Analysis of the Forces in the Exponentialoid Growth in Construction

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ABSTRACT: The construction industry is a major contributor to emissions generation and pollution and is a main world resource consumer (prime matter, energy, labor, capital). Because of this, the industry is formulating short and long-term sustainability targets. Europe has issued long-term objectives that require huge adaptations by the industry. Voluntary incentive programs such as LEED, and all of the presently conceived conservation, green and high-performance sustainable measures including Carbon Trading strategies, even if adopted globally, are vastly insufficient to achieve the 'necessary targets' in a timely manner because of the exponentialoid nature of the problem.

This paper identifies the multiple and complex forces in the exponentialoid growth of global construction. At the front end are population (driven by need and want) and resource consumption (driven by increased affluence); at the back end is emissions generation. These forces exhibit an exponentialoid growth trend.

"Exponentialoid" is a term introduced by García Bacca (1989) to differentiate it from an exponential. An exponential is an algorithm with limited variables, whereas an exponentialoid denotes a condition when multiple complex forces conspire to create growth with logarithmic properties. This paper argues that construction is experiencing logarithmic growth in resource consumption and emissions generation caused by complex forces.

Keywords: Exponentialoid, Demographics, Resource Consumption

1.1 INTRODUCTION

According to Kuhn (1976), there are a few periods in history that deserve the label of “transforming eras,” during which circumstances change sufficiently in response to challenges to warrant a major shift of assumptions in what he calls a paradigm shift. This paradigm shift occurs when people depend on working assumptions that become so
inappropriate that they break down, to be replaced by a more appropriate set.

Building construction history is affected by internal and external forces that are characterized by long periods of stability in a paradigm, punctuated by relatively short periods of high instability (pre-paradigm shift or crisis). This exemplifies history as a staircase rather than a ramp (Kanter, 1983). The construction industry, when considering the magnitude of the challenges, is at a historical pre-paradigm threshold, a time during which, in order to surmount the crisis, an ‘exponential step’ will be needed—one that is proportional to the exponentialoid character of the challenges: population numbers and especially, demographics.

A better understanding of the needs and wants forces behind construction is essential to frame the issues behind exponentialoid growth in materials consumption and emissions generation. The latter one, emissions generation, is a force whose consequence, global climate change, has the potential to become the catalysis for ‘the transforming era’ alluded to by Kuhn (1976).

1.2 METHOD OF ANALYSIS OF THE CHALLENGES

Population growth, significant global increases in affluence, unbridled resource consumption, and environmental degradation, among others, form the complex forces that are “pushing” the industry into an uncertain future. These challenges originate from the natural environment’s internal embedded factors such as population growth, and increase in standards of living by large segments of the global underdeveloped populations, as well as external factors such as depletion of natural resources (by a growing building construction industry – 30-50% of most nations GNP) and environmental climate change1.

Rate of population growth appears to be coming under control; however, runaway increases in global affluence, environmental issues and depletion of natural resources remain unchecked, although there is growing concern and action regarding emissions. These issues are investigated by using:

- Multiple sources of evidence
- Multiple explanatory applications
- Theoretical propositions, rival explanations
- Case studies

Population has two aspects (Ehrlich 1969, Malthus 1983), the first of which is numbers, which are an estimate, derived from the population’s

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1 The earth warming theory may have a real basis considering that the years 1980 to the present are the warmest years in world-wide weather record, with 1998 being the warmest (Raven & Berg, 2004). The most comprehensive presentation of the state of the art research can be found in The Stern Review Report 2006.
rate of natural increase (which is composed of estimated births and death rates). Second, this study uses the transition or migration of a population set from a developing to a developed state, which is an even more uncertain estimate.

We argue that the exponential growths of population and demographic affluence directly translate into building construction’s rate of resource consumption and emissions generation.

2.1 THE CHALLENGE OF POPULATION GROWTH

According to the US Census Bureau International Data Base, the total world population at midyear for 2005 was estimated at 6.5 billion\(^2\), and with very optimistic rates of growth, the population in 2035 is estimated to be 8.5 billion. Other sources with a slightly different growth rate have the 2035 population estimated at 10.0 billion, while other sources using past and current growth rates show a doubling of the population to approximately 12.0 billion people by the year 2050. The characteristic J curve of exponential population growth shown in Figure 459.1 reflects the decreasing amount of time it has taken to add each additional billion people to our numbers.

