The statistician's guide to Utopia: The future of growth

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Abstract. In this article I paint a concise portrait of world economic and population history. Key factors include the world population and Gross Domestic Product (GDP). The role of technology in relation to the environmental impact of economic activity is represented by an *Environmental Efficiency Factor* (EEF). It is asserted that any modern political theory aspiring to comprehensiveness should deal with four subject matters: The legitimate level of human interference with the rest of nature; the level of the human population; the nature and extent of the economy and technology. Past GDP growth rates combined with UN population projections result in a number of scenarios of future real GDP to the year 2300. In the course of inquiry, three measures of all time economic activity are introduced: *All time world GDP per capita*, *accumulated world GDP* and the *annual growth rate of accumulated world GDP*. In conclusion, I describe under what circumstances it is conceivable that the growth economy can persist for at least 300 more years. Directions of inquiry are offered to three groups: Those who want to maintain the growth economy for as long as possible; those who want world population to stay, in the long run, at a level comparable to that of today; and those who want to minimize environmental pressure.

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1. Introduction

If we put the causes of the ecological crisis on a formula, the outcome would probably be something in the line of this:

Environmental pressure = (World population) * (Consumption/person) * x

where 'x' represents our consumption's degree of environmental impact. Now, suppose that we can replace '(Consumption/person)' with Gross Domestic Product

(GDP)[1] per capita, and reshape 'x' as an *Environmental Efficiency Factor* (EEF). The equation would then appear like this:

Environmental pressure = (World population) * (GDP per capita) * EEF[2]

During the last century, population increased by a factor of four, and GDP per capita at least by a factor of five (cf. Tables 1 and 2). World GDP, in result, increased by a factor of at least twenty. Clearly, any descriptive explanation of the rise of the ecological crisis has to take these material facts into account. But what are the long-term prospects of the growth economy? If you ask a contemporary economist, chances are (s)he will maintain that the scope of any reliable economic prediction must be limited to the very near future. As any observant reader of economic news will know, the level of economic growth is at times hard to predict even a year in advance. And still, your question wouldn't be quite as silly as it might sound. After all, how can we possibly deal with the so-called environmental problems, if we know nothing at all about the future state of the economy?

Decades after the advent of a vocabulary of environmental problems, it is evident that the effect of environmentally friendly advances in technology and lifestyle are in many fields eaten up by growth in the volume of the economy. Moreover, particular problems are often solved through means by which new, often unanticipated kinds of problems arise. There is no such thing as a problem-free technology. Since 1973, the size of the world economy has more than doubled (cf. Table 3). For how long can we expect improvements in terms of what I call the Environmental Efficiency Factor to go on?

What most economists tend to neglect is that the growth economy, considered as a historical phenomenon, has a beginning, and, in the time scale of civilizations, is likely one day to come to an end. While eternal growth might in theory be a defendable position, it definitely calls for articulated justification. All too often it is simply taken for granted that our economic system is representative of *a future without end*.

If there is one assertion mainstream economists seem to find particularly ridiculous, it is this: That growth is no longer an option. And indeed, it would be ridiculous to make such an assertion (for one example, see Goldsmith 2001). In general, assertions of this kind seem to originate from two environmentalist fallacies. First, the mistaken view that we are running out of resources. In economic terms, however, what can be used as a resource is not given *a priori*, rather, it's a matter of technology. In economic history, there is a clear tendency that more and more 'parts' of the natural environment are made use of and thus transformed into resources. Second, the mistaken view that environmental

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1 Gross Domestic Product is a standard measure of all the economic activity that takes place within a country during a year. Estimates of GDP are normally presented in nominal figures, calculated at current prices and exchange rates. In this article GDP is to be understood as real GDP, which is calculated at fixed prices. This enables us to use GDP as a tool in historical comparisons.

