Defining the Force that Tames an Exponentialoid

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ABSTRACT

The projected growth in resource consumption and emissions generation in response to global population growth (on the short-term horizon) and especially improving standards of living (on the long-term horizon), point toward an unsustainable future within the next 75 years.

The trends are analyzed in the form of so-called “exponentialoids” as introduced by García Bacca (1989) to differentiate it from an exponential. An exponential is an algorithm with limited variables, whereas an exponentialoid is the term coined by García Bacca (1989) to denote a condition when multiple complex forces conspire to create a growth with logarithmic properties. Construction has experienced a logarithmic growth that is caused by complex forces. There are no reliable studies or system representations that predict whether the required reductions in ecological impacts can actually be realized, and if so, on what time scale.

This paper identifies and analyzes the elements that influence change in population growth to better understand the dynamics of exponentialoids. Furthermore, sustainability is defined as the force that tames an exponentialoid.

Keywords: Exponentialoid, Sustainability, Emissions Generation, Resource Consumption

1.1 INTRODUCTION

The topic of sustainability in the construction industry has been addressed from different perspective such as: economic (alluded to in the Stern Review Report 2006), economic accounting (macro-environmental-economics by Pearce 2003, 2006; nCRISP 2004); auditing sustainability in construction (Turner 2006, Pearce and Turner 1990); issues of human
capital in construction sustainability (Briscoe 2004); a European perspective on the Pearce Report by Kohler (2002, 2005, 2006) and Carassus’ (1998, 1999, 2004) meso-economy and sectors. However, these approaches do not address the challenges as framed in this series of papers.

The Forrester (1968, 1971) and Sterman (2002) models, based on such algorithms, have initial chaotic assumptions. We argue the derivation of a new definition for sustainability as the force that tames an otherwise exponentialoid growth. By observing the exponential growth of population and identifying the forces that influenced that growth, we arrive at a higher level integration of forces that are one level above algorithmic formulations (consisting of state variables, decision variables, constraints, dynamic equations and criteria).

1.2 METHOD OF ANALYSIS OF THE CHALLENGES

The issues behind population are analyzed using the arguments presented by Ehrlich (1969), Malthus (1983) and other critics. From this work we arrive at elements that influence (EoI) the growth dynamics, which are then translated into vectors. These issues are investigated by using:

- Historical literature search
- Causal Loop Analysis
- Multiple sources of evidence
- Multiple explanatory applications
- Theoretical propositions, rival explanations

2.1 RE-DEFINITION OF THE SUSTAINABILITY CONCEPT

According to Malthus (1983), nature has its own way of applying “sustainability” (controls) to population growth. Up until recently, it functioned through the conditions that caused child-birth-death, mother-birth-death, pandemics, epidemics, diseases, plagues, famine, droughts, tornados, hurricanes, and blizzards, with impetus added by human social behaviour and practices of wars, slavery, and genocide, that created a fertile ground for death, disease, and plagues (see Figure 469.1).

These forces were a form of natural ‘species’ sustainability, in a pre-modern medical, technological, and social world, among other cultural interventions. In the cold sense, nature events take no sides, have no morality, extrinsic value or ethics (as we have seen in natural catastrophes). Thus, the population curve was relatively flat for thousands of years, except for the bubonic plague that shows as a remarkable dip in an otherwise slightly slanted line; a dip that lasted approximately 400 years.
The $t_c$ (doubling time) was what is now termed ‘geological time’ that is a relatively slow time for doubling the species. Human interventions in the life-death cycle of humans, through Philosophy (science, technology etc), theology, medicine, law and the exponentialoid proliferation of other specialized knowledge areas (Kuhn’s 1962, 1976), negated nature’s sustainability processes.

Figure 469.1 Relationship of Exponentialoid growth curve and sustainability
After this global human (counter to nature’s sustainability) intervention, the population curve resumed the latent shape of an ‘exponentialoid’ a term coined in Spanish by García Bacca (1989) to depict the observable growth with multiple variable causes – Bacca further characterizes sustainability as restrained-infinite or infinite with finitude.

