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Sustainability as the Force that Tames an Exponentialoid

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ABSTRACT

This paper defines sustainability ‘as the force that tames an exponentialoid’, and discusses a method for better capturing multiple and complex elements that influence an exponentialoid. The concept “exponentialoid” was conceived by Born (1969), used by McHale (1978) and expanded by García Bacca (1989) to differentiate it from an exponential. An exponential is an algorithm with limited variables, whereas an exponentialoid is the term used when multiple complex forces conspire to create a growth with logarithmic properties. Population, resource consumption, and emissions generation are three examples of a logarithmic type of growth which are caused by complex forces.

If multiple forces conspire to create a growth with exponential characteristics, it can be inferred that the same multiple and complex forces must somehow conspire to tame the exponentialoid. Are the current ‘sustainable’ initiatives sufficient to tame a resource consumption exponentialoid? Sustainability cannot be looked at in isolation, (i.e. the building industry). Sustainability is not the ‘property of an object’ but falls in the domain and has the characteristics and ‘properties of a process’.

We focus on one vectorial characteristic, the sense or direction, and how it affects an exponentialoid. We found: (i) a method for understanding the Malthusian Positive Checks (MPC) regarding the population exponentialoid is transferable and useful for a better understanding of the exponentialoids of other complex systems such as building construction industry, resource consumption, and emissions generation, and therefore (ii) (artificial) sustainability can be better understood as a force that tames an exponentialoid.

Keywords: Exponentialoid, Sustainability, Emissions Generation, Resource Consumption
1.1 INTRODUCTION

This paper is a qualitative treatment of the forces that contribute to sustainability, acknowledging that a lack of matching empirical evidence places this work in the area of philosophy and not science. As philosophy, this work leads us to a framework for better understanding how to identify the general forces that affect sustainability, and the exponentialoid nature of sustainability in a post Forester era. Currently every domain and stakeholder is working from a limited world-view, although not necessarily utilizing the wrong instruments. These instruments and their contributions are significant; however the question remains if they are sufficient to tame the intended exponentialoid.

2.1 NEW UNDERSTANDING OF SUSTAINABILITY

This paper relates the protection of the environment with the unstoppable creation of built objects and asks how the building industry can make a contribution. The question, re-phrased is: How are the exponentialoids of growth tamed so that this understanding represents a sustainable preference accounting for present and long-term future welfare? To do this we must be certain that all the major elements that influence the forces which create the exponentialoid growth are accounted for and that a rational method is derived, such as Chichilnisky (1997) did with her mathematical work on the General Economy in relation to consumption.

2.2 THE CONCEPT OF SUSTAINABILITY AS THE FORCE THAT TAMES AN EXPONENTIALOID

In this paper we develop and substantiate an argument evolving from soft-systems to hard systems thinking (see Figure 460.1) We have identified the issues surrounding population, affluence, consumption, and emissions growth. We have addressed the nature of the issues as being both exponentialoid and unsustainable. Furthermore we have identified that the issues are complex and have multiple elements of influence.

From analyzing MPC we have developed a concept of how some of the complex elements of influence have, through time, appeared on the scene. Next, through a system of positive checks developed by Malthus (1983) we have noted that there was a time when nature provided forces that maintained a sustainable condition and that through human intervention the sense of those forces changed, making the natural sustainability increasingly less influential and human intervention more influential. The result has been an exponentialoid population growth. This paper substantiates the concepts preparing the way for future work: design the
system's architecture, test the system and implement the system (see Figure 460.1).

Figure 460.2 is a categorization of the systems as envisioned in this paper (adapted form Checkland 1981). The boundaries between natural and artificial systems are characterized. Figure 460.3 is a categorization of the elements of influence decision circle as envisioned for the systems architecture once the protocols are developed. This figure highlights the idea that we have two interacting systems, the natural and the artificial. Actually these are two meta-systems; therefore, we can expect a very high degree of complexity and an abundance of interstices according to Palmer (2003).

The System of Interest has been defined, as shown in Figure 460.5, by the systems objective to tame an exponentialoid. The containing artificial and natural environments are also identified.

