ISSN 1804-4158

DYNAMICS OF GROWTH IN HUMAN POPULATION: THE EFFECT OF INFECTIOUS DISEASES

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ABSTRACT

In this paper, we present a new approach to modeling and analyzing the dynamics of growth in human population. Our analysis clearly shows that by now human population should have long reached and surpassed the 7 billion mark. The analysis also suggests that there possibly a whole array of factors hampering the growth of human population with infectious diseases being probably the most important one. The paper describes the most dangerous infectious diseases in human history and hypothesizes that they might be regarded as the “hidden factor” behind slowing down the exponential growth of human population. We conclude by proclaiming that infectious diseases might act as a natural mechanism of clearing out human population and therefore perform the role of the cleaning mechanism.

JEL CLASSIFICATION & KEYWORDS

■ C02 ■ I10 ■ J11 ■ Demography ■ Mathematical model ■ Population growth and dynamics ■ Infectious diseases

INTRODUCTION

Not long ago the world media announced that the human population reached the 7 billion mark [11]. Although already quite high, this figure could (and possible should) have been much higher judging by many accounts [6; 13; 14; 15].

It appears that there is some hidden factor that enters the calculations and prevents human population from growing exponentially. Tossing wars and natural disaster aside (however gruesome and unfortunate, they cannot be blamed for as major responsible factors), all evidence suggests that there must be infectious diseases that bear the whole burden of responsibility.

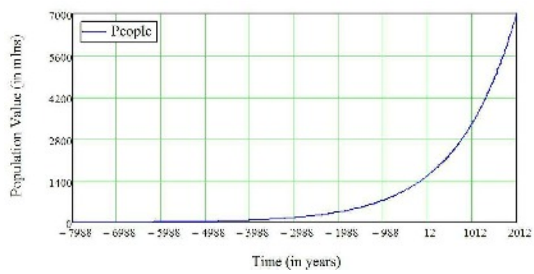
Throughout its known history, humanity has lost about million people to various infectious diseases [1; 4] and it is still counting.

Growth of human population

According to Worldometers [16], human population has grown considerably in the last two thousand years. The industrial revolution became a milestone for the giant leap in the size of world’s population. By 1800, the population of Earth had reached 1 billion [8]. It had added another billion within 130 years (1930) and the 3rd billion within the next 30 years (1959), 4th billion within 15 years (1974), 5th billion within 13 years (1987), and 6th billion within 12 years (1999). For just 40 years, from 1959 until 1999, the world’s population has doubled from three billion to six billion [13]. By many accounts, by the end of 2011 mankind will reach its 7th billion, the process taking just 12 years [6].

Today, the world’s population is growing at a rate of about 1.15% per year. The rate of growth reached its peak at the end of the 1960s, when it reached the level of 2%. The rate of population growth is due to decrease in the next few decades. However, the average annual change in population is estimated to be at a rate of more than 77 million people. It is a widely-accepted concern today that the world’s population will set itself at slightly above 10 billion after 2200 [6]. Chart 1 that follows shows the human population actual growth.

Figure 1: Growth model of world’s population from the 8000 B.C.



Source: Own calculations

As seen from the examples above, the world’s population grows at a high rate. The Malthusian law states that small populations typically grow exponentially (especially in the absence of threatening natural enemies) [7]. Applying this law to the human population would mean that mankind that lives in a comfortable built environment it has created for itself and is not threatened by any natural enemies will grow progressively and abundantly.

Calculating population growth dynamics

Assume that the world’s population is to follow the exponential growth rate *x(t)*, and by the beginning of 2012 (x_1) will reach 7 billion people (t_1). This dynamics can be expressed by the following differential equation:

$$\frac{dx}{dt} = kx, \qquad (1)$$

where k represents the coefficient of the population growth.

Using the method of division of variables we would arrive to the following solution:

$$x(t) = x_0 e^{k(t-t_0)}, \qquad (2)$$

where x_0 is the total volume of population at the initial time period t_0.

It seems logical to assume that the exponential phase in the growth of our planet’s population started at the moment the first civilizations formed themselves (i.e. mankind stepped onto the certain level of socialization that allowed for the reproduction of the human species regardless the caprices of nature). It was scientifically proven that the first civilizations on Earth were those dating back to around 8000 B.C. (e.g. Egyptian, Sumerian, Assyrian, Babylonian, Helenian, Minoan, Indian and Chinese civilizations) [12].

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Quite curiously, only Indian and Chinese civilizations have remained in existence until today, all others went extinct. This might lead to the conclusion that there was indeed a factor hampering the exponential growth of the human population throughout the ages.

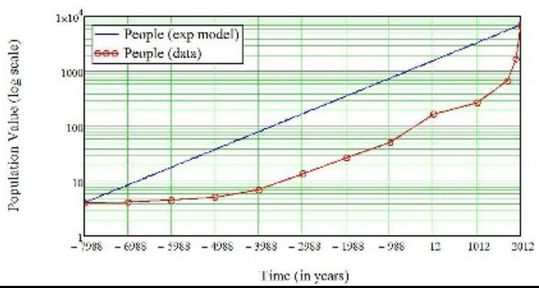
According to [8], 10 thousand years ago the population of Earth was about four million people. The initial conditions can be formalized as the following: t_0 = - 8000, x_0 = 4 million people. The coefficient of the world's population growth is equal to:

$$k = \frac{\ln(x_1 / x_0)}{t_1 - t_0} = \ln[1 + T_{ry}] = 7.46 * 10^{-4}, \qquad (3)$$

where T_{ry} is the annual growth rate of population.