2 If we rearrange this equation, we see that the Environmental Efficiency Factor is defined as EEF = (Environmental pressure)/(world GDP).

problems will somehow make further growth too costly. There is not much solid evidence supporting this view. Sure, environmental costs change price formation, thus redirecting investments. But the more fundamental economic mechanisms, such as the drive for growth in the economy, are generally left intact. There are no signs that the era of the growth economy is about to end anytime soon. The end of the growth economy is not a matter of faith. It is a matter of choice. Accordingly, unless our worldviews and values change profoundly, the depletion of the natural environment is likely to deepen and broaden in scope for a long time still.

2. Matters of scale

There are at least four subject matters that any political theory aspiring to comprehensiveness should deal with, all of which are encompassed in the aforementioned equation:

– the legitimate level of human interference with the rest of nature
– the level of the human population
– the nature and extent of the economy[3]
– technology

These are all matters of scale. The significance of scale should be obvious. What is perfectly legitimate behavior at a certain population level can have disastrous consequences when carried out by ten or a hundred times as many. In general, the ecological impact of a particular pattern of behavior lies just as much in the scale of actions as in the type of behavior itself.

As initially stated by Arne Næss (1989:105–106) more than 30 years ago, it remains the case that “among activists within the ecological movement, people have been so fed up with unecological policies that the term ‘economics’ itself has become a kind of nasty word” – “nothing can be expected, think activists, from a study of economics – the economists are to be fought”. As Næss notes, it “is highly destructive to the deep ecology movement that supporters are silenced because they cannot stand up in public discussions with people who are well acquainted with economics.”[4] As I attempt to demonstrate in this article, it makes good sense to talk about long-term scenarios in statistical terms.

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[3] Basic issues of importance to the ecological crisis include traditionally anthropocentric notions such as *property* and *territory*. Cf. Tønnessen 2003:296.

[4] Deep ecology, as advocated by Arne Næss, can be summarized by means of the deep ecology platform. Cf. Tønnessen 2003, which is mainly a Uexküllian interpretation of the deep ecology platform – the term ‘Uexküllian’ here referring to the Umwelt theory and theory of meaning of the Estonian-German biologist Jakob von Uexküll (1864–1944). One of the versions of the platform appears in Næss 1993:197. As for matters of population and economy, the deep ecology platform states that “[t]he flourishing of non-human life requires a smaller human population”; that basic economic, technological, and ideological structures must be changed, and that the “resulting state of affairs will be deeply different from the present”. “The ideological change”, according to Næss, “will be mainly that of appreciating life quality rather than adhering to an increasingly higher standard of living”.

I will start by giving a brief account of the demographic and economic world history. While there can be no accurate prognosis of future GDP in the long term, past GDP growth rates, combined with UN population projections, result in a number of scenarios of future world real GDP to the year of 2300. These will further be made use of in an investigation into application of the Environmental Efficiency Factor, which should be suitable to shed light on different attitudes to technology. In the course of my research, I will present three measures of all time economic activity.

3. Population

The following population estimates and projections are taken from Kremer (1993) and the United Nations (*World Population to 2300*) respectively[5].

Table 1. World population 1 mill. B.C. – 2300, Million

		Projections		
Year	Population	Low	Medium	High
–1 000 000	0.125			
–300 000	1			
–10 000	4			
–1000	50			
1	170			
1000	265			
1500	425			
1750	720			
1900	1 625			
1950	2 516			
2000	6 100			
2100		5 500	9 100	14 000
2200		3 200	8 500	21 200
2300		2 300	9 000	36 400

After a long period of population growth at a rate previously unheard of, UN *most probably* expects the world population to stabilize at about 9 billion around the year 2070. Whereas the world population did not even double between year 1 and year 1000, in the last millennium it increased by a factor of 23. The UN expects the world population in 300 years to be somewhere in the range of 2.3 to 36.4 billion. It is worth noting that the only thing that distinguishes the high projection from the medium is an extra 0.2 children per woman. Similarly, in 300 years time 0.2 children less per woman results in a population not of 9 billion, but of 2.3 billion.