Population growth is defined as the rate at which the number of inhabitants is increasing or decreasing in a given year, expressed as a percentage of the base population size. This percentage also takes into consideration the birth and death components of population growth. Most analysts predict a decrease in the population growth rate toward the end of the century (see Figure 459.2).

According to Davis (1999), when the world population was approximately 6 billion, there were between 1 and 2 billion buildings on earth. Using 6 people per household, Davis estimates that housing accounts for approximately half of the total buildings in existence\(^3\). A household is defined as a person, or a group of persons, who occupy a common dwelling, or part of it, for at least four days a week, and provide themselves jointly with food and other essentials for living. In other words, they live together as a unit. People who occupy the same dwelling but who do not share food or other essentials are enumerated as separate households. The dwelling unit type and quality ranges from a shantytown or slum cardboard and corrugated metal shelter, to a tepee, an igloo, a cabin, a high-rise apartment, a stand alone residence or duplex, a mansion or a palace.

McHale (1978) suggests the household unit concept as a useful unit of measure, which can be made operationally specific to different local

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\(^2\) Billion in this study is per USA standard of 1,000 (one thousand) millions and not UK standards of one 1,000,000 (one million) millions.

\(^3\) Sebestyén (1998), on the other hand estimates that “between 1/3 and 2/3 of the total building volume in any particular country is (estimated) housing and the greatest investment sub-sector of the construction industry.” Carassus (2004) estimates the size of existing global stock of built structures in 2000 at: global housing 43%, non-residential buildings 35% and civil engineering (infrastructure) 22%.
situations. The household unit mode can also be extended to the community unit, to extended kinship networks, and to other groups or settings more applicable in different social and cultural settings.

Adequate shelter (housing) is one of the core human needs, since so many of the other basic needs are satisfied in relation to the household or home – food storage and preparation (energy consumption), primary health maintenance, child care, early socialization (sense of belonging), education, storage of clothing, sleeping and resting, and of course shelter from inclement weather.

![World population (extrapolated)](image)

![World Population Increase](image)

*Figure 459.1 Predicting Population size*
McHale’s (1972, 1978) detailed studies classified nations in comparative development terms, or according to levels of living analyzed by professionals. The studies separated the world into two divisions of developed or developing and lately, third and fourth world categories have been introduced. McHale admits that within this there is considerable variance and gradation, ending up with a scale from A through E. The 1978 study includes in group A (developed) the US and USSR along with 20 other countries; Group C (developing), China along with 52 other countries; and in Group E (under-developed), India along with 36 other countries. A household of five persons per unit was chosen as typical of a medium size family unit.

For this paper, we are considering small, medium and large family sizes; thus we assume an average household family size to be six persons per family or household unit. For the purpose of this study, we have adopted the simplified developed and developing structure which conveys the transition from one scale to another.

Although the projections of net population growth (the first driving force) and assets in place are considered a soft number by most accounts (Haupt and Kane, 2000), by 2050 (a span of 45 years) the total additional demand for housing units and correspondingly other building types may approximate 2 billion\(^4\). From 2050 to 2100 (a span of 50 years), additional demand may approximate 3-4 billion before predictions call for a decrease in the population growth rate (see Figure 459.3). However, the UN has issued a 2002 population report with different long-term implications.

Wattenberg, B. (2005) states that prior to 2002 the UN assumed that worldwide population growth would slow to about 2.1 children per woman. New UN projections assume a TFR (Total Fertility Rate) of 1.85. The TFR of what the UN considers the More Developed Countries (basically the countries thought of as the “West” and Japan) is 1.6, well below replacement rate\(^5\) (see Fig. 459.1-3).