With no sustainable or opposite force, the typical expected growth is exponentialoid, as attested by bacterial culture and other examples in his work (McHale 1972, 1978; Born 1969) that have no ‘restraining force’. Human intervention in ‘nature’s sustainable practice, due to a concerted and global set of human centric (anthropocentric) values and interventions, allows the exponentialoid curve to become manifested. Therefore we re-define the sustainability concept as:

**Sustainability is the force that opposes an otherwise exponentialoid growth curve/force embedded in nature.**

Natural sustainability is McHale’s restraining force. First, natural sustainability and negative human behaviour kept population growth in check. Human intervention is multiple, diverse and forceful, starting circa the time of the Industrial Revolution and accelerating in Modern times, allowing population to grow unimpeded on its exponentialoid natural curve.

McHale (1972) asserts, “The exponentialoid does not grow isolated one from another, although that is how they are shown graphically.” Population growth has concomitant growth in wealth, demographics, resource consumption, material depletion, waste and pollution generation, which are also exponentialoid in nature.

According to García Bacca (1989) building construction, as well as all knowledge (and corroborated by Kuhn’s 1962, 1976, 2000) observations, sciences and technological processes follow an exponentialoid growth curve. Born (1969) stated “the process of finding and applying knowledge, seen as the enterprise of the human raze throughout large time periods, has to follow the law of exponential growth and cannot be detained.”

Based on these observations, we can examine the effects of population exponential growth, the exponentialoid nature of waste generation, resource depletion, building construction inventions, practices, processes and building construction capacity for change.

Exponentialoids are also found at a macro level. Hawking (1998) theorizes that the big bang exhibits ‘inflationary’ characteristics, meaning that the universe is expanding at an increasing rate rather than a decreasing rate.
2.2 RELATIONSHIPS BETWEEN POPULATION GROWTH, DEMOGRAPHICS AND ENVIRONMENTAL DEGRADATION

The relationships that exist between population growth, demographic demands on Natural resources and environmental degradation are complex (Raven and Berg, 2004). There are two population related drivers: First, in developing nations, the resources essential to individual survival needs are small (estimated at 20% of global resources and energy) but the large and rapidly increasing number of people (estimated at 80% of the global population) tend to overwhelm and deplete the non-renewable resources rapidly (overpopulation footprint)\(^1\).

Second, in developing and highly developed nations, the numbers of population and population growth are small relative to the total global population (estimated at 20%) but have a higher standard of living, see Figure 469.2. This higher standard of living carries a higher resource and energy consumption (estimated at 80% of the global resources and energy) producing an exponential depletion of resources with the accompanying degradation of the environment (over-consumption footprint). However, a recent event--large masses of population rapidly transitioning from developing to a developed state (estimated at an approximate annual shift of 5-10% of the global population)--further aggravates the resource consumption and environmental degradation curves, again an over-consumption footprint (Raven and Berg, 2004; Venetoulis and Talberth 2005).

\(^1\) There are renewable and non-renewable resources. For example the Sun is the renewable resource that civilization until the last three hundred years has principally depended upon for survival. This study focuses on non-renewable resources, a one-time gift, which includes minerals and fossil-fuels (coal, oil and natural gas) that are present in limited supplies and are depleted by use (mostly by developed countries). Renewable resources (trees, fishes, fertile soil and fresh water) can be used forever as long as they are not overexploited in the short term (such as by developing populations that depend on these resources for daily needs and survival). In this case even renewable resources are termed as potentially renewable.
2.3 PHASES OF POPULATION GROWTH

The population graph, when analyzed using Malthus and his critics, can be characterized by four phases. The population graph is a time-line embedding historical events on the ‘x’ axis and population numbers on the ‘y’ axis. The time-line then is more than time, it is also encompasses human history. Phase I displays a continuous gradual slope in population increase that corresponds to the living conditions of each period with their gradual advances and setbacks. Phase II displays a significant population increase attributed to improved overall living conditions after the major setback of the bubonic plague, to which as a major catastrophe, scholars attribute major structural changes in society. Phase III continues population growth but at an exponential rate, due to impressive advances based on the previous phase’s significant societal structural changes. Phase IV projects into the future the current growth path towards infinity, which scholars deem unsustainable or is moderated by forces at work within society, which, in this case, is taming the exponentialoid.

