Global Thermoeconomics

Mario W. Cardullo
The Belfield Group, Inc., Alexandria, Virginia, USA
mario_cardullo@yahoo.com

Manhong Mannie Liu
Renmin University, Beijing, The People's Republic of China
maniemm@gmail.com

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ABSTRACT

This paper illustrates that basic global economic concepts can be directly related to the First and Second Laws of Thermodynamics. We believe that all economic returns are from nothing except from current and past human expenditure of human energy; this is the result of the First Law of Thermodynamics. It is shown that everything is a product of energy in the form of labor and that the basic principle of Labor Theory of Value is still valid and this principle is validated not relying on economics and finance models, rather on thermodynamic principles. This is illustrated by the development of the Labor Value Equation based on the application of the First and Second Law of Thermodynamics and how it can impact employment, asset valuation, supply/demand, productivity, global conflict, global reserve currency and global stability.

JEL Classification: C; G; J; P; F; A

Keywords: Thermodynamics, Labor Theory of Value, Labor Value Equation, Global Reserve Currency, Financial Stability, Employment, Asset Valuation, Productivity

1. INTRODUCTION

"What has gone wrong with the world?". This is the opening line of the seminal work by Nobel Laureate Frederick Soddy in 1933 on thermodynamic economic theory. Today we still are trying to answer this question even though over 80 years have passed. While science and technology have given a higher standard of living to many people, yet many others are still in poverty, "insecure, being now never free from the specter of unemployment and consequent submersion into destitution and degradation." The objective of this paper is to present a system study of global finance based on the Laws of Thermodynamics to investigate the nature of capital instability.

The use of thermodynamic concepts has been primarily applied to environmental, energy, and general economics. Bryant has used the gas laws, the distribution of income, the Laws of Thermodynamic applied to economics processes. However, the basic Laws of Thermodynamics have lacked a global approach by many prior academic contributions.

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It appears that the financial markets are measured in ways that only indicate the symptoms. It is like a group of individuals who are blind, feeling an elephant to describe what they are feeling. While the measures are symptomatic they are only partial indicators of the underlying processes and usually are lagging, or leading, or shifting. In all instances, we believe it is energy that produced by labor and the productivity based on human energy consumption that drives the system.

In this paper, we argue that everything is a product of energy in the form of labor and that the basic principle of Labor Theory of Value is still valid. We validate this principle not relying on economics and finance models, rather on thermodynamic principles. We believe it is the energy created by labor that is the core element of the system, and is the fundamental variable to explain the nature of capital market and of the entire financial systems.

While economics has a social science basis, thermodynamics is based on physical science, yet both are different views of the same universe. This multiplicity results in a more total system understanding of the basis of interactions of human agents in developing value. Together, these approaches result in 'global thermoeconomics'.

The nature of capital is multilevel; it can consist of property, resources, human labor and various other assets. But it is the ability to trade one asset for another asset. In this regard, capital like money can be used to acquire another asset like someone's labor or a physical asset. In a way, it is barter because liquid capital is only a way of exchange. From a market perspective, an asset has value only because someone wants it. If that asset was placed in a forest or desert or a high mountain and no one was there to claim it, then it would have no value. So, for an asset of any type to have value someone must want it otherwise it would be valueless.

However, while its value depends on someone desiring it, the asset has a more fundamental value in the thermodynamic sense. That thermodynamic value is the amount of human labor expended to produce it. That must be the total labor cycle from basic resource acquisition to the final asset. This includes the labor to build any device and the material in that cycle allocated to that device. Thus, nothing on this planet is produced de novo, that is, without human labor.

Therefore, the Laws of Thermodynamics hold and economic processes are not an exception. Thermodynamics consist of two fundamental laws:

- the First Law of Thermodynamics is the law of conservation of energy or energy balance. The first law of thermodynamics shows the equivalence between heat and work but not the direction of transformation.
- the Second Law of Thermodynamics places limitations on the direction of transformation and that processes evolve in one direction only.

Exploring these laws in the framework of capital markets is the basis of this paper.

2. LITERATURE REVIEW

The seminal work by Nobel Laureate Frederick Soddy in 1933 on thermodynamic economic theory can be considered the foundation of this theory. Other initial formulations of these concepts and relationships to economics and resources followed. This initial development has been expanded upon from both resource economics and valuation. The evolution of Georgescu-Roegen's thought about valuation and the environmental and social policy recommendations arose out of his concepts of bio-economic theory. These various studies have not been without controversy. Bryant has used the gas laws, the distribution of income, the Laws of Thermodynamic applied to economics processes. A measure based on human expenditure has been proposed by Cardullo and Liu, which expands existing studies.

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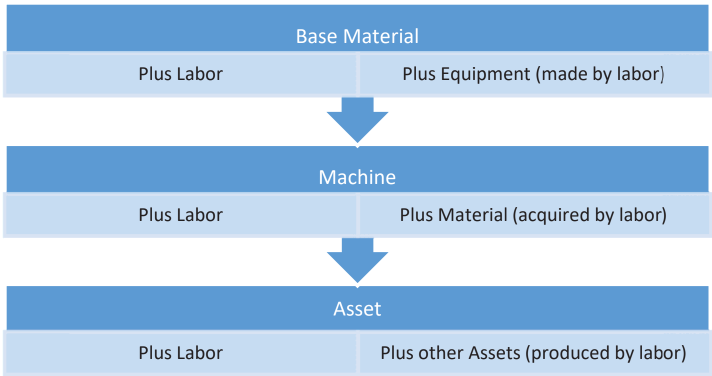
3. VALUE OF ASSETS

3.1. Thermodynamic Theory of Assets

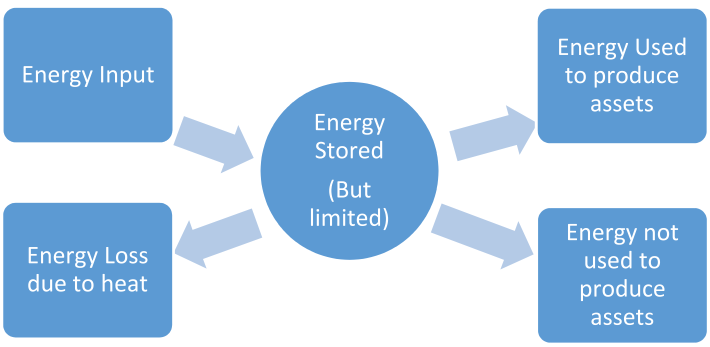
Let us consider a hard asset. An asset must be mined, transported, manufactured, and used. In this case, human labor is the only way of completing this asset. That human labor requires use of human energy. All assets are derived from human labor, i.e. nothing arises except through the application of human labor through the expenditure of labor (Figure 1). As an example, a hammer consists of a wood handle plus a steel head. The wood is processed trees which are cut down by machines operated by human labor, and the machines are made through labor, on and on.

