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DISCOUNTING THE FUTURE

By Herbert N. Woodward

An old folktale concerns the young man who, having performed a great service for his king, was gratefully asked by the king to name his own reward. The young man proposed that a chess board be set out and that the king should pay him an amount of corn at the rate of one kernel for the first space, doubling each space thereafter. The king gladly accepted the proposal, believing he was committing to a small price. There are 64 squares on a chess board. When one kernel was handed over for the first square, two for the second, four for the third, and eight for the fourth, the king was certain that, indeed, the cost would be low. But for the twelfth square he paid 2,048 kernels, for the 21st square he paid over a million kernels and for the 34th square the price was over eight billion kernels. Shortly thereafter, and long before all the squares had been counted, the king saw he was ruined, handed over the entire kingdom and threw himself on the mercy of the young man who had taken advantage of his ignorance of exponential arithmetic.

Today we are like this king, unconcerned or unaware that nature works by the laws of exponential arithmetic and is playing the same game with us. Growth trends accelerate so rapidly that we find it hard to believe that what we thought would be the far distant future is already upon us. Like the sorcerer's apprentice, we sense that the whole system is out of control. It is hard to understand how our world works without some feel as to what exponential (or geometrical) arithmetic is like.

In plain terms, exponential arithmetic is `compounding.' Growth is projected in the economy, in population, and in business at assumed compound rates. Business persons are accustomed to figuring the present value of a sum to be paid a number of years in the future. As an example, the standard compound interest and annuity tables tell us that the $100 we are to receive in ten years discounted at 6 percent (compounded monthly) is worth only $54.96 today. (Nature compounds not monthly, but continuously; but monthly is close.) Armed with this kind of information, the buyer and seller can determine what a purchase made in installments over a period of years is really worth now.

But when the time periods are longer than a few years, compound interest produces strange results. For example, at 6 percent assumed interest, $100 paid in 50 years is worth only $5.02 today and if it is paid in 100 years, only 25 cents. Many people now living will still be alive 50 years from now and their children and grandchildren in 100 years. But do these figures mean that what happens then has almost no significance now? I hope not, but most purely economic calculations would say `yes.'

Most economists seem to believe that growth in a capitalist system may continue indefinitely even though certain resources will become scarce. They often rely on the theory that the supply-demand system in a free market will drive up prices enough so that we will turn to substitute materials which are too expensive today. If this is true, the argument goes, even though some resources may become scare there need be no limits to growth.

Since our economic system is based on short-term considerations, however, this doesn't work well enough. Prices do not rise fast enough to anticipate when a resource is running out. Why? Because the economic system puts little value on what will happen even a few years hence, so there is little anticipation of scarcity.

We come back to exponential arithmetic. We discount the future as a matter of course in every compound interest calculation. If a growth rate is assumed at any fixed rate compounded, the growth starts slowly and then accelerates almost unbelievably — as the fabled king found to his dismay.

Today we still find it difficult to believe how small increments mount up. For example, a 3 percent annual population growth (which is currently exceeded in many countries in the less-developed world) produces a population 19 times as large in 100 years. Yet how many people would realize how fast the figures climb? Our schooling gives us no preparation for this, even though the arithmetic is simple. In the present generation, scientists in many fields are becoming increasingly aware how important mathematics is to real understanding. Projections that sound reasonable for 5 or 10 years somehow seem absurd when extended to 50 or 100 years. Here are a few examples:

Electric utilities project the demand for electricity at least ten years ahead so that they can estimate how many power plants they will need. Present ten-year projections tend to assume a growth rate of demand averaging about 5 percent per year compounded. In ten years, this figure comes to 64 percent growth. But, in 50 years growth at that rate is over 12 times the original amount, and in 100 years it is over 146 times! Obviously such rates of growth cannot be considered seriously for more than a very few years. (All power users pay the price of high projections via rate increases to provide capital funds to build the plants to satisfy the projected demand. Such projections tend to be self-fulfilling in that once the plants are built the utilities have to use high-powered advertising to sell the power they now produce, whether it is needed or not.)