5 Up until 1950 Kremer asserts that the rate of growth of human populations was roughly proportional to their total level. 1 mill. B.C. – 1950: Kremer; 2000–2300: UN.

Observations:

1. Population growth is likely to be far slower in the 21st century than in the 20th.
2. What lifestyles and policies we carry out today and during the next few decades are crucial in determining the state of the population in 100 or 300 years.
3. From the viewpoint of the present, it seems achievable to enter a period of conscious decrease in world population at some point during the last half of this century.

4. It's the economy, stupid

In 1998 J. Bradford DeLong, a Berkeley economist and former Clinton administration advisor, wrote a draft paper entitled "Estimating World GDP, One Million B.C. – Present" (Bradford DeLong 1998). Primary economic data is drawn from *Monitoring the World Economy, l820–l992*, a publication by OECD economist Angus Maddison (1995), now an emeritus professor at the University of Groningen. DeLong's basic assumption is that the correlation between the level of wealth and population growth found in Maddison's material is no coincidence. In other words, he assumes that the rate of population growth in pre-modern history can be interpreted as a sign of a corresponding growth rate concerning wealth. DeLong takes his population estimates from the abovementioned Kremer. One adjustment is made, however. Referring to William Nordhaus (1997), DeLong states that Maddison in his approach does not take account of the additional value of new goods introduced during the last two centuries. This theoretical disparity has the consequence that while Maddison states that modern wealth in the poorest countries is comparable to that of the first centuries A.D., DeLong claims that their level of wealth is clearly above the subsistence level of earlier human societies. His preferred estimates, as a result, are significantly lower than 'Maddisonesque' estimates, which he also calculates (here referred to as 'Ex-Nordhaus').

Table 2. Annual world real GDP per capita 1 mill. B.C. – 2000, 1990 USD

Year	Ex-Nordhaus	DeLong
–1 000 000	340	92
–10 000	344	93
–800	530	143
1	404	109
350	350	94
1000	494	133
1500	512	138
1800	722	195
1900	1 263	679
1950	2 138	1 622
2000	6 103	6 539

Observations:

1. Prior to the last 500 years or so, human wealth was fairly stable at a rather low level.

2. By 1800, quite a few countries had reached a level of wealth never before experienced in the history of mankind.

3. Most of economic growth to date (considered as a rise in the level of wealth) has taken place during the 20th century.

The data in Tables 3 and 4 are taken from two more recent works by Angus Maddison (2000 and 2003).

Table 3. Annual world real GDP 1500–2000, Billion (million millions) 1990 USD

Year	GDP	Index (1500 = 1)
1500	0.24	1
1820	0.69	3
1870	1.12	5
1913	2.74	11
1950	5.37	22
1973	16.05	67
2000	36.50	152

Observations:

1. The size of the present global economy is at least 150 times that of the global economy in year 1500[6].

2. The growth of the last half millennium can be attributed to two factors: Population growth and growth in GDP per capita, both of which have contributed significantly to overall growth[7].

Table 4. Annual world real GDP per capita growth rate 1500–2000, 1990 USD

Period	Growth rate, %	Name of period
1500–1820	0.05	Proto-capitalist
1820–1870	0.56	
1870–1913	1.30	
1913–1950	0.90	Capitalist
1950–1973	2.88	
1973–2000	1.44	

[6] Note that DeLong's assumptions would result in an even more significant increase, roughly by a factor of four.

[7] In Maddison´s account these factors are of more or less equal significance; in DeLong's account GDP per capita is the most significant.

Observations:

1. The global level of wealth did not start to grow steadily until around 1820.
2. Since then, growth rates have varied in cycles of half a century or less.

5. Measures of all time economic activity

In the preceding section I referred to a few basic facts about the development of the world economy to date. However, a more careful reading is in place. First, let us calculate *all time world GDP per capita*. In other words: What is the average level of wealth for all the 70 billion people or so that have ever lived? Calculations in Tables 5 and 6 are based on DeLong's "Estimating World GDP" and Maddison 1998 (prognosis 1995–2015).