Figure 1
Assets derived from human labor



Labor results from the expenditure of approximately 9 x 10^6 joules per day per person[1]. Therefore, all assets are related to human energy. However, Energy Used is a function of Energy Input [$E_U = f(E_1)$]. Under the First Law of Thermodynamics energy cannot be destroyed only converted. The First Law of Thermodynamics states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but cannot be created or destroyed, this is known as the conservation of energy. The energy allocation is basically composed of several distributions as shown in Figure 2.

Figure 2
Human energy distribution



[1] Based on 2,000–2,500 kilocalories per day per person.

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During a year on this planet hard [A_H], soft [A_s] and liquid assets [A_L] are produced Therefore the sum of all assets [A_T] is a function of World Gross Product:

$$A_T = A_H + A_S + A_L = f(WGP) \qquad \text{Eq. (1.)}$$

No hard assets [A_H] are produced without labor. Now the question could be how intellectual pursuits are countered. These soft assets [A_S] however are also based on human energy to produce those soft assets. On a first approximation basis, all 7.0 billion humans use 6.3 x 10^{16} joules per day or 2.3 x 10^{19} joules per year. Therefore, this total planet expenditure of human energy must be directly related to all assets produced [A_T] in a year and thus related to WGP. In 2011, the WGP totaled approximately USD84.97 trillion (10^{12})[2] in terms of purchasing power parity (PPP)[3], and around USD71.83 trillion in nominal terms. The per capita PPP WGP was approximately USD11,071 in 2011. WGP is composed of a base [WGP_B] plus productivity [WGP_P]. [WGP_B] is related to all the human energy [E_{H_n}] for that year [n]. WGP_P is related to prior assets produced through human energy less losses given by:

$$\left[\sum_{n=0}^{n=k} E_{H_n} - \sum_{n=0}^{n=(k-1)} \alpha E_{H_n}\right] \qquad \text{Eq. (2.)}$$

Where $\sum_{n=0}^{n=(k-1)} \alpha E_{H_n}$ represents the entropy[4] loss in the total asset formation system and $E_{H_{2012}}$ = 2.3 x 10^{19}. However, based on a base going back to the point in time when there was little or no productivity, the first century of the Common Era[5], then $WGP_{P_0} \cong 0$ and WGP_{B_0} = USD102.5 x 10^9 or USD513 per capita in PPP terms and 2011 USD. If we assume that population then was 200 million, this would equate to 6.9 x 10^{17} joules per year, and then value of joule would be USD1.49 x 10^{-7}. The value of a joule in 2011 was still \$1.49 x 10^{-7} in 2011 USD, this basic global average value will likely continue. This value can serve as the basis of a new global reserve currency. However, in terms of individual economies, the value of the joule will vary as the Gross Domestic Product (GDP) varies.

3.2. Labor Theory of Value

In economics, labor is a measure of the work done by human beings and is conventionally contrasted with such other factors of production as land and capital. Capital can be considered as 'Solid Labor' or 'realized Labor' or 'indirect labor'. Modern economics considers the interrelations among the labor (direct labor), the goods, the money, and the foreign trade. It looks at how these interactions influence macro variables such as employment levels, inflation rates, aggregate income and Gross Domestic Product (GDP). The social science of economics seldom considers that how human labor contributes to the total system. Some economists have postulated that understanding the labor market is fundamental to understanding modern economy. Labor economics tries to determine how labor is exchanged for wages. It does not explain how that labor results in an asset and what is the basis for that exchange.

"The labor theory of value presents one of the most puzzling and intriguing phenomena in the history of thought" (Foley, 1997). Many researchers believe that John Locke (1632–1704) was one of the pioneers of Labor Theory of Value or LTV. Even though Locke assumed that all natural resources had been provided by God, he believed that when people took natural things and

2 Values are in 2011 USD.

3 Purchasing-power-parity (PPP) adjustment attempts to make currency among different countries comparable based on the amount required to purchase the same volume of goods in each country. These values are expressed in a theoretical currency that corresponds to real (inflation-adjusted) 2011 U.S. dollars.

4 Entropy measures a system's unavailable energy.

5 See Table 1.

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reshaped them into products, they mixed their labor with the raw naturally provided materials, and thus had the right to own the products. For instance, picking an apple off a tree, that labor entered into the object, and so the object became property of that person, which is the base of value, therefore, Locke indicated in his work the concept of LTV.

Others argued, however, that while Locke did indicate LTV, "the relative value or price of a thing was dependent upon its usefulness and scarcity and not the amount of labor it contained". These researchers, therefore, argued that Locke would have agreed completely with Archbishop Whately's famous dictum: "it is not that pearls fetch a high price because men have dived for them; but on the contrary, men dive for them because they fetch a high price".

Adam Smith (1723–1790) and David Ricardo (1772–1823) were among the classic economists who advocated LTV. Smith lectured that labor – rather than the nation's quantity of gold or silver – is the cause of increase in national wealth. According to Smith, human activity rather than natural endowment of resources or treasure is the spring of prosperity and wealth. Smith distinguished the concepts of 'value in use' and 'value in exchange'; the former is the usefulness of this commodity, or its utility, while the latter is the ratio of this commodity exchanges for another. Smith further concluded that labor is the 'real measure' of any product's value.

Smith explained: the real price of everything, what everything costs to the man who wants to acquire it, is the toil and trouble of acquiring it. What everything is really worth to the man who has acquired it, and who wants to dispose of it or exchange it for something else, is the toil and trouble which it can save to himself, and which it can impose upon other people. Even a person drinking water from a good stream at his doorstep must "spend" labor to gain this value, at least if this action is relevant to economics. He suggested that the amount of labor used in the production of a good was a measure of its value. "If among a nation of hunters, for example, it usually costs twice the labor to kill a beaver which it does to kill a deer, one beaver should naturally exchange for or be worth two deer."

