FROM OUR MEMBERS

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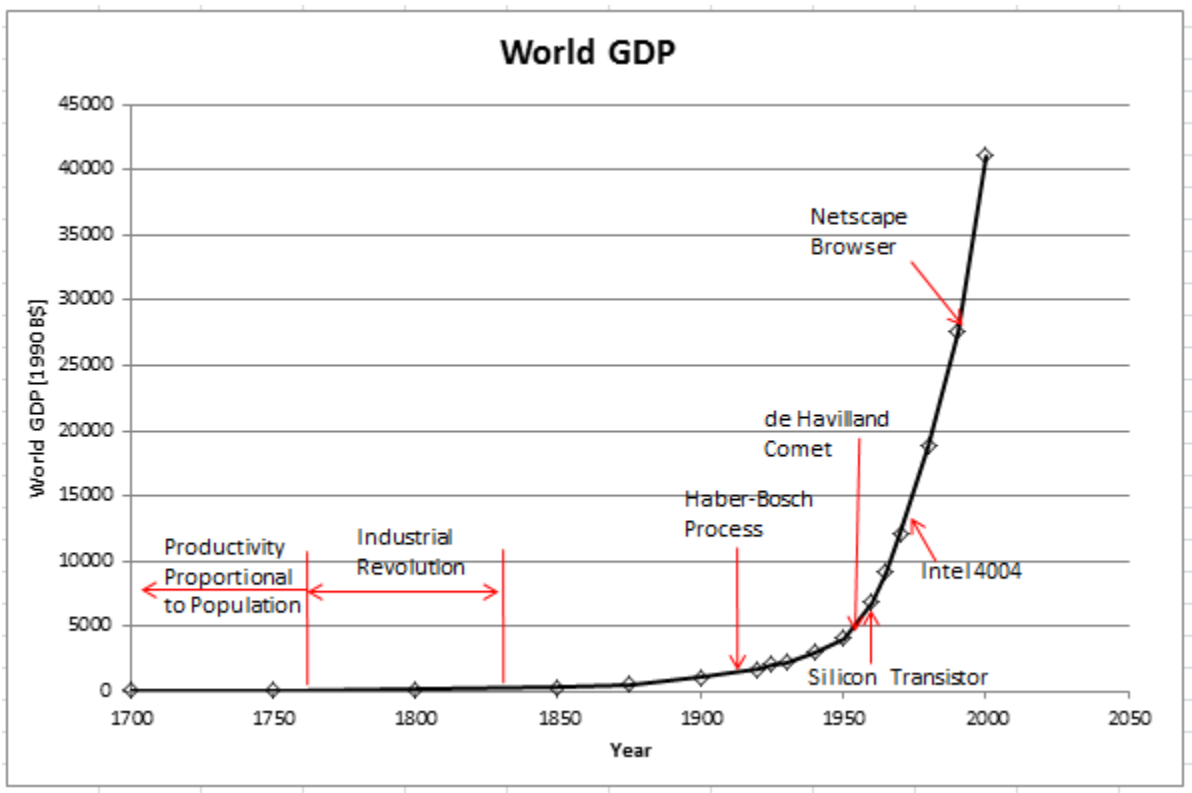
In my introduction to this column, I promised to write about engineering in terms of the parable of the blind man and the elephant. I claimed that business and economics is one of these viewpoints, and I wrote the following paragraphs to support that claim.

In the figure below, I plotted productivity (Gross Domestic Product, GDP) data provided by Bradley DeLong in his *Estimates of World GDP, One Million B.C. – Present.* Note that the GDP is in 1990 dollars.

Economists have determined that productivity through almost all of human history has primarily been determined by population size. This economic rule by population size was true until the advent of the Industrial Revolution which introduced labor-enhancing machinery. Since it takes time for any newly introduced technology to "diffuse" from isolated usage to widespread adoption throughout society, the productivity rise over succeeding years evolution after the Industrial Revolution likely reflects that diffusion.

To borrow from biology, that rise is so steep that it reminds me of the "Cambrian Explosion" of life in the geological record. To put numbers to this chart, this productivity increase of approximately 40,000 percent over the last three centuries represents only a small fraction of the history of Homo Sapiens (on the order of 0.001 percent of human history. Despite the title above, modern man has not been around 1 million years.). Productivity has redefined the human condition.

But what happened after 1950? My annotations to the timeline provide some technologies that might come to mind. The first technology that comes to mind is the rise of Chemical Engineering. The Haber-Bosch process produces artificial fertilizer from natural gas, feeding a large fraction of the world today. Next, I added first commercial passenger jet, the de Havilland Comet, to represent transportation technology. Finally, I added electronics dates for the introduction of the silicon transistor, the first commercial microprocessor and the first commercial web browser. So which technology drove this historic explosion in productivity?



Economists provide insight into this question in what they call Input-Output tables. The 1973 Nobel Prize for Economics was awarded to Wassily Leontief for inventing this method. The international set of these tables are constructed by the World Bank. For example, the entry for total output in the row titled "Manufacture of computer, electronic and optical products" was 206.9 billion US$ in 2014 and 116.0 billion US$ in 2004. I have listed the values in "current dollars" as provided in the tables, and I have not corrected to 1990 dollars (2014 dollars should be adjusted downward by the "GDP deflator."). That said, this is almost a doubling of that sector in ten years. This sector, electronics manufacturing, was 0.13 percent of world output in 2014. [Truth be told, you may notice that the WIOT data does not exactly match DeLong's data.] In any case, this table does not directly explain what inventions drove this productivity explosion. My own speculation is that the innovations of the 20th century are coupled.

Will this is whether this remarkable power law growth in productivity continue? The famous economist Robert Gordon wrote a 762 page book titled *The Rise and Fall of American Growth* in which he argues that this trend will not continue, because, to use a colloquialism, mankind has picked the low-hanging fruit.

The bottom line is that whether mankind continues upward productivity or stalls rests on the inventiveness of engineers and scientists, the types of people whose contributions, often unsung, are described in this newsletter series.