However recently (Financial Times, 09/13/05), countries such as Japan, France and Germany with severe declining population growth are considering implementing governmental economic programs to benefit families with children! How this will play into the predictions, pending governmental approvals and implementation, is to be seen and will be the subject of additional studies. Pearce 2006 states that “work at the World Bank suggests that even quite low rates of population growth – a little over 1% per annum – can threaten sustainability.”

\(^{4}\) This may be difficult to achieve considering that according to Sebestyén (1998) “the gross amount of housing available can be increased by a rate of only 2-3% per year, the net increase (i.e. new housing minus demolition) is even smaller. However this hypothesis has been overturned by the recent explosive increase in housing in China which is estimated at 33% for the years 2004 and predicted for 2005, although there is no indication of this level of increase being sustainable in the long run.

\(^{5}\) The US has the highest rate among all these countries at 2.0, while Europe as a whole is only 1.38. Using a slightly higher TFR for Europe, or 1.45, European population is expected decline from 728 million people today to about 632 million by 2050 (FT Sept. 13, 2005).
In the final analysis, there are three major insights that can be obtained from current data and predictions. First, there is a continued population growth in this century following the ‘J’ curve before a predicted and hopeful tapering off, then becoming an ‘S’ curve. Second, most countries with a declining TFR will be looking at immigration to maintain economic growth; Third, some countries with major populations that are not prone to migration or immigration are on a fast track toward higher standards of living. These scenarios reflect demographic forces with direct impact on the aspects of construction resource consumption and emissions generation.

![Figure 459.2 Predicting Total Fertility Rate](image)

![Figure 459.3 Predicting Population per Total Fertility Rate (TFR)](image)
2.1.1 Population Numbers and Resource Consumption

Population ‘need’ and ‘want’ for shelter as well as ancillary buildings, drives the demand for construction and thus resource utilization as well as waste production. Regarding the first driving force, net population growth, Watt (2000) of the University of California-Davis, stated that he and about 100 other scholars “believe that energy (consumption) and number of births will be the two key variables in determining the character of the future.” To this statement, this study adds high-grade metallic ore resource depletion and climate change (with possible catastrophic consequences) as concomitant forces directly affecting the character of the future.

In 1992 the National Academy of Sciences and the Royal Society of London issued a statement (quoted by Speth 2005) that “if population growth continues at currently predicted levels, much of the world will experience irreversible environmental degradation and continued poverty.” This is attributed to both overpopulation and over-consumption. People overpopulation is defined as the environment worsening because there are too many people placing a demand on resources to meet basic needs. Over-consumption occurs when a population consumes too large a share of resources. According to Raven and Berg 2004, “both overpopulation and over-consumption cause pollution and degradation of the environment.”

The link between exploitation of resources, wealth and population is the subject of numerous studies. Ludwig et al. (1993) observe that the history of resource exploitation is remarkably consistent: ‘Resources are inevitably overexploited’, often to the point of collapse or extinction. This exploitation, adapted from Ludwig, has the following common features:

1. Wealth or the prospect of wealth generates the power that used to promote ‘unlimited’ exploitation of resources.
2. Large levels of natural resources mask the effects of overexploitation. Initial extractions or uses are not indicative of resource depletion until the scarcity becomes severe or irreversible.
3. The processes of using the resources usually lack control and simply replicate models therefore the extinction of one resource location is interpreted as the need to move to another.
4. Trial and error determine optimum levels of exploitation (if at all, and in the case of mineral consumption not at all).
5. The ‘more’ immediate prospect for financial gain, the greater wealth or prospect for wealth, generates greater power to facilitate unlimited exploration.

Ludwig is concerned that resource managers may be resorting to ‘magic,’ substituting the word sustainability for reality. “As long as human desires are unlimited, we shall invent magical theories (such as
sustainability) in an attempt to reconcile the irreconcilable.” If sustainability is to be more than a magic word, he feels it is essential to:

- Halt human population increase
- Reduce per capita human consumption resources

Thus the question is not ‘whether’ but ‘when’ the foreseeable permanent fossil and high-grade mineral ore depletion will occur. Likewise the question is not ‘whether’ but ‘when’ will humanity experience long term climate change (Arnell et al. 2004) producing unintentional and unforeseen catastrophes on a global scale. Watt (2000) continues, “This next paralyzing and permanent shock will not be solved by additional discoveries, redistribution patterns or economic cleverness because it will be a consequence of pending and inexorable depletion of the worlds’ conventional resources. Few economists, as of this date, can bring themselves to accept that resources are geological finite.”

