econometric methods, but the resulting estimates will vary over time, by region, by political system, by the ages of populations and families, and by technological changes. Any such estimates will thus not have great precision or consistency.

### 3.8 Goodhart's Law

Named after economist C. A. E. Goodhart, this law was first described in 1975 and suggests that “[W]hen a financial indicator becomes the object of policy, it ceases to function as an indicator.” Said another way, when a measure becomes the target, it can no longer be used as the measure. This “law” is one that pertains especially to economic stability and is probably the bane of central bankers the world over.

The core concept is once again difficult to evaluate because the point at which and length of time needed before a financial indicator lapses in predictive capability is not known.<sup>29</sup> Goodhart's Law thus falls into the economic twilight zone because, although we know that it is probably true, it is either an unknown known or a known unknown (as per the ontology of Donald Rumsfeld).

### 3.9 Laffer's Curve

Economist Arthur Laffer first showed his curve, depicting how tax rates affect government revenues in 1979. The theory in support of the curve, illustrated in Figure 4, posits that there is a short-run “arithmetic” effect in which every dollar in tax cuts translates directly into one less dollar in government revenue. In addition, there is a long-run “economic” effect in which lower tax rates leave more money in the pockets of taxpayers, who then presumably spend the excess and drive growth of demand in the economy. This then ultimately ends up generating a larger tax base – thereby more than offsetting the initial revenues lost from the tax cut – and suggests that beyond a certain point imposition of higher tax rates is counter-productive.

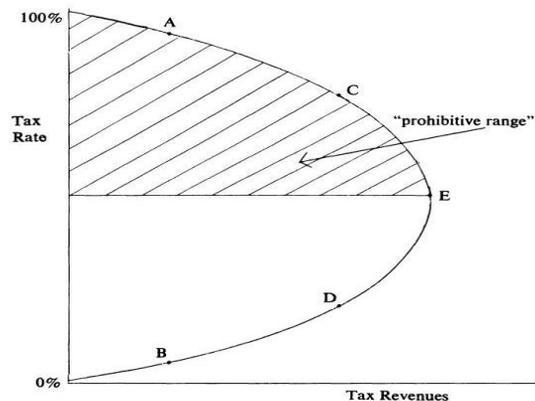


Figure 4. The generic Laffer Curve by Arthur Laffer

Theoretical problems, however, begin with its rather simplistic assumptions of a single tax rate and labor supply. There is also no accounting for tax avoidance schemes and other real-world complexities. Again, over time, even though some empirical studies appear to indicate that revenue maximizing tax rates might be around 70%, other studies suggest that such maximization might occur at much lower rates. Hence, there is no exactitude or necessarily any stability of this relationship as all it takes to change marginal tax rates is an election.

## 4. Summary

Although economics has many deep roots and has produced many useful and interesting hypotheses and estimation approaches, it remains populated largely by conjectures and theoretical

<sup>29</sup> See A.E. Goodhart (1975), *Monetary Relationships: A View From Threadneedle Street, Paper in Monetary Economics*, FRB, Australia and also Rickards (2014, p. 71) in which policy control is emphasized.

notions rather than hard, repeatable, and precise universal facts in the form of reliable constant proportions and relationships.<sup>30</sup>

Economists are always, of course, vaguely and inherently aware of this. But the contrasts to the hard sciences are stark, explicit, and unsettling. Economics may thus best be described as a discipline or, perhaps, as a craft. A science it is not. Or at least not yet.<sup>31</sup>

As in theoretical physics, for laws and constants to be able to withstand empirical challenges, the laws and constants must be independent of the background setting: To be taken seriously, they must be background-independent and encompass all backgrounds.

But as the selected reviews here illustrate, this is something that economics has thus far been unable to provide. The ever-shifting backgrounds in economics involve politics, religion, culture, demographics, technology, psychology, and a host of monetary and fiscal interventions and interactions.

Other harder sciences have their own lengthy lists of issues, problems, and concerns, too.<sup>32</sup> But not to the extent that is seen in economics and finance. As Barrow (2004) has explained, “[S]cience... has laws. Laws are not contingent. They describe the way the universe works, unconditionally. And they have been crucial in permitting life to develop.”<sup>33</sup>

Power laws – which are not specific to economics and finance because they operate in all forms and areas of human endeavor and are usually able to display empirical regularities – thus far appear to perhaps be the only "laws" that are widely and descriptively applicable in both physical and economic phenomena.

In economics, the search for hard laws and constants continues apace. Do such laws and constants even exist and can they yet be discovered? It's possible but not probable that they do and they can be.

But the way forward is definitely not through ever-more complex advanced mathematics and assumptions applied to equilibrium-seeking classical physics-like models such as those which have for so long dominated the field. Economic laws and constants are, it seems, more likely to reside in the realm of behavioral and emotional finance pertaining to money and credit, in the psychology of winning and losing, and in biological systems.<sup>34</sup>

The truth, as they say in science fiction, is out there...somewhere.<sup>35</sup> It's just that in economics it hasn't yet been found.

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<sup>30</sup> Economist Russ Roberts, interviewed in Peterson (2016), quips, “How do you know macroeconomists have a sense of humor? They use decimal points.”

<sup>31</sup> What's known as “econophysics” might arguably lead eventually to more robust methods, constants, and conclusions. See Mantegna and Stanley (2000) and Jovanovic and Schinckus (2017).

<sup>32</sup> Aside from recently found evidence (in 2012) that the Higgs boson exists there has in physics been relatively little progress, with many of the remaining unresolved issues on scales far removed from everyday life and experience on earth.

<sup>33</sup> Barrow (2004, p. 143).

<sup>34</sup> Tuckett (2011, pp.174-7) writes that standard economic theories ignore uncertainty and leave out important aspects including memory, experienced time, and anxiety and excitement that are central to the emotional finance approach.

<sup>35</sup> From *The X-Files* television series, 1993 to 2002, with brief revival series in early 2016 and 2017.

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