Evidently, LTV is a major pillar of traditional Marxian economics, created by Karl Marx (1818–1883) and Friedrich Engels (1820–1895) in Marx's masterpiece, "Capital". The theory claims that value of a commodity can be objectively measured by "socially necessary labor-time," required to produce that commodity. We believe that the concept of "socially necessary labor time" should be adjusted according different environment and different historic period.

Marx believed that value has its duality: value and use value, and similarly labor: concrete labor and abstract labor, the former is the base for commodity's use value and the latter for value itself. If the commodity is to be traded, it has an exchange value. However, LTV is considered by many not the creation of Marxism, rather, Marx and his friend and co-author Engels' contribution is the theory of surplus value. They believed that surplus value is the excess of the value the proletarian has produced above what it takes to keep the proletarian working, and surplus value is the source of profit for the capitalists.

In the post Marxism period, debates on LTV have never been stopped, especially in China. Right after the economic reform took place in 1979, numerous papers were published among outstanding and eminent Chinese economists.

In 1981, for instance, Prof. Yu Guangyuan claimed that all labor involved in production, including labor in education, science, art, services can create value. Prof. Sun Ye Fang, however, believed that it is only physical labor that produces value.

In the 1990s, Gu Shu Tang emphasized nonphysical labor also created value and considered that labor productivity is also an element in measuring labor time (Gu 1993). Su Xing, on the other hand, indicated only active labor is the sole source of value. At the same time, Qian Bo Hai argued that both active labor and materialized labor created value (Qian 1994).

The debate carried on into the new century. In 2000, Mr. Gao Shang Quan raised a proposition that scientists, technician and managers should be all considered as labors and therefore create value. This claim induced a serious debate in "Economic Daily" in November of that year.

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As economic reform continues in the new century in China, the discussion on LTV continues, yet more and more towards modifying and redefining Marxist theory.

Wu Jie believed that labor can be identified as "superior labor" and "inferior labor", and therefore, intellectual labor and innovative labor create more value (Wu 2002).

Liu Shi Bai believed that modern technology innovation is a product of technological innovative labor. It has four characteristics: high creative labor; high intellectually accumulative labor; high specialized labor and high socially syndicated labor.

Wei Xinghua distinguished labor into four different categories: physical production labor; spiritual production labor; commercial services labor and social public labor. Generally speaking, the first three types of labor create value, not the last category.

To further explore Labor Theory of Value in modern society, Liu Guan Jun identified three different value fountains and thereafter three value flows, namely: "the primary value chain"; "the secondary value chain"; and "the tertiary value chain". The primary value chain defines production labor at the working location in the absence of science and technology; the secondary value chain defines production labor partially at the location; and the tertiary value chain defines labor not at the location, such as scientists and technician who contributed basic scientific foundation to the modern production labor.

Among western scholars and researchers, the debate on LTV has never stopped, for instance, how value can be transformed into the price of production. The so called "New Interpretation" of Marx's LTV by French scholar Gérard Duménil and US professor Duncan K. Foley, for instance, argued that the value of labor-power should be measured as the ratio of the money wage to the monetary expression of labor, not as the labor embodied in the commodities workers consume (Foley, 1997). LTV can be used to determine the totality of economic value production, which is consisted of functionally relevant parts (Foley 2000).

While some argued that Marx clearly suggested that the exchange value or market price of a commodity is determined by the labor producing it (Guerrero,2007) and that the magnitude of value is itself an expression of the socially necessary labor-time embodied in the commodity-form (Lucarelli, 2007), Marx tries to break free from classical political economy through applying the Hegelian method of "systematic dialectics" (Brown, 2004) and empirical correlations between relative prices and relative values is log linear (Shaikh 1984). However, Marx had been in a struggle to reconcile the concept of value represented by the amount of labor embodied in it, and the exchange value reflected supply and demand and the principal fallacy in the labor theory of value is that it ignores Hume's notion of causality (Fulda, 2007). In contrast to Marxian theory of value, the Sraffan economists suggested that aggregating capital can be used as dated inputs of labor (Sraffa, 1970).

Scholars' favor of the basic principles set by Marx and his co-author, Engels. argued that the labor theory of value can be demonstrated empirically, and all the elements of the cost of production can be reduced to labor, and to labor alone and that prices are the monetary expressions of labor values, and a pure economic theory can be developed properly in terms of labor values only, regardless of price (Hagendorf, 2009).

3.3. Thermodynamics Approach

The basic approach is that everything requires labor and labor requires energy. The only energy that enters our planet comes from the sun. Even coal and oil are products of past sunlight. Radioactive material was deposited when the planet was formed and like the planet itself is here. Meteors and galactic dust enter our planet but do not contribute much to the energy input.

The earth receives a net of about 20 to 30 metric tons of energy per day or 8,000 to 12,000 metric tons per year based on Einstein's equation [$E = MC^2$]. Human beings now use only about 0.25 metric tons per year or approximately 0.00208% to 0.00312% of the net solar energy input.

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All human endeavors are a result of the total energy used by the world population due to the First Law of Thermodynamics. Therefore, all assets produced are directly related to this mere 0.25 metric tons of solar energy plus the productivity resulting from prior energy inputs. Even the energy used by humans must be extracted and that extraction and associated equipment are a result of human energy expended.

On average, each person on earth uses approximately 10,000 kilojoules of energy per day to meet their needs. This unit requirement is approximately of the same magnitude as required in the Neolithic era. Now that implies that approximately 6×10^{13} kilojoules per day or 2.2×10^{16} kilojoules per year can be related to all asset formation in combination with past human endeavor resulting in productivity or leverage through the application of existing past assets. Nothing results except from current and past human expenditure of human energy; this is the result of the First Law of Thermodynamics.

In one way or another all humans contribute some energy to the formation of assets either by forming those assets or using them to develop other assets. This is independent of whether the worker is in a factory, farm, or office, or is unemployed. All humans must acquire sources of energy to survive and to accomplish their individual endeavors whatever they may be. The only source of this energy is the sunlight past and current and radioactive material formed when the earth formed. Thus, all assets and capital are directly related to these expenditures of human energy.

Based on this premise we can develop a model explaining how this is related to World Gross Product and Capital and what its relationship to Liquid Capital or soft assets and in turn what may be the cause of the instability of the global financial system.