The challenge of population growth by itself puts pressure on building construction’s capacity to satisfy the numerical demand. In previous years this type of demand would be met through an increase in building activity, components or unit manufacturing, and industrial productivity. Nonetheless, the population increase challenge is still concatenated with other challenges, such as the above mentioned climate change through waste generation and the previously termed third driving force, an increase in populations seeking a higher standard of living (over-consumption) which is the next challenge to consider.

2.1.2 Standard of Living Mobility

A second driver in housing demands relates to the demographic movement of a population from needs to wants, from developing to developed, in a drive to improve the standard of living, accompanied in this case with bigger and more sophisticated housing accommodations. The goal of technology is human freedom from needs and geared towards wants. This human freedom through technology is achieved through material mastery in order to escape from the limitations of nature (Mitcham 1994). This “improving quality of life” driver is expected to continue the

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6 Deffeyes 2005, states “as of 2003, there was no major underutilized oil source left on the planet.” According to some geologists, as reported by Williams 2005, “we have discovered 94% of all available oil. Debate on the depletion of fossil fuel is well advanced and documented since it critically affects the General Economy which has been based primarily on this source of energy since the onset of the Industrial Revolution. This study uses fossil fuel depletion as an example, but will not focus on this example. Similar statements will be provided in this study regarding high-grade mineral ore exploration and consumption.

7 Improving standards of living increases consumption but generally is considered to lower the rate of births down the generational lines.

8 Raven and Berg (2004) state that “it is impossible to quantify the ‘carrying capacity’ of earth for humans in any meaningful way, in part because our impact on natural resources and the environment involves more than the number of humans. To estimate ‘carrying capacity’ for
demand for new construction well into the future. However, these projections do not take into consideration additional demand due to population shifts (immigration) from political, economic and catastrophic causes (a third driving force) that complicate and expedite the demands.

2.2 CASE STUDY: CHINA’S POPULATION AND STANDARD OF LIVING GROWTH

China is an interesting case study regarding increase in standard of living for several reasons: (i) at the present time it has close to zero population growth; (ii) its land area approximates that of the United States\(^9\), thus eliminating two variables in a comparative exercise; (iii) its recent economic growth explosion and accelerated building construction program has global repercussions that are well documented; and (iv) this accelerated growth is placing economic and structural demands on global resources that are significant and also well documented.

Case in point of a very large standard of living mobility population (the second driving force): China had a population of 1.3 Billion in 2004 (see Fig. 459.4). China’s economy has been growing at an average of more than 9.5 percent annually for the past twenty-eight years, except in 1995 it grew more than 14%. During this period, more than 400 million people have been lifted above the poverty line into middle class consumption. “Never before, has so large a country emerged so rapidly from so eviscerated an environment base.” This translates to a doubling of the economy in less than 7 years using a conservative 10% rate of growth. This information checks with published data indicating that between the years 2000-2004, the Chinese economy grew 53% (a 50% increase in two years), which roughly corresponds with a doubling of the economy in four years. The Organization for Economic Cooperation and Development, using Chinese government figures (released September 16, 2005) states that China’s economic transformation is well placed to maintain its average 9.5% growth rate of the last two decades for “some time”.

Kynge (2006) poses the strong probability that China may become the world’s largest economy by 2010 or sooner. Although this growth is fueled mainly by trade surplus and foreign investment expansion, a higher percentage is being generated every year by domestic consumption. China’s own engine of growth is primed while inflation remains low at 1.5%. The epic scale of China’s commodities and fossil fuel needs have begun to be fully appreciated only in the last three years. The same FT reports that in 1993 China became a net importer of oil. In 2003 it overtook Japan, and in 2006 it is second to the United States as an importer of oil. The rate of imported oil continues to rise and in 2030 it will import 80% of

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\(^9\) China’s total area is 9,596,960 sq. km. compared to the US 9,629,091 sq. km.
its projected oil needs, which equals the total oil consumed by all other nations combined.