Malthusian Positive Checks (MPC) infers that natural sustainability’s suppressive forces on population increase (see MPC Phase I in Figure 469.4) were eventually negated by human advances in science and technology (MPC Phase II).

Table 469.1 Malthusian Positive Checks

<table>
<thead>
<tr>
<th>Influence/Phase</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment – Resource consumption/Climate change</td>
<td>+/-</td>
<td>-</td>
<td>-</td>
<td>-/+?</td>
</tr>
<tr>
<td>Social Urbanization</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/-</td>
</tr>
<tr>
<td>Economic Needs to Wants</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/-</td>
</tr>
<tr>
<td>Technology Infrastructure</td>
<td>N/A</td>
<td>+/-</td>
<td>-</td>
<td>-/-</td>
</tr>
<tr>
<td>Government Wars</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/+?</td>
</tr>
<tr>
<td>Education</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/-</td>
</tr>
<tr>
<td>Agriculture</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/-</td>
</tr>
<tr>
<td>Medicine - Hygiene/Disease/ Pandemics / Pestilence</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>-/+</td>
</tr>
<tr>
<td>+ (positive) Totals</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>- (negative) Totals</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>
Figure 4.2 Elements of a World-view

Population (TFR)
Population

Preliminary list of MPC elements that influence change:
Environment
- Climate change
Social
- Urbanization
Economic
- Needs to Wants
Technology
- Infrastructure
Government
- Wars
Education
Agriculture
Medicine
- Hygiene/Pandemics
- Pestilence/Disease

Building Construction
Infrastructure
Resource
Emissions
Others

Environment
Climate Change
Building

Interacts with
Partially determine
Influence
Results in

Human advances on all fronts of knowledge created a dynamic condition allowing the Total Fertility Rate to manifest its exponentialoid at the time of the Industrial Revolution (MPC Phases II and III). García Bacca (1989) introduced the exponentialoid concept that was discussed in Chapter 2 and will be elaborated in the following sections.
In MPC Phase IV we see the effects of artificial sustainability, i.e. medical and cultural methods, education and voting rights of women, migration to urban environments, concerted efforts of governments to limit population growth to one child, such as in China (Kynge 2006), increased affluence, and the influential forces of global communication (such as cross boundary national and cultural exchanges with satellite TV and radio) among others.

In the words of García Bacca 1989 and McHale (1972), “the world has shrunk exponentially with the advent of technology.” Human manipulation and control of these forces testify to the polarity of the elements of influence.

The elements identified through a literature search based on the Malthusian Positive Checks are actors, in general. Each element is a collective so that the sum of the totals in each collective has an influence on the Total Fertility Rate. However, one actor’s collective may not be sufficient to affect or alter the Total Fertility Rate such as in MPC Phase I, when Malthus (1983) theorized that high mortality ultimately kept a population increase in relatively stable form.

However, when a critical number of elements of influence coalesce in a force with particular sense, direction and magnitude, the Total Fertility Rate is sufficiently altered to result in a population growth change such as in MPC Phase II. MPC Phase II is indicative of a period with advances in medicine, agriculture, technology (more efficient and available energy sources: wood, carbon, coal, fossil fuel, gas; machinery, trains), urban living, (food, work, sanitation and potable water, resources) and other actors (such as the advent of technology and sciences.)
The potential within the Total Fertility Rate became a high birth rate with increasingly lower mortality rate – i.e. longer life with more relative affluence by larger numbers of the population, dynamics which accelerated the exponentialoid growth evidenced in MPC Phase III. MPC Phase IV, likewise, has the same elements of influence moving towards a different position resulting in a decrease in the Total Fertility Rate, and an increase in life expectancy. The decrease in the Total Fertility Rate is currently being observed in many nations.
2.4 ELEMENTS THAT INFLUENCE CHANGE IN AN EXPONENTIALOID

Population number is the measure, Total Fertility Rate is the multiplying factor, and the forces behind it are the elements of influence. A change in population number is achieved only through a change in the TFR through a change in the elements of influence’s sense, direction and magnitude. The elements of influence and the constituents of these elements appear to be vectorial. The elements of influence in population and the elements of change in industry have the same characteristics.