Table 5. All time world real GDP per capita 1 mill. B.C. – 2015, 1990 USD

Year	Ex-Nordhaus	DeLong
–1 000 000	341	92
–10 000	342	92
–800	351	95
1	362	97
350	362	98
1000	369	99
1500	377	101
1800	401	108
1900	436	126
1950	505	181
1995	832	510
2015	1 151	876

Observations:

1. Unlike the annual level of wealth, which has sometimes been increasing and sometimes been in decline, the all time level of wealth has probably been continuously growing for three millennia, although at first very slowly.

2. By some point during the last half of the 20th century the all time level of wealth had doubled compared to the starting point.

Next, let us consider *accumulated world GDP*. This is a measure of all economic activity that has ever taken place.

Table 6. Accumulated world real GDP 1 mill. B.C. – 2015, Billion (million millions) 1990 USD

Year	Ex-Nordhaus	Percentage of 2005-value	DeLong	Percentage of 2005-value
–300 000	84	4	23	2
–10 000	275	14	74	5
1	364	18	98	7
1000	446	22	120	9
1500	521	26	140	10
1900	733	37	212	15
2005	2 008	100	1 391	100
2015	2 509	125	1 910	137

Observations:

1. By the year 1500, the economy of the era of hunting and gathering still accounted for at least half of the economic activity that had ever taken place.

2. As of today, most of the economic activity that has ever taken place has taken place within the last century.

Finally, the *annual growth rate of accumulated world GDP* (based on DeLong's paper). In other words, an answer to the intriguing question: How much does one year of activity in the world economy amount to, in terms of all time economic activity?

Table 7. Annual growth rate of accumulated world real GDP, 10 000 B.C. – 1995

Year	Ex-Nordhaus, %	DeLong, %
–10 000	0.0006	0.0006
1	0.02	0.02
1000	0.03	0.03
1500	0.05	0.05
1900	0.4	0.7
1950	0.7	1.6
1975	1.6	3.0
1995	2.1	3.5

Observations:

1. The all time economic activities of humankind have grown progressively faster ever since the agricultural revolution.

2. Ever since some point during the 20th century, one year of economic activity has surpassed 1 % of all the economic activities that have (to that date) ever taken place.

3. Due to the (relative) stabilization of the world population, this particular growth rate can probably be expected to reach a peak at some point during the 21st century.

6. Future scenarios

Now that we have studied the past and present world economy in some detail, it's time to return to matters of the future. First, let us assume that either the highest or the lowest growth rate from 1820 onwards (referred to in Table 4) materializes once again, or the average growth rate 1820–2000. If the future world economy develops somewhat in line with what it has done in the last two centuries or so, then how wealthy will an average human being be in 100, 200 or 300 years time? Tables 8 and 9 build on Maddison 2000 and 2003[8].

Table 8. Annual world real GDP per capita 2000–2300, 1990 USD. Scenarios

Scenarios 2000–2300	Growth rate		
	Low	Medium	High
Model period	1820–1870	1820–2000	1950–1973
Annual growth rate	0.56 %	1.23 %	2.88 %
GDP per capita 2100	10 509	20 415	102 829
GDP per capita 2200	18 368	69 321	1 758 774
GDP per capita 2300	32 107	235 391	30 081 927
Index 2300 (2000 = 1)	5	39	5 004

Observations:

1. Given the lowest growth rate, the average human will reach a level of wealth comparable to that of USA today in 300 years.

2. Given the medium growth rate, the average human will reach a level of wealth comparable to that of Europe today in 100 years, and a level never before experienced in 200 to 300 years time.

3. Given the highest growth rate, the average human will reach a level of wealth never before experienced in 100 years, after which an era of true science fiction will be entered.