In 1949, the number of Chinese cities with a population of more than a million was only five, and those between 500,000 and 1 million inhabitants numbered eight. In the year 2000, the numbers have risen to 40 and 53, respectively. “The investment required to settle so many people in an urban environment is impossible to calculate with any accuracy, but it is clear that worldwide demand for steel, aluminum, copper, nickel, iron ore, oil, gas, coal and many other basic materials and resources may remain strong for as long as cities in China expand at a rapid clip.” From almost no significant automobile presence in the 1960’s to 60 million in 2005 and 160 million minimum predicted by 2010, China is the fastest growing auto market in the world. By the year 2008, the FT (11/6/06) reports, China will consume more iron ore than the rest of the world together.

Kynge (2006) provides an in-depth analysis of the forces behind China’s growth, the potential of an extremely large population with barely minimum global poverty wages and the advanced tools of the Industrial Revolution, capable of an unheard of productivity across all segments of manufacturing and even service industries. “With the need to create 24 million new jobs each year just to keep up with population growth, is a nightmare of epic proportions”. “So while China appears to the rest of the world to be enjoying an amazing growth bonanza, the official working behind the high walls of their leadership compound in Beijing feel trapped in an endless employment crisis.” Even when the economy grows at 9 or 10 percent, it fails by a margin of several million to create the 24 million new jobs required each year. The reason for this growth is that 700 million form a pool of people that are thought to get by on less than two dollars a day. “This provides a huge pool of labor that is willing to work at pre-industrial wages in factories capable of producing goods at a speed that is many times faster than was possible during the Industrial Revolution in England some 230 years ago. The marriage of cheap labor and modern factories does much to make China competitive, and the competitiveness justifies the huge investments required to carry forward the expansion of cities.”

China has an increasingly ageing population that may never see prosperity. Partially because of the ageing population, FT (10/06) reports that China has relaxed the one child rule and is adding a net of 7M people per year.

During 2004, China is reported to have brought 70,000 Mega watts of new capacity on-line, the amount almost equivalent to Great Britain’s entire power generating capacity, and China expects similar increases in 2006 and 2007 (Financial Times 08/10/05 by Richard McGregor, Beijing). China’s booming economy led to an increase in power consumption of about 15% in 2004 and 13% in the first six months of 2005. About 75% of this new power is consumed by new users.
Approximately 80% of this power is generated by coal, although nuclear power plants, now under construction, will affect the ratio. To put this in perspective, the same sources state that China still has more than 400 million inhabitants without power, approximately double the size of the United States population (Morrison, Dyer, FT 5/10/06).

Even more, in a country where the net population growth in recent years is zero (see Figure 459.4), growth in new housing construction was approximately 33% in 2004 and is expected to continue into the foreseeable future. This translates to a doubling of new house construction in approximately less than two years! The price increases (doubling of mineral resources and fossil fuels) experienced globally (see sample below) in the last two years (2003-2004), and the related demands on resources, are being attributed by economists to the first doubling of this building construction economy. Economies contain two sorts of activity: tradable (manufacturing and services that can be supplied at a distance) and non-tradable (haircuts, childcare, construction, and so on). With economic development, such as in China and India, productivity in tradable activity tends to rise faster than in the non-tradable. In China, the tradable activities of the last decade are the economic forces (like the 2006 soaring account surplus) pushing considerable growth in the construction non-tradable sector.

This is equivalent to a population increase of roughly 261 million people between 1995 and 2025 and a population decline of 3.7 million between 2025 and 2050. In other words, during the three decades between 1995 and 2025, China’s population will increase by a number roughly equivalent to the total population of the US, in a total area that is

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1. In contrast US annual production of new homes (National Association of Realtors) was 7.02m in 2004 and predicted to be 6.89 m in 2005, a net decrease of approximately 1.85%.
equivalent to that of the US (see Figure 459.4). However, the population and densities are considerably different: China’s population estimate (2005) is 1,306,313,812 and the US is 295,734,134 translating into a density of 136 humans per sq. km. for China vs. 28 humans per sq. km. for the US. In other words, China has approximately five times the density of the United States.