This paper argues that the forces that affect the building construction industry are directly related to both population numbers and increasing affluence (see Figure 469.4).

Therefore, building construction is directly affected by the elements of influence found through the Malthusian Positive Checks (MPC). Population growth and demographic migration in affluence apparently are the primary forces affecting the global economy in the twenty-first century and, by
default, building construction, resource consumption and emissions generation.

The consequences to building construction directly and indirectly through climate change are characterized in Figure 469.6.

For example, current population estimates are at 6.5 Billion. If 20% consume 80% of resources, the population estimated to be in this level of developed consumption is 1.3 Billion. However, if 10% of the developing population is migrating yearly to a developed level of consumption we have an additional 0.65 Billion (650 million) people, each year, placing demands on resources and producing emissions at the higher level. This estimate is a good approximation of reality.

Figure 469.6 World-view: Building Demand and Emissions, Resource Consumption, Climate Change
Overall economic indicators of commodities used in construction, relatively stable otherwise, are increasing at an average rate of approximately 20% yearly which tends to corroborate a higher demand on resources. The projected estimated increase in population of 3 Billion by the year 2050 (Raven and Berg 2004) add to the developing pool of people, which affects the possible future migration from “developing to developed.” Increase in affluence is attributed to global incentives by governments, non-government organizations (NGO) such as charities, philanthropies, and the United Nations, and globalization, education, and technology that promote a decrease in mortality rates and affluence increase.

3. CONCLUSIONS

In this paper we have addressed the issue of building challenges: population numbers (how population numbers have increased in a historical time line), demographics (change from developing to developed status by large segments of the population), referenced the case study of China (example of the number and demographic change affecting both resources and emissions).

We focused on the question of exponential growth, first in population and secondly in population dynamics (demographics) to understand the growth dynamics that telescope into all other areas, specifically building construction’s rate of resource consumption and emissions generation. We are confronted with a ‘pincer’, dual problem: Resources on the input and emissions on the output with strong links to population and wants.

What we found on the population growth time line is nature’s sustainability or better yet human intervention that unleashed an exponentialoid hidden in nature’s sustainability. In other words, nature had its own way of defining ‘sustainability’ – a balance between resources and conditions and population that was relatively steady for thousands of years, based on pandemics, drought, weather related disasters, etc…which human benevolent intervention (toward the human race specifically!) negated, unleashing an exponentialoid growth first in numbers and secondly in interminable wants. Then, accepting the fact that the human race has grown exponentialoid, along with greater exponentialoid wants, the adaptation of artificial methods for an artificial-sustainable future has become a necessity.

Nature has a way of interpreting ‘sustainability’ which is different than human ‘artificial-sustainability.’ Along these lines, nature’s sustainability encompasses catastrophic implications to humans such as pandemics, drought, and weather related disasters. If we have crossed a threshold of natural feedbacks and checks and balances in what we are beginning to experience as adverse climate change, then the last 3000 years are no longer benchmarks for design and construction or for human expectations.
Meanwhile industry and academia are busy with ‘transformation:’ developing so called ‘sustainable’ processes and ‘high-performance green buildings.’ It appears that we need to view artificial-sustainability with greater precision, first philosophically and then heuristically, as the force that tames an unsustainable exponentialoid and then we need to ‘look in the face’ of the magnitude of that force to be tamed and ask if our current efforts do in fact tame the exponentialoid of growth.

The Stern Review Report is the most up to date scientific and research oriented exposition and analysis of environmental issues, a milestone of human knowledge intended to marshal the necessary forces to tame an exponentialoid growth, even though they do not approach the subject in this manner. The Stern Review Report widens the debate on the environment by examining the economic ramifications that different scenarios present. The report claims that climate change could shrink the global economy by about 20% and that taking action now would cost 1% of global domestic growth. According to Tony Blair, British Prime Minister, the consequences of global warming could be “disastrous” and inaction is not an option.

“The era of procrastination, of half-measures, of soothing, and baffling expedience of delays is coming to a close. In its place, we are coming to a period of consequences”. Winston Churchill, quoted by Al Gore in “An Inconvenient Truth.”

4. REFERENCES

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