![Diagram](Figure 460.1 Bridging from Soft to Hard systems of understanding (Based on Hitchins 1993))
Natural Systems

including

Boundaries

That affect

Homo Sapiens

Who create

Artificial Systems

Physical Systems (building our SOI)

Figure 460.2 Categorization of the Elements of Influence
Decision circle

Assess Elements of Influence

Identify Scale + / - Threats/Opportunities

Generate Magnitude Options

Select Option per Scale

Compare Results with Case Studies

Insert into System Architecture per Protocols

Fig. 460.3 Categorization of the Elements of Influence
Decision circle
Regarding the System of Interest, Table 460.1 identifies two prime directives, a strategy and the actors. This table is a matrix of two independent actors, Population and Building Construction with a vertical relationship as well as a horizontal relationship based on the identified items. Chichilnisky’s (1997) General Economy prime directive, “Humanity as an organism who seeks its own welfare over time” is implicitly contained in Prime Directive 1 and would be a redundancy.

<table>
<thead>
<tr>
<th>Item</th>
<th>Prime Directive 1</th>
<th>Prime Directive 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime Directive 1</td>
<td>Population</td>
<td>Building Construction</td>
</tr>
<tr>
<td>Prime Directive 2</td>
<td>Survival of the Species</td>
<td>Shelter from Adverse Environment (needs)</td>
</tr>
<tr>
<td>Strategy</td>
<td>Propagation of the Species</td>
<td>Shelter and Comfort (needs and wants)</td>
</tr>
<tr>
<td>Actors</td>
<td>Influence Total Fertility Rate</td>
<td>Demand: Anticipate needs and or react to wants for Shelter</td>
</tr>
<tr>
<td></td>
<td>Position Elements of Influence to “best” exploit fertility</td>
<td>Position Elements of Influence to “best” fulfill Demand</td>
</tr>
</tbody>
</table>

The strategy and the threats in relation to environmental rate of change and consequent adaptation rate of change are shown in Figure 460.6. Statement of Strategy (adapted from Hitchins 1993). The concern of this statement of strategy for our argument is: If our current levels of emission have already initiated a long term wave of climate change (environmental rate of change), there will be an adaptive and reactive ‘consequential adaptation rate of change’ that Building Construction needs to be aware of, in its role of fulfilling the two prime directives (see Figure. 460.6)
Population: Dynamics Demographics

Sustainability: Resources Emissions

Elements of Influence

Exponentialoid

Figure 460.4 Net Contribution Balance Using Vectors (direction, sense-positive and negative and magnitude)

Figure 460.5 System of Interest
A net contribution balance using a vectorial methodology (adapted from Hitchins 1993) for the elements of influence is presented in Figure 460.4 where the population and affluence issues need to be balanced against resources and emissions through a balance of the elements that influence an exponentialoid growth rate. The elements of influence, in the argument of this paper, form a set called ‘artificial sustainability.’

Identified threats to taming the unsustainable exponentialoid are shown in Table 460.2, Process Based Theory Symptoms (adapted from Hitchins 1993). The argument is to identify the multiple and complex elements that influence our current inadequacy of controls and a mechanism for better understanding how these elements interact with the rates of growth that cause the exponentialoid.
Table 460.2 Process Based Theory Symptoms

<table>
<thead>
<tr>
<th>Item</th>
<th>Excess</th>
<th>Inadequacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Dynamics</td>
<td>Numbers</td>
<td>Control of Total Fertility Rate</td>
</tr>
<tr>
<td>Population Demographics</td>
<td>Developing Needs/Developed Wants</td>
<td>Control of: Total Fertility Rate &amp; Rate of Affluence Growth</td>
</tr>
<tr>
<td>Resource Consumption</td>
<td>Needed for National and Organizational Survival Personal Wants, Desires</td>
<td>Control of Rate of Economic Growth</td>
</tr>
<tr>
<td>Emissions Generation</td>
<td>Existing &amp; Growth</td>
<td>Control of Rate of Emissions</td>
</tr>
</tbody>
</table>

Figure 460.8 shows the rules we are adopting in our argument. The basic premise is that the elements of influence are able to affect the rate of change. The assumption is that the elements of influence come from a certain capacity or potential for change that must be present whether it is actuated or not. Furthermore, that capacity or potential needs to be of such magnitude that it can affect the exponentialoid.

For example, current initiatives (Kyoto, EU 4/10 initiatives, Carbon Trading, LEED, BREEAM, GTool, HQE²R) form part of the elements of change, although the argument has been made that, in themselves and collectively, they do not have the capacity to affect exponentialoid growth.
The other premise is that we can discern a ‘universal’ sustainability construct (how the elements of influence affect the exponentialoid) and that the nature of the vectors can be also discerned from a world-view and can be modeled and tested.