China’s population planners can do nothing about this structural increase. The problem they face is keeping fertility at the current low level. However, with China’s economic modernization, this may be an uphill battle, because in a more liberal society many Chinese might not accept the government’s strict one-child family policy. This policy has already been relaxed for parents who were single children themselves, for farmers, and for ethnic minorities. In fact, most population projections for China assume that fertility will increase slightly to the replacement level of 2.1 children per woman. Policymakers in China are of course aware of this challenge. The family planning program still has very high political priority, even under the most recent political administration.

Allen et al. (2002) discuss China’s recent dynamic economic growth. The factors that influence China’s growing economy seem to defy the factors usually associated with economic growth. “Despite its poor legal and financial systems, China has the largest and one of the fastest growing economies in the world.” The factors that seem to influence China’s economic growth include China’s culture, international trade status, and unmatched human resources pool. The lines of expansion are deep: Beijing plans by 2030 or sooner, to have laid 53,000 miles of road networks (about 10,000 more than exist in the US), along with rapid trains, cargo trains, improved port facilities, airports and airplanes, trucks and terminals. “Each year since 2004, China has installed the equivalent of all the generating capacity of a country such as Spain, and it is expected to continue repeating that feat in years to come.”

A deeper understanding of the emergence of China and India as global powers in a continually deteriorating global environment is essential. The industrialized world’s practice of unbridled consumption, pollution and cleaning up later testifies that no developed economy has succeeded in containing its impacts: it remains steps behind the problems it creates. Furthermore, developed and now developing countries externalize the growth problems to others. The approach to local consumption and exports by China is the opposite to that of Japan. Once an item begins successful and profitable mass production in China, the local market becomes saturated with producers driving down local margins and saturating local demand for the product. Japanese companies are known for financing their forays into export markets by charging more for their products at home than they do abroad. Chinese corporations do just the opposite; many export as a means of staying afloat at home.

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11 David League writing in the International Herald Tribune, June 4-5, 2005 “the total for rent Real Estate deals in the first quarter of this year (2005) exceeded $300 B, according to Government figures.”
Today’s industrialized mega-countries (such as the US, Europe, China and India) are in a highly capital-intensive socially divisive material and energy-intensive general economy where critical investments to equity compete with costly environmental and sustainable growth. For example FT (10/20/06) reports that China has seven of the world’s ten most polluted cities, 80% of the epic increase in electricity is generated by coal, the dirtiest source, and within a few years, China’s coal fired energy sector alone will turn it into the world’s leader in greenhouse emissions. In 2004, the US produced 6,000 million tons and China produced 4,300 million tons of Carbon Dioxide. A graphic projection of EIA Comparison of US and China Carbon Dioxide Emissions indicates that the year 2006 could be a milestone when China surpasses the US in greenhouse emission generation (see Table 459.1).

Table 459.1 United States and China Carbon Dioxide Emissions (millions of metric tons) Comparative Table with Projections into 2005, 2006 and 2007

<table>
<thead>
<tr>
<th>Country</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>5,807.71</td>
<td>5,912.21</td>
<td>6,016.70</td>
<td><strong>6,121.20</strong></td>
<td>6,225.70</td>
</tr>
<tr>
<td>China</td>
<td>3,897.98</td>
<td>4,707.28</td>
<td>5,516.58</td>
<td><strong>6,325.89</strong></td>
<td>7,135.19</td>
</tr>
</tbody>
</table>

With concern growing about global warming, researchers have developed a new system, Carbon Tracker, to track carbon dioxide in the atmosphere. Being able to determine where and when this major greenhouse gas increases or decreases should help in projecting future climate change and evaluating efforts to reduce releases of carbon (quoted in Peak Oil News 3/21/07).

Carbon Tracker samples the air at 20 places in the United States and 60 worldwide, with a goal of expanding that to "hundreds, maybe thousands" of sampling points. Pieter Tans, chief scientist at NOAA's Earth System Research Lab in Boulder, Colo., notes that once carbon dioxide is released into the atmosphere, it can remain there for thousands of years.