3.3.1. General Equations

The recent worldwide financial crisis illustrated that a real systematic understanding of the relationships between financial systems may not be fully understood in terms of a total system. If we consider the world as a system, the only things that enter earth are sunlight, radiation and extraterrestrial bodies; thus, the financial system only results from labor, use of resources and productivity. While this is a simplistic system in fact its complexity and interactions can become extremely unstable. Financial crises have been the “sine qua non” of the 1970 to 2010 period with over 124 worldwide

Starting with the premise that we are dealing with a system, on a global level we need to understand the general interaction between the measures of the world’s economic factors. Initially these factors can be given by the World Gross Product [WGP] and the World Capital [WC] and how they are related.

These factors when analyzed in a systematic and quantitative manner may allow the understanding of the system and variables which when perturbed can cause a cascaded instability.

The world gross product [WGP] or world gross income [WGI], is a basic measure of a world’s economic performance, and is the market value of all final goods and services made in the world in a year. WGP can be defined in three ways, all of which are identical. First, it is equal to the total expenditures for all final goods and services produced in the world in a year. Second, it is equal to the sum of the value added at every stage of production (the intermediate stages) by all the industries in the world, plus taxes less subsidies on products, in the period. Third, it is equal to the sum of the income generated by production in the world in the period – that is, compensation of employees, and gross operating surplus (or profits).

The most common approach to measuring and quantifying WGP is the expenditure method:

WGP = private consumption (C) + gross investment (I) + government spending (G), or,

$$WGP = C + I + G \quad \text{Eq. (3)}$$

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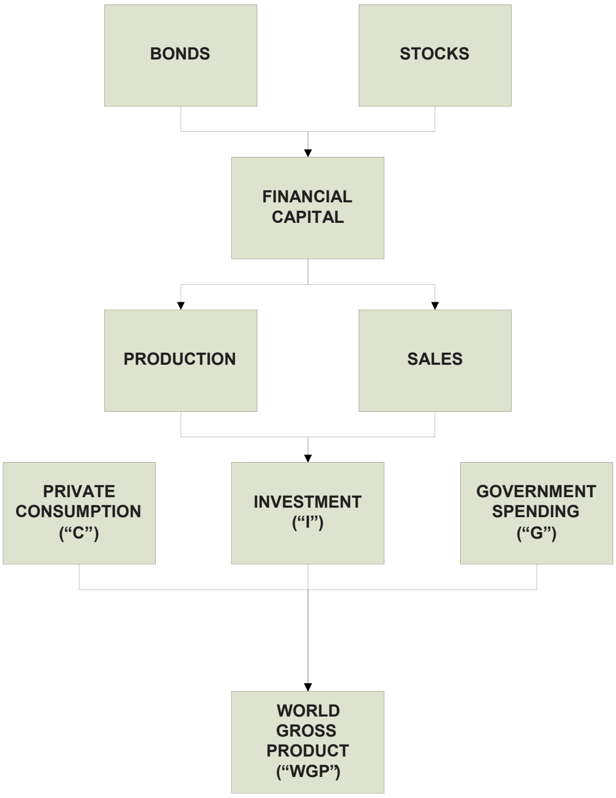
"Gross" means that depreciation of capital stock is not subtracted out of WGP. If net investment (which is gross investment minus depreciation) is substituted for gross investment in the equation above, then the formula for net domestic product is obtained. Consumption and investment in this equation are expenditure on final goods and services.

Figure. 3
World gross product



World Gross Product can be related to world population and productivity. Since caloric use per individual has been relatively constant for over thousands of years then based on estimates of WGP during periods of low productivity such as the first century of the Common Era, the basic WGP per population was approximately USD513 per person in PPP 2011 dollars. Table 1 shows estimates of WGP, population and the results over a 2,100-year period.

Therefore:

$$WGP_B = K_p * P_{T_t} + P_{r_t} \quad \text{Eq. (4)}$$

Where, K_p = average value in terms of USD per person [USD500] or in terms of joules per person per year (3.3×10^9) if joules are used, then WGP would be in terms of joules.

P_{T_t} = world population at time (t)

P_{r_t} = productivity value in terms of 't' or $\alpha_t * P_{T_t}$ where α_t is the measure of productivity per person at time 't'

The population can be estimated by:

$$P_{T_t} = 4.43 * \text{arccot}\frac{(2007 - T_t)}{42} \quad \text{Eq. (5)}$$

Where, T_t = year of population estimate.

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Therefore:

$$WGP_t = P_{T_t} * (K_p + \alpha_t) \qquad \text{Eq. (6)}$$

Let us assume that 'α_t' can be described by logistic equation in the form:

$$\alpha_t = \frac{\beta e^t}{\beta + (e^t - 1)} \qquad \text{Eq. (7)}$$

Where 'β' represents the maximum range of the productivity. However, this productivity must relate to prior human energy expenditures less loss of assets from a First Law of Thermodynamics viewpoint. Therefore, the total amount of world "human thermodynamic assets" consists of human energy plus all prior expenditures less losses. When pseudo-assets and hard assets approach this value, instability in global finances may result.

There are many different definitions of capital. According to Adan Smith, he defines capital as "That part of Man's stock which he expects to afford him revenue is called his capital." Capital is something owned which provides ongoing services. In the national accounts, or to firms, capital is made up of durable investment goods, normally summed in units of money. Broadly: land plus physical structures plus equipment. But it is also a measure of the accumulated financial strength of an individual, firm, or nation, or the world created by sacrificing present consumption in favor of investment to generate future returns above investment costs. It can be defined also as assets available for use in the production of further assets or as wealth in the form of money or property owned by a person or business and human resources of economic value.

We will use the definition that total capital [C_{T_t}] at time 't' is the value of all the equipment, land and liquid assets.

Now capital [C_{T_t}] consists of current and past capital [$C_{T_{(t-1)}}$] plus input from past World Gross Product [$WGP_{(t-1)}$].

Applying a preliminary analysis, we can show that:

$$C_{T_t} = \left\{ \frac{K_p * [1 + R] * [1 * S_f]}{\left[1 - \frac{C_{S_t}}{C_{T_t}}\right]} \right\} * \sum_{i=0}^{i=t} \left(P_{T_i} + P_{T_{t-1}}\right) \qquad \text{Eq. (8)}$$

Where,

R = is a logistic function over a period '0' to 't' (assumption)

S_f = is an unknown function now, possibly another logistic function (assumption)

C_{S_t} = is the amount of liquid or soft capital at time 't'

This equation seems to indicate that as liquid or soft capital (C_{S_t}) grows where it represents most the total capital (C_{T_t}) the equation will 'balloon', i.e. a bubble and likely lead to instability! We believe this is what happened during the 'Great Recession of 2008'.