Figure 460.9 is a Causal Loop Analysis (CLA) of the Systems of Interest (based on Hitchins 1993), indicating in bold the stronger lines of influence. This analysis shows the elements of influence that were first developed, one regarding Population and the other regarding the Industrial Revolution. Both are related to building construction; however, building construction direct elements of influence (not shown in this figure) were obtained independently through the analysis of the high rise, air conditioning and the elevator.

![Figure 460.9 Causal Loop Analyses of Systems of Interest](image_url)
2.3 SYSTEM OF VECTORS, ASSUMPTIONS, PREMISES, RULES AND RELEVANCE ISSUES

Forces in nature manifest themselves through vectors and with a “coherent system of axioms, principles and concepts through which certain conclusions or deductions may be tested and compared with experience” (adapted from Chichilnisky 1997 and García Bacca 1989). This section establishes the relevance issues, argues the principles, discusses the premises and proposes the assumptions in a coherent system (not of theory or quasi-theory but of analog thinking and with heuristics) for analyzing multiple, complex elements that influence an exponentialoid. In our case with analog thinking, not to be confused with a theory, we propose a set of assumptions, premises, principles and relevance issues as our set of rules, heuristics, to apply them.

Up to now, we have done different types of inquiry (historical, philosophical, methodological, epistemological) and now we conclude with a novel analog based on our inquiry. This analog identifies a vector field of changing sustainability forces. The hope of this paper and its legacy will be to have future research into these vectorial-like forces and be able to exploit this analog in the architecture of systems with quantifiable forces.

2.3.1 Vectors as a force of change

Vectorial concepts are presented in Cartesian terminology using two or three coordinate systems. We shall examine the vectorial characteristics of origin, direction which includes sense, and magnitude. The forces in our system representation are vectorial-like; these are the forces that induce change over time. We have identified the elements of the forces that influence change and propose that they can be characterized vectorially.

We have identified the exponentialoid as the result of these forces and in our argument we propose that this exponentialoid is also a force that is vectorial in nature. However since we do not have the origin and magnitude of forces that created change (only the sense of its direction), and we have the resulting change, namely the exponentialoid, we use the result to analyze backwards what the forces could have been and in what direction. We present this effort in an analog thought pattern, that is, the rudiment of a method, not a theory, to identify a process of quantifying the exponentialoid and its related forces.

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1 Vector calculus or vector analysis has its origins in quaternion analysis formulated by J. Willard Gibbs. Three operations are important in vector calculus: gradient: measures the rate and direction of change in a scalar field; the gradient of a scalar field is a vector field; curl: measures a vector field’s tendency to rotate about a point; the curl of a vector field is another vector field; divergence: measures a vector field’s tendency to originate from or converge upon a given point. A fourth operation, the Laplacian, is a combination of the divergence and gradient operations. There are three theorems related to these operations: Gradient theorem, Stokes’ theorem and Divergence theorem.
Origin
The point of origin in a static linear system can have the vectors superimposed or not. In this paper we assume that they all operate on the same node, for our qualitative study of the resulting net force. Origin carries the connotation that a vector may appear or disappear in the time-line construct.

That is, the forces may be dormant or potential in nature and at some point in time they become active, dynamic. At the same time, forces that are active, dynamic, may not only change direction (sense) and magnitude but may altogether cease to be active and dynamic, and revert back to a potential rather than a dynamic mode. In summary, this paper poses that through historical analysis (using CLA and other methods) the origin of forces and thus of vectors can be determined.

Direction (which includes sense)
Direction in Cartesian thinking is the location of a vector in relation to the coordinate system of space and time and in relation to other vectors and its sense. ‘Sense’ is the major focus of this paper. ‘Sense’ in the terminology of space/time is ‘now moving this way, and then moving that way’. In summary, this paper posits that through historical analysis (using CLA and other methods) the direction of forces and thus of vectors can be determined.

Magnitude
Magnitudes are conceptually presented in our argument with explanatory value. Magnitude carves out of space/form the properties of dimension, shape, substance and number. Magnitude is relegated to future research, as this may be the most complex vectorial element to uncover from a soft system on its way toward a hard system.