A simple calculation of the annual growth rate of Earth's population in accordance with this dynamics yields the number 0.075%. This is 15 times less than the average population growth in 2010 [6].

Figure 2: Logarithmic scale of Earth's population growth (blue line – exponential model of population growth, red line – actual model built using the values from [8])



Source: Own calculations

Chart 2 depicts the logarithmic scale of the exponential dynamics and the actual dynamics built using the values of population growth starting from 8000 B.C [8]. It is obvious that there is some hidden factor preventing human population from the explosive growth.

Amongst such factors one can come up with wars, famines, natural disasters and diseases. Even though wards, famines and disasters can no doubt be gruesome and bloody, there are infectious diseases that the world accounts the most victims for [4;9]. Let us look closely at the history of some known infectious diseases to support our argument with facts and figures.

The role of infectious diseases in human population dynamics

Human history is full of infectious diseases that would leave tens of thousands and more dead. The diseases were caused either by bacterial infections or by the viral ones and humans can call themselves lucky for not dealing with the most effective killers – the most efficient diseases usually kill their hosts too quickly. And if the disease eliminates a human before it can move on, it will die out itself.

According to Jared Diamond [4], human history is full of diseases that once caused terrifying epidemics but then disappeared without a trace. The so-called "English sweating sickness" that raged in 1495-1552 and killed tens of thousands but then disappeared without a trace might be one of the examples. Another example might be the "sleeping sickness" (which became known as "Encefalitis letargica") which appeared in 1916 and quickly spread up in Europe and America. In 10 years the disease killed 10 million people but then vanished completely.

While most of the diseases caused by bacteria can be cured with antibiotics, viral diseases prove to be more dangerous and unpredictable. Viruses are so small that only the invention of electronic microscope in 1943 allowed scientist to take a good look at them. Viruses are inert and harmless in isolation but when put in action they react and multiply quickly. There 5 thousand types of viruses that are known to science: from flu and cold to smallpox, Ebola, polio and HIW. They prove to be very dangerous human killers: smallpox alone killed 300 million people on Earth in the 20th century.

The worst epidemic in history is often called "The great swine flu epidemic" or the "The Spanish flu epidemic". WWI killed 21 million people in 4 years. Swine flu did the same in its first 4 months. According to Bill Bryson [3] most 80% of American causalities in WWI came from Spanish flu (in some units the mortality was around 80%).

Swine flu arose as a normal flu in a spring of 1918 but mutated into something more severe. A smaller proportion of victims suffered only mild symptoms but the rest became very ill and quickly succumbed (their suffering lasted from several hours to several days). The first deaths in the U.S. were amongst sailors in Boston in August 1918 but the epidemic quickly spread throughout to the whole country. Between the autumn of 1918 and spring 1919 549 152 people in total died in the U.S. In Britain, the toll was 220 000 with the similar numbers of deaths in France and Germany. Some estimates put the world toll from Spanish flu at between 20 and 100 million (due to the poor statistics from the Third World).

Therefore, the role of infectious disease is devastating for human population growth. Many sources show that most of the infections diseases might put human population in great danger [2; 9]. Just recall the recent medical thrilled "Contagion" which portrayed a hypothetical disease (similar to swine flu) swiping over the world and killing millions.

Infections spread violently like zombies (or vampires) from the popular horror movies. Just to recall Romero's timeless classic "Night of the Living Dead" from 1968 or most recent Boyle's "28 days later" (or its sequel "28 weeks later"), a British parody "Shawn of the Dead", and of course "Resident Evil" and its sequels.

If scenarios shown in most of zombie films were real, pretty soon the world would have been taken by zombies. Mathematicians from the University of Ottawa claim that zombies would have eventually taken over the world unless quick and aggressive attacks are made [10]. The progression of zombie infection is fast and unless isolated, quarantined and killed, very soon everyone will become a zombie (and then dies, as far as there is nothing left to feed on). The same would hold true for the infectious diseases. Quarantine, isolation and (if available) vaccination are a must before most of the population is whipped out by a disease (or humanity becomes an endangered spices according to the IUCN definition [5]).

The role of diseases in human population dynamics and growth cannot be underestimated. Slower growth of human population than the one predicted by our mathematical models might be attributed to the existence of diseases that act as a hidden factor in human population spread over the globe. These diseases, however, might be a good thing because they keep the world from overpopulation and therefore almost sure extinction.

Conclusion

The paper analyzed the dynamics of growth of human population using the population data and statistics and applying mathematical modelling to them. Overall, it becomes apparent due to that fact that human population lives in a comfortable built environment it has created for itself and is not threatened by any natural enemies, its growth rate should have been much higher than it is today.

The analysis of available data and applying mathematical models to them reveals the fact that there has always been a hidden factor preventing human population from entering the path of exponential growth.

One possible and plausible explanation for this might be the existence of infectious diseases that act as a natural mechanism of clearing out human population. Without them the Earth would soon have been overpopulated and natural resources would soon have been exploited leading to the inevitable extinction of human population.

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