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Table 1
Estimated relationship between WGP and population

Year	WGP (Million USD)	Population (Million Persons)	WGP/Pop (USD per Person)	Productivity Ratio (Year to Year 1)	Base WGP (Million USD)	WGP Due to Productivity (Million USD)
1	102,536	200	513	1.00	102,536	0
1000	116,790	310	377	0.73	158,931	-42,141
1500	247,116					
1600	329,417					
1700	371,369					
1750		791			405,530	
1800		978			501,401	
1820	694,442					
1850		1,262			647,002	
1870	1,101,369					
1900		1,650			845,922	
1913	2,704,782					
1950	5,336,101	2,519	2,118	4.13	1,291,441	4,044,660
1955		2,756			1,412,946	
1960		2,982			1,528,812	
1970		3,692			1,892,815	
1973	16,059,180					
1975		4,068			2,085,582	
1980		4,435			2,273,736	
1985		4,831			2,476,757	
1990		5,263			2,698,235	
1995		5,674			2,908,946	
1998	33,725,635					
2000		6,070			3,111,968	
2005		6,454			3,308,837	
2007	55,000,000		8,100	15.80	3,481,160	51,518,840
2008	61,070,000		9,600	18.73	3,261,392	57,808,608
2009		6,796			3,483,944	
2050		8,909				
2150 (Estimated)		9,746				

Source: Based on data contained in.

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4. PRELINARY RESULTS

4.1. What drives world financial instability

As we have seen world financial instability may be driven because the growth of liquid capital overwhelms real capital, i.e. capital formed due to labor not just paper. We should divide total capital [C_{T_t}] at time 't' into also real or hard capital, i.e. assets based on labor [C_{H_t}] at time 't' and representational or soft assets such as mortgages, bonds, stocks, derivatives, etc. [C_{S_t}] at time 't'. The assets based on labor [C_{H_t}] can be divided between the base assets [C_{Hb_t}] when they were originally placed into service and their growth based on either supply-demand or other pricing mechanisms (C_{Hp_t}):

$$C_{Hp_t} = \gamma_t * C_{Hb_t} \qquad \text{Eq. (9)}$$

Where
γ_t = growth factor for assets at time 't'
So, if Eq. 8 is reviewed in reference to these factors, then:

$$C_{T_t} = C_{S_t}\left[\left(\frac{C_{Hb_t}}{C_{S_t}}\right) * (1 + \gamma_t) + 1\right] \qquad \text{Eq. (10)}$$

Therefore, when representational or soft assets such as mortgages, bonds, stocks, derivatives and other non-labor based assets become so large that base assets become much debased then as:

$$C_{S_t} \rightarrow C_{T_t} \qquad \text{Eq. (11)}$$

Then an asset 'bubble' occurs and instability becomes very likely. Basically, this result from the First Law of Thermodynamics, which you cannot obtain, more than enters the system. Financial crisis in any era is an illustration of this factor, as is the collapse of financial markets.

4.1.1. Basis for global financial systems model

We believe while we have initially shown a relationship in the global markets, these factors also hold in all financial systems from global down to individuals. This factorial relationship is illustrated by various situations. We have demonstrated the initial global case now let us consider some other areas.

The Asian financial crisis that held much of Asia in its grip began in July 1997. This crisis started because Thailand floated its currency due to severe financial overextension. This overextension was due to a large foreign debt that caused a bankruptcy of the country. Foreign debt to GDP ratios increased from 100% to 167% in 1993–1996 in four major countries of the ASEAN region. This is a regional example of our preliminary thesis.

The major recession in many countries including Latin America in the 1950–1990 time periods provide other examples. In these cases, countries borrowed heavenly from various international organizations. This caused hyper-inflation and eventually bankruptcy as many of these nations defaulted on their debts.

Industries also experience over expansion with a rise of equity values far exceeding their real asset values, leading to a collapse of equities and the collapse of many companies due to the growth of pseudo-capital, i.e. capital without a labor base. This was the case of the technology equity "bubble" in 2000. Corporations similarly fail by incurring debts, which exceed available assets. Similarly, individuals fail for the same reasons. The failure of the American and British housing due to mortgages that exceed the real value of the assets is also illustrative of this failure.

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In many instances when the First Law of Thermodynamics has been ignored, the overall cascade also destroys much more than the failure of just the industry, company or individuals involved, causing further hardships in human terms.

As the availability of soft capital or assets increases then per the First Law of Thermodynamics, the system balance can only be maintained by decreasing the value of and/or amount of labor. Therefore, promoting more soft capital or assets that are not directed into producing hard assets through capital injections, debt issues and derivatives and other instruments decreases the portion of hard assets and thus soft capital or assets becomes a higher proportion of the total capital. The real impact of this is that labor loses its value through inflation/deflation and other economic mechanisms and/or the proportion of labor used to make assets decreases. Therefore, generating more soft capital or assets that do not result in hard assets has negative impacts on labor either through reduced value or lower utilization or both. Thus, central bank's 'quantitative easing' rarely results in an equivalent increase in hard assets but an increase in soft assets, which can lead to eventual financial instability.

This paper shows the importance of the First Law of Thermodynamics in determining the stability of financial markets from global down to individuals. The analysis in this paper shows that the basic principle of Labor Theory of Value explicated by Marx in his "Capital"' is still valid and we validate this principle not relying on economics and finance models but rather on the Laws of Thermodynamics. This is illustrated by the following set of equations.

Let us define the energy used by human by:

where;

E_{T_d} = total energy used by a person per day

E_{P_d} = personal energy per day

E_{H_d} = energy used to produce assets = σE_{P_d} where σ is the proportion of the population devoted to labor

E_{S_d} = energy stored in body per day

E_{L_d} = energy lost due to heat and mass per day

But,

$E_{L_d} = \alpha E_{T_d}$ where α is the proportion of the total energy (E_{T_d}) lost which in magnitude does not vary significantly

$E_{S_d} = \beta E_{T_d}$ where β is the amount of total energy (E_{T_d}) stored but there is a limit

Then;

$$E_{T_d} = \frac{E_{H_d}}{\sigma} + \alpha E_{T_d} + \beta E_{T_d} \qquad \text{Eq. (13)}$$

Therefore;

$$E_{H_d} = \sigma E_{T_d}(1 - \alpha - \beta) = \sigma\tau E_{T_d} \qquad \text{Eq. (14)}$$