Second, assume that one of the three UN population projections referred to in Table 1 will actually resemble the future population development. Combined with the aforementioned estimates of future GDP per capita, these projections result in the following scenarios of future world GDP:

[8] Note again that DeLong's assumptions would result in even higher growth estimates.

Table 9. Annual world real GDP 2000–2300, Billion (million millions) 1990 USD. Scenarios

Year	Growth rate	Population		
		Low	Medium	High
2100	Low	58	96	147
	Medium	112	186	286
	High	566	936	1 440
2200	Low	59	156	389
	Medium	222	589	1 470
	High	5 628	14 950	37 286
2300	Low	74	289	1 169
	Medium	541	2 119	8 568
	High	69 188	270 737	1 094 982

Observations:

1. Given the lowest population estimate and the lowest growth rate, the size of the world economy in 2100 as well as in 2300 will be more or less comparable to that of today.

2. Given the medium population estimate and the medium growth rate, the annual size of the world economy by 2300 will be comparable to all economic activity that has (as of today) ever taken place.

3. Given the highest population estimate and the highest growth rate, the *daily* size of the world economy by 2300 will be comparable to all economic activity that has (as of today) ever taken place.

7. Technology

So far we have covered future scenarios of world population and economic growth. Where does this leave the environment? In Table 10, future technology – in a broad sense the way in which economic activity is carried out – is quantified in terms of the Environmental efficiency factor (EEF). The basic formal assumption underlying these calculations is that the environmental pressure as of year 2000 remains constant for the next three centuries. In other words:

$$\text{EEF} = 1/(\text{World GDP})$$

For reasons of readability the formula is subsequently inverted. The numbers in Table 10, in other words, express by what factor environmental efficiency (per 1990 USD of GDP) has to increase in order to keep environmental pressure constant at 2000-levels.

Table 10. Environmental efficiency factor 2000–2300
Inverted

Year	Growth rate	Population		
		Low	Medium	High
2100	Low	2	3	4
	Medium	3	5	8
	High	15	26	39
2200	Low	2	4	11
	Medium	6	16	40
	High	154	410	1 021
2300	Low	2	8	32
	Medium	15	58	235
	High	1 895	7 417	29 998

Observations:

1. Given the lowest population estimate and the lowest growth rate, $2 of future GDP must not cause more problems than $1 of GDP does today in order to keep environmental pressure constant.

2. Given the medium population estimate and the medium growth rate, $5 of future GDP in year 2100, $16 in year 2200 and $58 in year 2300 must not cause more problems than $1 of GDP does today in order to keep environmental pressure constant.

3. Given the highest population estimate and the highest growth rate, $39 of future GDP in year 2100, about $1.000 in year 2200 and about $30.000 in year 2300 must not cause more problems than $1 of GDP does today in order to keep environmental pressure constant.

8. Concluding remarks

1. Future growth is hard to predict, as is the life expectancy of the growth economy. However, there is always history. Given a low growth rate, comparable to that of 1820-1870, it is conceivable that the growth economy can persist for at least 300 more years. This presupposes a decline in world population that will leave the population of year 2300 at about a third of today's level. Even under such circumstances, $2 of future GDP would have to cause no more problems than $1 of GDP does today in order to keep environmental pressure constant.

2. Higher growth rates, such as those of 1973–2000, are likely to result in a significantly higher environmental pressure in the long run than what is the case today.

3. Those who want to sustain the growth economy for as long as possible should start to discuss what growth rate is desirable in the long run[9], and the desirability of a long-term decline in the world population.

4. Those who want the world population to stay at a level comparable to that of today in the long run should start to discuss the desirability of a shift from growth economy to a more stable economic system.

5. Those who want to minimize the environmental pressure should pay attention to both the desirability of a long-term decline in the world population and of a shift to a more stable economic system.

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[9] A 'low growth'-policy would have to include a policy of *controlled (or restricted) productivity growth*, thus changing our way of relating to technological development.