The adverse impact of growth manifested in un-historical rates of resource consumption and emissions generations, when not tempered, can be disastrous. However, China and India cannot afford to follow the industrialized countries’ model of waste and pollution followed by clean up and efficiency.

The environmental, green and sustainable movements of developed countries that happened after and during a period of wealth generation, waste and emissions generation argue for containment of waste and emissions but do not have the foresight and ability to argue for the re-invention of the waste and emissions paradigms. Sustainability is understood by the limits of existing paradigms of consumption, waste and emissions: trade, containment, and sequestration. The answers to change in this worldview are intractable and impossible unless the questions are re-invented, a new paradigm is developed, and a more accurate worldview is achieved. At the current economic growth rate,
China’s projected population of 1.45 billion in 2035 will surpass the US annual income per person of $38,000 per year (China’s is currently $5,300).

“Not enough to go around: natural resources and environmental catastrophe” is a confirmation of the premises of the paper and should be read in its entirety. The environmental degradation in China at the present time eclipses that of the Soviet Union in its worst apocalyptic scenario and is getting worse. Meanwhile, hundreds of millions of Chinese have begun to seek a new life, and many of the things they demand – fuel, metals, food, materials, and a certain quality of life – are simply not available in sufficient quantities within the boundaries of their environmentally exhausted nation. “China can drive down, through labor, the average level of working wages and the prices of manufactured products worldwide, while propelling the prices of most sources of energy and commodities through the roof. The cleavage between these areas of influence falls neatly between the things China makes and the things it needs.” Human rights in China have been redefined as “...having guaranteed access to energy. It means having petroleum to run your car.” “If the Chinese were ever to consume at the American (oil) levels of 2001, they would need to guzzle three times the world’s total consumption.” Another FT (11/8/06) report on aluminum states that in 1996, China produced 1.5 m tons compared with the US (ranked number one) production of 3.6 m tons. In 2006, China is expected to produce 9.3 m tons, compared with 2.3 m tons in the US (slipping to fourth place).

A new era in international relations has dawned, one defined by the geopolitics of scarcity. As recently as five years ago, Beijing’s leaders hardly worried about where and how their companies would secure supplies of oil, gas, and a host of traded commodities and resources. In those days, the nation’s demand, though significant, was relatively easily accommodated by world markets. But now China is the second-largest importer of oil in the world, after the United States. Its imports of aluminum, nickel, copper, and iron ore have risen from an average 7 percent of world demand in 1990 to a predicted 40% by 2010. As a result, Beijing has become anxious, in case supplies of crucial resources run out or are diverted to other countries, threatening the growth that produces the 24 million new jobs it must create every year. Thus scarcity, or finding ways to alleviate it, has in a few short years leapfrogged up Beijing’s agenda to become the key motivator of foreign and domestic policies. Kynge (2006) observes that “although trade increases the mutual economic dependence of the countries that engage in it, trade does not make the peoples of those nations any fonder of each other.

To give a sense of the magnitude and the scale of our current global trend, with the current models of consumption and the materials and energy sources available, if China were to consume oil at the rate that the US does, China would need 99 million barrels of oil per day (a figure expected to be reached in 2030) when the current global production is approximately 79 million barrels of oil (Brown, 2005a). This same principle applies to building construction materials and resources. That is a
sobering size of an ecological footprint (Venetoulis and Talberth 2005); a legacy of the systems humanity has created.

Of particular interest in Figures 459.5 & 459.6 is the shape of the curves in the oil (Deffeyes, 2005) and automobile consumption in China, pointing to a “J” curve of significant import.

The U.N. document “World Housing Conditions and Estimated Housing Needs 1965” deemed at a minimum that the need would be approximately forty seven million new housing units per year for the foreseeable future (McHale 1978). These estimates were derived from the following categorized needs:
(a) Additional dwellings needed due to population growth.
(b) New dwellings to replace obsolete housing stock (calculated on the assumption that all buildings are to be replaced after 30 years)
(c) Additional dwellings require remedying existing shortages

The U.N. document does not address the upper mobility of increased family size, changing locations, upscale drivers (more space, better quality) and others such as catastrophic events that destroy substantial building stock. Also, the U.N. document does not take into consideration the increase in affluence by large segments of the world underdeveloped population. In most economic charts and data, the global developed (affluent) population was considered to be stable.