Where,

$$\tau = (1 - \alpha - \beta) \qquad \text{Eq. (15)}$$

Now the total capital or assets during time (k) is given by:

$$C_{T_t} = C_{H_t} + C_{L_t} \qquad \text{Eq. (16)}$$

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Where,
C_{T_t} = total capital (assets)during time 't'
C_{H_t} = hard capital (hard assets) during time 't'
C_{L_t} = liquid or capital (soft assets)during time 't'

But;

$$C_{H_t} = \mu_t P_{T_t} E_{H_t} = \sigma_t \mu_t \tau_t P_{T_t} E_{T_t} \cong GWP_t \quad \text{Eq. (17)}$$

Where,
μ_t = value of energy at time 't', however, as we have shown this global average value has remained relative constant over 2,000 years at UD\$1.49 x 10^{-7} per joule, and

$$\mu_t = \frac{\sum \mu_{t_k} P_{t_k}}{P_t} \cong \text{Constant}$$

μ_{t_k} = is labor value for the individual economy 'k'
P_{T_t} = total population at time 't'
P_{t_k} = population of each individual economy 'k'

But; the total capital (C_{T_t}) at time 't' can also be written as the net capital additions (C_{N_t}) plus the net capital from prior years less any losses and changes in valuation, i.e. $\left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} C_{N_i}$

Where,

$\left(\frac{V_t}{V_{(t-1)}}\right)$ = average value of prior assets at time 't' in reference to time (t − 1), but;

$$\sum_{i=0}^{i=(t-1)} C_{N_i} = \sum_{i=0}^{i=(t-1)} C_{H_i} - \sum_{i=0}^{i=(t-1)} C_{H_{Loss\,i}} + \sum_{i=0}^{i=(t-1)} C_{L_i} - \sum_{i=0}^{i=(t-1)} C_{L_{Loss\,i}} \quad \text{Eq. (18)}$$

$$C_{N_t} = C_{H_t} - C_{H_{Loss\,t}} + C_{L_t} - C_{L_{Loss\,t}} \quad \text{Eq. (19)}$$

But;

$$C_{L_t} = C_{L_t} - C_{L_{Loss\,t}} + \sum_{i=0}^{i=(t-1)} C_{L_i} - \sum_{i=0}^{i=(t-1)} C_{L_{Loss\,i}} \quad \text{Eq. (20)}$$

$$\sum_{i=0}^{i=(t-1)} C_{H_{Loss\,i}} = \sum_{i=0}^{i=(t-1)} \epsilon_i C_{H_i} \quad \text{Eq. (21)}$$

Where ϵ_i = percentage of hard assets lost at time 'i', then;

$$\left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} C_{H_i} - \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} C_{H_{Loss\,i}} =$$

$$= \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} C_{H_i}(1-\epsilon_i) = \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \mu_i \gamma_i P_{T_i}(1-\epsilon_i) P_{T_i} \quad \text{Eq. (22)}$$

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Therefore,

$$\nabla_t = \left(C_{T_t} - C_{L_t}\right) = \sigma_t \mu_t \tau_t P_{T_t} E_{T_t} + \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1-\epsilon_i) P_{T_i} \qquad \text{Eq. (23)}$$

Therefore, this equation shows that the difference between total capital $[C_{T_t}]$ and liquid capital $[C_{L_t}]$ is strictly a function of human energy. This equation basically shows the impact of the First and Second Laws of Thermodynamics on capital. As the availability of liquid capital increases then the right side of the equation must decrease. The only way this can occur is by decreasing the amount of labor $[\sigma_t]$ and the value of prior hard assets $\left(\frac{V_t}{V_{(t-1)}}\right)$, such as housing. Therefore, promoting more liquid capital through capital injections, debt issues and derivatives and other instruments decreases "∇_t" since liquid capital $[C_{L_t}]$ becomes a higher proportion of the total capital (C_{T_t}). The real impact of this is that labor is reduced and thus increasing unemployment and existing hard asset value. Also as Eq. 8 shows this also results in a 'bubble'. Thus, injection of capital beyond a certain level could result in human value destruction in current and past assets. This is exactly what occurred during the "Great Recession of 2008", when unemployment increased and housing and or existing hard assets declined in value.

4.2. Impacts

The implications of Eq. (23) are many. These implications include:

- Employment
- Value of existing hard assets such as property
- Supply/Demand
- Productivity
- Global reserve currency
- Gross World Product and how it can change

4.2.1. Employment

The basic variable in Eq. (23) that cover employment is σ_t, which represents the percentage of the population P_{T_t} capable of producing hard assets. However,

$$\sigma_t = (1 - \omega_t) \qquad \text{Eq. (24)}$$

Where, ω_t = percentage of the population which is not producing assets.

As soft assets increase without a commensurate increase in total assets, then one aspect of Eq. (23) is an increase in proportion of the population not engaged in production of assets ω_t. This value is increased by both unemployment (both seekers and dropouts), retired, and underage.

4.2.2. Asset valuation

Prior hard assets, such as property, have a valuation when acquired. However, the current value of those assets can be higher or lower based on how they are impacted by Eq. (23). This is determined how the current valuation $[V_t]$ changes about prior valuation $[V_{(t-1)}]$. Therefore, as $\nabla_t < \nabla_{(t-1)}$, then, $V_t < V_{(t-1)}$.

This results in decreased prior hard asset values. This is precisely what occurred in the "Great Recession of 2008", when housing and other hard assets decreased substantially in value.

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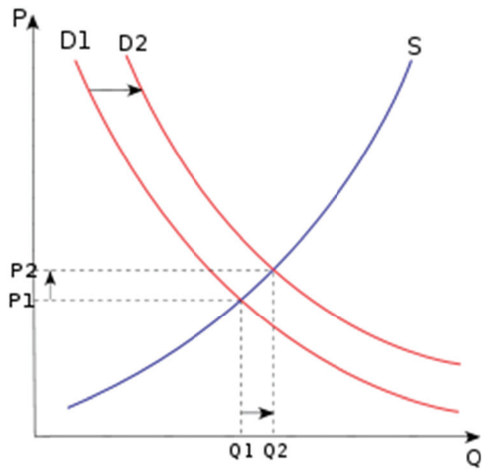
4.2.3. Supply/Demand

Figure 4 shows the classical supply-demand curves. However, Eq. (23) will impact this classical economic concept.

Figure 4
Classical supply-demand



The price P of a product is determined by a balance between production at each price [supply S] and the desires of those with purchasing power at each price [demand D]. The diagram shows a positive shift in demand from D1 to D2, resulting in an increase in price [P] and quantity sold [Q] of the product.

