ECONOMIC / ENVIRONMENTAL SYSTEM INTERACTION

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Abstract

This work is focused on identifying the relationship an economic system and its policies have with the environment. The biosphere is chosen in particular as object of analysis but this can be extended by means of an ecosystem recursive properties. The common factor involved in the relationship analysis is that currently associated with entropy, being the underlying measure of any transformation process. Ashby's viable system model (VSM) is used as a means of appraising the attribution of sustainability while establishing a consistent system of units for both the solar flux and economic transformation processes. Conditions for a virtuous cycle dynamic in relation to sustainability is expressed, adhering to non-equilibrium thermodynamics.

Keywords: Sustainability, Entropy, Variety, Viable, Change

1. INTRODUCTION

In 1987 the Brundtland report, also known as "our common future", alerted the world on the urgency of attaining progress in economic development while making it durable and not to deplete natural resources or have environmental degradation. The report stated an important definition, "Sustainable Development" as development that meets the needs of the present without compromising the ability of future generations to meet their needs (WCED, 1987).

In this papers development, the statement of the biospheres most fundamental limit of transformation is made as a prerequisite to sustainability.

This limit to the biosphere is defined by the transformation capacity of solar energy, from a relatively high temperature towards a lower. This physical process is measurable by means of the entropy concept.

In the development of this article, the importance of transformation (second law of thermodynamics) is emphasized beyond the concept of energy and its conservation (first law of thermodynamics), matching the vision stating the possibility of life only in relation with the second law as Ilya Prigogine has stated, to mention but one well known voice in this line of argument.

To the effect of appraising the attribution of sustainability adhering to Ashby's(1956) viable system model (VSM), we need to converge both the solar flux and economic transformation processes.

The first step in conceiving the VSM for the biosphere is related to identifying an entropy budget in correspondence with radiant energy transformation in its process of falling temperature.

The second needed contribution is the attribution of a specific but not fixed entropy to the economic system, this approach is accessible by two means. The first makes use of the relationship between rate of energy flow and the frequency with which economic activity takes place, the second approach makes use of the relationship between available money supply and energy price levels.

Both of these contributions represent the foundation over which this paper is developed, they further express the possibility of generating a virtuous cycle in relation to conditions for sustainability expressed in accordance to non-equilibrium thermodynamics.

2. METHOD

Hypothesis:

Entropy flow identified by the systemic relations between the environment and economic subsystem determines environmental sustainability.

Giving a recollection of entropy expressions:

$S = E_T / T$ (classical entropy, standing for amount of energy stored in matter at a given temperature)

$S_B = k \ln N$ (Boltzmann, N is degrees of freedom for a macro-ensemble)

And since:

$E_T = n\, h\, v$ (Planck, total amount of energy a stream of –n- photons have)

$E = k\, T$ (Boltzmann, standing for the temperature a given photon may represent to have at a particular energy level, ie. frequency)

Then

$S_V = k\, n$ (Vildosola, standing for entropy directly correlated to the amount of photons enclosed in a system void of matter) (1)

Since entropy measurement does not take into account descriptive dynamics (i.e. linear dynamics, non-linear, chaotic, etc.), we have no concern for time scale in the following expression:

$S_U = S_V + S_B$ (Vildosola, if Boltzmann's entropy expression holds and no photon-matter interaction is present, it is implied the Universe or closed system entropy S_U is constant.) (2)

When photon-matter interaction takes place, it is implied:

$$N_f = N_i e^{(n_i - n_f)} \quad \text{(Vildosola)} \qquad (3)$$

When radiant energy is transformed through the biosphere and gains entropy, the biosphere transforms complex molecules into simpler, more unstable ones. When the biotic system nourishes from simple assemblies of molecules, it builds more complex and stable (high entropy) ones.

When radiant energy following increased quanta in S_V is not decoupled from matter after modifying its structure(entropy change), this is associated with internal energy loss.

Comparing Eq.(2) with S.K.Lin(1996) maximum entropy equation (4) it may be understood there's an isomorphism between them, where L = S_U, S = S_V , I = S_B,

$$L = S + I \qquad (4)$$

Having concluded a general overview of matter and radiant energy interaction, it is reasonable to make use of Ashby's viable system model for the general objective of sustainability.

We define the biosphere available entropy flow by that being conducted in transforming of radiant energy, its only means of exchange with the environment (Kennedy, 2001). This available entropy is exported out of the biosphere and estimated by

$$\Delta S_B = 1.7x10^{24} erg / seg\left(\frac{1}{T_f} - \frac{1}{T_i}\right) \qquad (5)$$

Where $1.7x10^{24}$ is the average amount of radiant energy flowing through the biosphere, T_i=6000K represents its incidence temperature and T_f=255K is the mean temperature of emission.