Concatenated with housing are minimum living standards, and considered the most critical dimensions of those standards are the needs for potable water and sanitation services, as well as other infrastructure needs that are beyond the scope of this study. When theorists talk about reducing consumption, there is a danger that what is implied is the reduction or elimination of accessibility to capital for developing societies. If this is not the case, we have little option other than to grow, even though we meant no harm, a la Dr. Seuss: *I meant no harm. I most truly did not. But I had to grow bigger. So bigger I got.*

### 3 CONCLUSIONS

The absence of consensus regarding the impact of global population growth and demographics in the area of building construction compels us to treat this area of research as in an early developmental stage and with heuristics. The criticality of the issues justifies the use of heuristics to jump start the process. At this stage we have a continual competition between a number of distinct views of nature, population growth and demographics, each partially derived from and all roughly compatible with the dictates of scientific observations and methods.

However, there is an apparently arbitrary element (such as the estimates of population growth, the number of people per household, actual Total Fertility Rates, actual resource consumption in developing and developed countries per capita, the number of inhabitants moving from developing to developed status in a society, precision on the Ecological Footprint concept) compounded by personal and historical accident, which according to Kuhn (1962) “is always a formative ingredient of the beliefs espoused by a scientific community at a given time.”

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12 Potable water is an identified threatened resource. However there is a discrepancy among scientists on the effect of global warming with some stating that more moisture in the atmosphere means more rain. On the long term horizon is the relation of population numbers and water resources. If we settle with a 9 billion population or even a 6 billion population and we become accustomed to ever increasing use of water (again based on an increase in living standards worldwide) and the water resource is plentiful because of global warming, what happens when the CO$_2$ problem is resolved and the world returns to current lower levels of rainfall?
These are the soft data, the uncertainty elements, the ‘messes’ that need to be managed, the wicked problems that are in the swamp of this study, a swamp of important and real problems which require non-rigorous inquiry and philosophical analysis before we can apply the tools of science.

History suggests that the road to a firm research consensus is extraordinarily arduous. In the absence of a paradigm, all of the facts that could possibly pertain to the development of a given science are likely to seem equally relevant. As a result, early fact-finding is far more a random activity (such as it may appear in this study) than the one that subsequent scientific development makes more familiar. Early fact-finding is usually restricted to the wealth of data that lie ready-at-hand. Pre-paradigm history is immensely circumstantial in detail, heuristic if you please, only later becoming the source of important illumination.

The case study of China is critical, but it appears that other major countries, with similar population growth and demographics are following, such as India, and Mexico to a lesser extent. If Heidegger’s (1954) theory that “technology uses all of reality, more or less distinctly, as resource to uncover a kind of energy that can, at will be independently stored and transmitted (distributed)”, then the issue and challenge of finding those new sources of energy that are sustainable, clean and indefinite are real.

However equally or even more critical is the issue of emissions generation. Meanwhile, time is of the essence as population grows and moves into higher levels of consumption and waste generation, and there has been no logarithmic leap in construction on materials and processes that accompany the logarithmic leaps of population and, more recently, demographic migration from developing to developed consumption.

REFERENCES


Brown, L., R., 2005b, China Replacing the United States as the World’s Leading Consumer, Eco-Economic Update of the Earth Policy Institute.

13 Kuhn’s (1962) definition of a paradigm: “Universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners.”
Carassus, J., 2004, From the construction industry to the construction sector system, In the Construction Sector approach: An international framework, CIB, Publication 293, Rotterdam pp 5-16.


Deffeyes, K., S., 2005, Beyond Oil: The View from Hubert’s Peak, Hill & Wang, 224p.


Kuhn, T., 1976, Theory-Change as Structure-Change: Comments on the Sneed Formalism, Erkenntnis, (10)179-199


Maslow, A., H., 1968, Toward a Psychology of Being, Princeton, Van Nostrand Company