Let us consider that all hard assets [A_t] are given by:

$$A_t = Q_t P_t = C_{H_t} \quad \text{Eq. (25)}$$

But,

$$C_{H_t} = \nabla_t = \left(C_{T_t} - C_{S_t}\right) = \sigma_t \mu_t \tau_t P_{T_t} E_{T_t} + \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1 - \epsilon_i) E_{T_i} \quad \text{Eq. (26)}$$

Therefore;

$$P_t = \frac{\sigma_t \mu_t \tau_t P_{T_t} E_{T_t} + \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1 - \epsilon_i) E_{T_i}}{Q_t} \quad \text{Eq. (27)}$$

Or,

$$P_t = \frac{\left(\sigma_t \mu_t \tau_t P_{T_t} E_{T_t}\right)}{Q_t} + \frac{\left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1 - \epsilon_i) E_{T_i}}{Q_t} \quad \text{Eq. (28)}$$

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Where,

$\frac{(\sigma_t \mu_t \tau_t P_{T_t} E_{T_t})}{Q_t}$ = must be ratio of value of hard asset units based on human energy to supply demand units at time 't'

$\frac{\left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1-\epsilon_i) E_{T_i}}{Q_t}$ = must be ratio value of the sum of net hard asset units based on human energy available in time (t – 1) to supply demand units at time 't'

Therefore, as $\nabla_t = (C_{T_t} - C_{S_t}) \rightarrow 0$ as then both the demand and the supply will need to decrease and so will the clearing price if the rules of economics are to be utilized. Here we see how the First Law of Thermodynamics impacts classical economics.

4.2.4 Productivity

Productivity is a measure of output from a production process, per unit of input. For example, labor productivity is typically measured as a ratio of output per labor-hour, an input. Productivity may be conceived of as a metric of the technical or engineering efficiency of production.

Production is a process of combining various material inputs and immaterial inputs to make an output. Technology is the means of combining the inputs of production to produce output. A production function, which describes the relation between input and output, depicts technology. The production function can be used as a measure of relative performance when comparing technologies.

Total productivity = Output quality and quantity / Input quality and quantity = ρ_t

The changes in productivity between any two periods is given by:

$$\Delta\rho = \rho_t - \rho_{(t-1)} \qquad \text{Eq. (29)}$$

But,

$$\rho_t = \frac{Q_{o_t}}{Q_{I_t}} \qquad \text{Eq. (30)}$$

Where Q_{o_t} = output quality and quantity and Q_{I_t} = input quality and quantity at time 't'

$$Q_{o_t} = \frac{C_{H_t}}{V_{o_t}} = \frac{\sigma_{o_t} \mu_t \tau_t P_{T_t} E_{T_t}}{V_{o_t}} \qquad \text{Eq. (31)}$$

Where V_{o_t} = unit value of the output in period 't'

$$Q_{I_t} = \frac{\sigma_{I_t} \mu_t \tau_t P_{T_t} E_{T_t}}{V_{I_t}} \qquad \text{Eq. (32)}$$

Where V_{I_t} = unit value of the input = unit value of the labor plus the unit value of the material in terms of labor in period 't'

But, for the global economy, $\mu_t \tau_t P_{T_t} E_{T_t} \cong$ constant $= \aleph_t$

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Then,

$$\rho_t \cong \frac{\sigma_{o_t}}{\sigma_{I_t}} \quad \text{Eq. (32)}$$

Therefore,

$$\Delta\rho_t \cong \frac{\sigma_{o_t}}{\sigma_{I_t}} - \frac{\sigma_{o(t-1)}}{\sigma_{I(t-1)}} = \frac{\sigma_{I(t-1)}\sigma_{o_t} - \sigma_{I_t}\sigma_{o(t-1)}}{\sigma_{I(t-1)}\sigma_{I_t}} \quad \text{Eq. (33)}$$

Therefore, the changes in productivity are due to the changes in input and output labor, or as Eq. (24) indicate the changes in unemployment (ω).

There are other implications that can be drawn from Eq. (23). This Labor Value Equation (LVE) can be used to address how conflict impacts economic issues and how it is possible to develop a new global reserve currency which can assist in maintaining global financial stability.

4.2.5. Global conflict

LVE, i.e. Eq. (23), has certain values that are impacted by conflict. These factors include:
σ = Labor percentage and unemployment
P_T = Population
V = Value of prior assets
ϵ = Entropy factor related to destruction of existing hard assets

These factors plus the need to issue more debt or soft assets are directly related to conflict. In fact, these taken together can eventually lead to global financial collapse.

4.2.6. Global reserve currency

A new measure based on human expenditure has been proposed. The nature of capital is multilevel; it can consist of property, resources, human labor and various other assets. But it is the ability to trade one asset for another asset. In this regard, capital like money can be used to acquire another asset like someone's labor or a physical asset. In a way, it is barter because liquid capital is only a way of exchange in fact since any asset, from a market perspective, only has value because someone wants it. If that asset was placed in a forest or desert or a high mountain and no one was there to claim it, then it would have no value. So, for an asset of any type to have value, someone must want it otherwise it would be valueless.

However, while its value depends on someone desiring it, the asset has a more fundamental 'value' in the thermodynamic sense. That thermodynamic value is the amount of human labor expended to produce it. That must be the total 'labor' cycle from basic resource acquisition to the final asset. This includes the labor to build any device and the material in that cycle allocated to that device, and intellectual labor that contributed any technological innovation. Thus, nothing on this planet is produced "de novo", that is without human labor. Starting with the premise that we are dealing with a system, on a global level we need to understand the general interaction between the measures of the world's economic factors. The First Law of Thermodynamics has been shown determining the stability of financial markets from global down to individuals.

Realizing that the maximum value of real assets is based on past and present labor, the First Law of Thermodynamics says that we cannot obtain assets that exceed a maximum number of "joules" during any period. Therefore, the world capital will grow through growth in population plus net additions due to World Gross Product (WGP), less losses. To determine this, additional research will be required including quantifying this premise. This preliminary analysis shows that based on the First Law of Thermodynamics, the world financial system is in fact a "Zero

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Sum Game". There are only gainers and losers in this "game" and it is imperative that we have a methodology to have a level playing field in global finance.