According to the viable system model, this entropy should not be surpassed by the entropy flow required by any of its subsystems, i.e. economic system.

$$\Delta S_E = S_{Ei} G_{S_E} \qquad (6)$$

In this last expression (6) S_{Ei} stands for the entropy state of the economy and G_{SE} stands for its proportional rate of change so that ΔS_E is net entropy change within a time frame.

Requisite variety must not surpass available variety (7) for the system and hence its subsystems to be viable, this is inferred to represent the condition for sustainability as stated in the Brundtland report.

$$\Delta S_E \leq \Delta S_B \qquad (7)$$

The origin of equation (5) is readily identified as classical thermodynamic entropy. The development of equation (6) is necessary for the expression of sustainability in the Viable System Model(7).

Given the following axiomatic definitions (Vildosola, 1991):

P W = Kc P Q = V Kc R = V

We may appreciate the economic systems energy state by two means,

W=Kc/P and W=Q/R

the first describes the energy state in monetary units, the second describes the energy state in physical units, so the entropy state of this subsystem is also expressed in these two:

$$S_E = \frac{Kc}{PT} \qquad (8) \qquad\qquad S_E = \frac{Q}{RT} \qquad (9)$$

were :

$$G_{S_E} = G_{Kc} - G_P - G_T \qquad (10) \qquad\qquad G_{S_E} = G_Q - G_R - G_T \qquad (11)$$

Equation (8) shows three new concepts or variables, Kc is the amount of circulating money an economic system is making use of, P is the mean prize per unit of energy contained in the system (erg in our case), T is the temperature the economic subsystem holds. Although it is not yet clear the meaning of this temperature, the following analysis will make a proposition as to alternatives for sustainable development without the use of the temperature concept.

Equation (9) is equivalent to (8) but its concepts are Q, standing for the rate of energy flow through the economic system and R standing for the turnover rate on energy contained in the subsystem.

By combining (5) and (6), equation (7) can be written as:

$$S_{Ei}G_{S_E} \leq 1.7x10^{24} erg/seg\left(\frac{T_i - T_f}{T_i T_f}\right) \tag{12}$$

By substitution of both S_{Ei} and G_{SE} and a little rearrangement of terms we have:

$$G_{Kc} - G_P - G_T \leq \frac{1.7x10^{24} erg/seg(T_i - T_f)PT}{T_i T_f Kc} \quad \text{Monetary units} \tag{13}$$

$$G_Q - G_R - G_T \leq \frac{1.7x10^{24} erg/seg(T_i - T_f)RT}{T_i T_f Q} \quad \text{Physical units} \tag{14}$$

3 RESULTS

We can introduce the concept of sustainability margin for both (13) and (14) as:

$$Mrg = \frac{1.7x10^{24} erg/seg(T_i - T_f)PT}{T_i T_f Kc} - G_{Kc} + G_P + G_T \quad \text{Monetary units} \tag{15}$$

$$Mrg = \frac{1.7x10^{24} erg/seg(T_i - T_f)RT}{T_i T_f Q} - G_Q + G_R + G_T \quad \text{Physical units} \tag{16}$$

A positive value for the sustainability margin will reflect compliance with the VSM.

This brings the question of, what means in economic policy making will aid stewardship of the environment and still meet the needs of the present generation?

4 DISCUSSION

A possible implication of variable T on the economic subsystem is only of greater structure differentiation from its surroundings. According to equation (14) the combination of G_Q and G_R should make a contribution to a positive sustainability margin, the same is true for G_{Kc} and G_P in equation (13).

5. CONCLUSION

The use of Ashbys viable system model aids the implementing of economic policy in accord with a view of limited world resources.

While an increase in sustainable margin is reached, a corresponding increase in entropy flow will be available for the bio-system in S.K.Lin's terms of asymmetry.

A greater diversity in the ecosystem aids greater assimilation and efficiency of solar energy although at the same time it requires or implies tighter cooperation. Accordingly, this can only be achieved by lowering the biospheres temperature of emission.

A lower temperature of emission is regarded as increasing the sustainable margin, so these three mechanisms form a virtuous cycle for the economic system with established viability in its structure

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REFERENCES

Ashby, W. Ross(1956). *An Introduction to Cybernetics*,Chapman & Hall, London, Internet (1999): http:// pcp. vub. ac. be/ books/ IntroCyb. pdf

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Kennedy, I.R.(2001). *Action in Ecosystems:biothermodynamics for sustainability*. England: Research Studies Press LTD

Lin, S.K. (1996). *Correlation of Entropy with Similarity and Symmetry* 1995 *J. Chem. Inf. Comput. Sci.* 1996, *36*, 367-376

Vildosola, L. (1991). *Economía Sintética*. RePEc
http://logec.hhs.se/scripts/paperstat.pl?h=RePEc:wpa:wuwpge:9805002

WCED(World Commission on Environment and Development)(1987). *Our Common Future.* Oxford University Press