Based on the above framework, we propose the following coherent system for analysis:

2.3.2 Heuristic assumptions, premises, rules and relevance issues:

Assumptions:
Our analog argument proposes two assumptions:

- **Assumption One** requires that exponentialoid rate of growth is unsustainable because it is open to the infinite (Torricelli’s acceleration diagram as quoted by Chichilnisky 1997).
- **Assumption Two** requires that the exponentialoid rate of growth is affected by multiple, complex, independent forces.

Rules:
Our analog argument proposes three rules:
Rule One states that there are elements that constitute a necessary and sufficient set of accelerators of the rate of growth called 'potential growth.'

Rule Two states that there are elements that constitute a necessary and sufficient set of inhibitors of the rate of growth called 'growth modifiers.'

Rule Three states that there is a resultant vector force which is dynamic, bounded, and independent (see Principle 3); that is, the resultant of the sum of 'potential growth' and 'growth modifiers' that track the characteristics of an exponentialoid rate of growth.

Principles:
Principles are laws or heuristics to guide a process. Our argument presents five guiding principles:

Principle 1: There are two types of sustainability: Natural sustainability and artificial sustainability defined by the boundaries of nature and artificial creation.

Principle 2: Sustainability is a resultant vectorial force that acts upon an exponentialoid rate of growth.

Principle 3: The exponentialoid rate of growth is not a deterministic force but is constantly affected (modified) by the elements of influence.

Principle 4: Elements of influence are multiple and complex vectorial forces whose resultants are vectorial inhibitors (growth modifiers) and accelerators (potential growth).

Principle 5: ‘Exponentialoid’ (as defined by García Bacca 1989) is used to express a growth curve that has a ‘striving’ towards the exponential in Cartesian terminology but differs from an ‘exponential’ in that it has multiple and complex sources and therefore its behavior is different than an exponential (consequentially Principle 3).

Corollary to Principle 5: There must be a set of elements that influence sustainability with the potential capacity of taming the exponentialoid (Varignon Theorem quoted by Forrester 1968, 1971: “Effects are always proportional to their causes” which in a sense repeats Newton).

Relevance issues:
We use relevance issues as verification and justification to use analog thinking at this stage of bridging the gap of knowledge between the identified elements of influence and how they behave and the resultant exponentialoid and its purported vectorial characteristics.

Relevance issue 1: The hope is that a vectorial interpretation of the forces at work will manage to transcend its instrumental status to acquire explanatory value (Chichilnisky 1997).

Relevance issue 2: The explanatory value is through universals which are highly symmetrical and perspicuous schema (Hitchins 1993 and Palmer 2003).
• **Relevance issue 3**: The forces in Lagrange’s words (quoted by Mitcham 1994) are “the cause, whatever it may be, which impress or tends to impress upon the body to which it is supposed to be applied.” In our case, the forces are real, multiple, and complex. The body (as the recipient of the action of the forces) is the resultant exponentialoid rate of growth that is an abstract construct of experience (Popper 1959, 1972).

• **Relevance issue 4**: Artificial sustainability’s elements of influence, target the rate of growth of an exponentialoid.

### 2.4 DERIVATION OF THE VECTOR ANALOG

The logic and reasoning are derived by analyzing how ‘natural’ and then how ‘natural and artificial’ sustainability’s elements of influence affect the Total Fertility Rate manifested in an exponentialoid population growth.

#### 2.4.1 Logic and reasoning of the arguments

We first analyze the assumptions, rules and relevance issues based on MPC to showcase the logic and reasoning of the arguments. Afterwards, using the same method, we apply the same logic, reasoning, and method to the elements that influenced the industrial rate of change during the Industrial Revolution. Lastly, we use the same techniques on a composite list of elements of influence derived from the high-rise, air conditioning and the elevator to model how the elements of influence affect the rate of change of an exponentialoid.

Unfortunately, data does not readily exist that allows us to analyze how each of the elements of influence affects a particular industry or a sector or a trade such as air conditioning. Further study is required to scan historical records to discern points of origin, the direction, and the magnitude of the different inventions regarding construction.

### 3.0 CONCLUSIONS

Although growth can be manifested through algorithms such as exponentials, when the causes of growth are multiple complex forces a better method for capturing the elements that influence logarithmic growth must be used. The proposed method is derived from vector calculus and proposes that the elements that influence growth have an origin, a direction (or sense) and magnitude. Further study is required to showcase through example how these elements of influence can be found and how they affect exponential growth such as population, resource consumption and emissions generation.
4. REFERENCES