The premise is that:

- Reserve currency total value cannot exceed the value of the global hard assets
- Hard assets value based on the First Law of Thermodynamics
- Therefore, the value of global reserve currency should be in joules

Let, R_T = Total global reserve currency in joules, therefore, a modified version of the Eq. 23 can be written as:

$$R_T = \sigma_t \mu_t \tau_t P_{T_t} E_{T_t} + \left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1 - \epsilon_i) E_{T_i} \qquad \text{Eq. (34)}$$

Let,

$$K = 1 + \frac{\left(\frac{V_t}{V_{(t-1)}}\right) * \sum_{i=0}^{i=(t-1)} \sigma_i \mu_i \tau_i P_{T_i} (1 - \epsilon_i) E_{T_i}}{\sigma_t \mu_t \tau_t P_{T_t} E_{T_t}} \qquad \text{Eq. (35)}$$

but, $E_{T_i} \sim E_{T_t}$ and $\tau_t \sim \tau_i$ and $\mu_t \sim \mu_i$

Therefore,

$$K = 1 + \frac{\sum_{i=0}^{i=(t-1)} \sigma_i P_{T_i} (1 - \epsilon_i)}{\sigma_t P_{T_t}} \qquad \text{Eq. (36)}$$

But hard assets have only a useful life of 'n' years, for a reasonable number of years the ratio $\frac{\sigma_i}{\sigma_t}$ is relatively constant, if not very close to unity

Therefore,

$$K = 1 + \frac{\sum_{i=0}^{i=(t-1)} P_{T_i} (1 - \epsilon_i)}{P_{T_t}} \sim e^{rn} \qquad \text{Eq. (37)}$$

Where r = population growth rate and 'n' is the average useful life of hard assets

Therefore,

$$R_T \sim \sigma_t \mu_t \tau_t P_{T_t} E_{T_t} e^{rn} \qquad \text{Eq. (38)}$$

This offers a means for determining the world reserve currency at any time 't' and determining a baseline for future estimates of reserve currency.

4.2.7. Global Stability

Eq. (8) indicates that as liquid or soft capital $[C_{S_t}]$ approaches where it represents most of the total capital $[C_{T_t}]$ the equation will "balloon", i.e. form a bubble and likely lead to instability. We believe this is what happened during the "Great Recession of 2008". These inflations tend to occur because we are dealing with a complex system like that shown in Figure 5.

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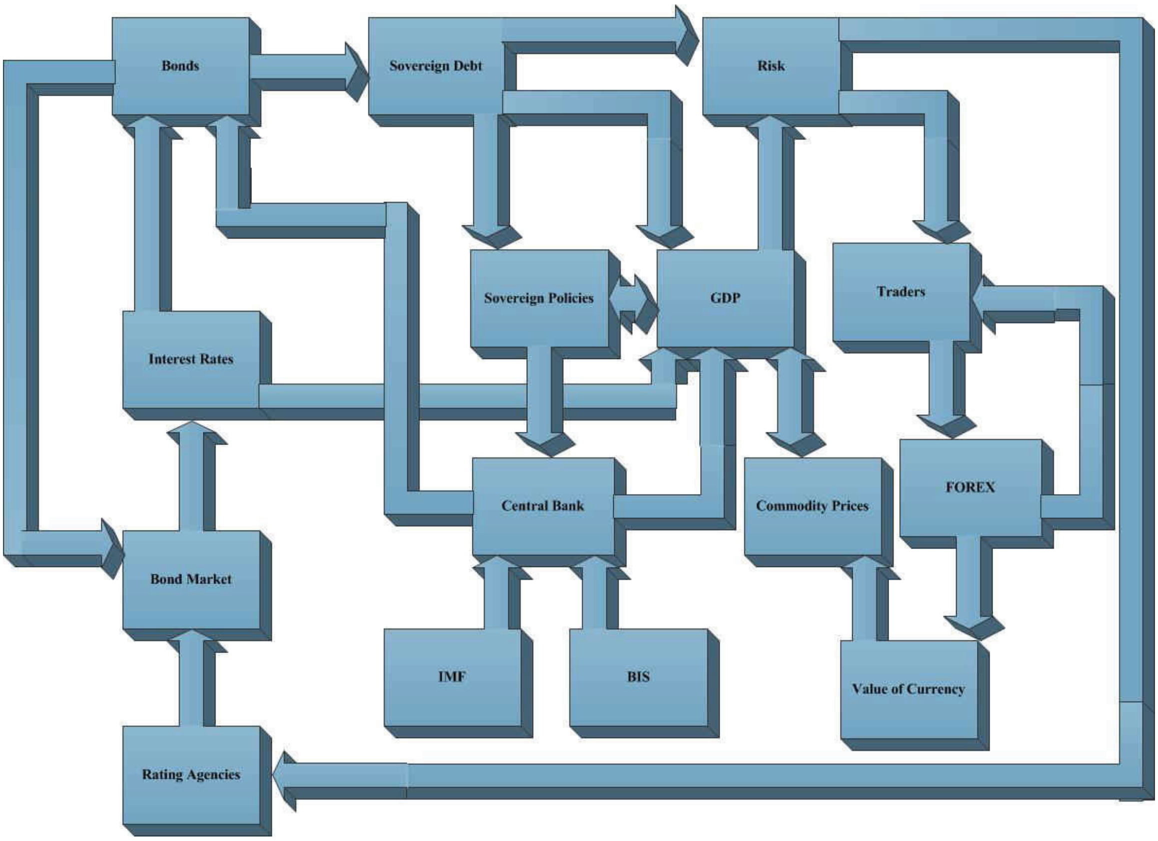
Figure 5
Simplified Financial Interactions



Source: Cardullo, 2013.

4. CONCLUSIONS

The recent worldwide financial crisis illustrated that a real systematic understanding of the relationships between financial systems may not be fully understood in terms of a total system. This paper illustrates that basic global economic concepts can be directly related to the First and Second of Thermodynamics. Nothing results except from current and past expenditure of human energy; this is the result of the First Law of Thermodynamics. In economics, labor is a measure of the work done by human beings and is conventionally contrasted with such other factors of production as land, and we consider capital is a form of realized labor. In this paper, we argue that everything is a product of energy in the form of labor and that the basic principle of Labor Theory of Value is still valid and we validate this principle not relying on economics and finance models, rather on thermodynamic principles. We believe it is the energy created by labor that is the core element of the system, and is the fundamental variable to explain the nature of capital market and of financial systems. This is illustrated by the development of the LVE and how it can impact employment, asset valuation, supply/demand, productivity, global conflict, global reserve currency and global stability.

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