The entrepreneur who plans that his business will double in size every five years (approximately 14 percent a year) probably doesn't realize that at that rate of growth, sales will be over a thousand times as large in 50 years, and over a million times as large in 100 years.

Normally we don't look that far ahead. Few economic decisions involve considerations more than five or ten years into the future. The short-sighted nature of our economic policy is the principal reason why the supply-demand system will not protect us from shortages. Price will not rise fast enough to anticipate that a resource is running out. The arithmetic (or lack of arithmetic) in our economic system encourages the attitude: *après nous le déluge.*

During periods of inflation the problem is accentuated. An increase in the compound interest rate has much more effect than one might expect. Doubling the rate from 6 percent to 12 percent, for instance, means that in 50 years a 20 times multiple at 6 percent becomes a 391 times multiple at 12 percent and in 100 years it goes from a 397 multiple at 6 percent to an almost unbelievable 153,000 times at 12 percent.

The accompanying table shows the effect of compound increases over 50 years and 100 years at a number of annual percentage rates. Particularly when we have high rates of inflation, purely monetary decisions give almost no weight to events or prospects as little as 50 years ahead, as the table clearly shows.

Advocates of continued growth point to the prospects of new discoveries of vast resources at current rates of consumption and, therefore, overestimate how long they will last. But if growth continues, even at a modest rate, supplies will be eaten up very rapidly. Because of this same exponential arithmetic, new discoveries do not extend our supplies for many centuries but for a much shorter time. As our rate of use continues to climb, we use up supplies faster and faster. Here are two examples of how this works:

(1) The ultimately recoverable amount of coal in the top 3,000 feet of the earth's crust would last about 5,000 years at the current rate of use. But if our use expands at the rate of only 4 percent per year, the same amount of coal would run out in 135 years.

(2) If we continue to use aluminum at the present rate, we have enough raw materials for 68,000 years. But at the present rate of expansion — 6.4 percent per year — we are only 140 years from exhausting the supply.[2]

Albert Bartlett capsulizes the effect of exponential arithmetic: "When consumption [of anything] grows at 7 percent per year, consumption in any decade is approximately equal to all consumption in previous history."[3] It is apparent that so long as the rate of use increases, exponential arithmetic automatically brings the future very close.

Improvements in technology cannot keep up forever at an exponential pace. Perhaps technology can keep on finding us substitutes for scarce resources but, if quality of life is not to suffer, such substitutes should be obtained at the same unit price as now prevails. Eventually, if quality of life is to improve, such substitutes must become less expensive and more available. Were this not true, there could be no real growth since it would take more effort and expense per unit to obtain the same result as today.

At this point the technological fix comes unstuck. If oil cannot be obtained from relatively shallow Arabian wells at the present estimated 50 cents a barrel cost at the well-head, but must be extracted from some relatively inaccessible place, is it reasonable to expect that it can cost *less*?

Necessarily, the giant oil companies are learning how exponential arithmetic works as they have to drill deeper and deeper to find oil, but this knowledge is hidden from most of us. Earl Cook describes it:

> *The exponential imperative, the barrier in work cost that we invariably encounter when we challenge scarcity...is well-illustrated by curves of drilling cost against depth of oil and gas wells drilled in Texas. In 1971, the drilling cost doubled with each 3,000 feet of depth. A hole drilled to 30,000 feet costs not six times more than one drilled to 5,000 feet, but 30 times more.*[4]

The oil companies rarely mention that the fuel they thus obtain will inevitably cost us that much more, although in their television commercials they applaud themselves for the great effort needed to obtain it.

Even a very low percentage of growth cannot be sustained indefinitely. Wilfred Beckerman, one of the more uncritical growth men, has stated that growth can continue at least another 2,500 years.

> *By that time, however, even if we assume only a 1 percent annual growth rate, the economy would be well over one trillion times its present size.*[5]

Continuous growth, therefore, is impossible. We must understand that it can only be a temporary phenomenon to be followed by stability or decline. It is not easy to recognize this — our whole lives cry out that it can't be true.

Ever since the eighteenth century, when the Industrial Revolution took off, growth has been the answer to every economic problem. Continuing inflation has accompanied this growth throughout this period, although at different rates at different times. Long ago we absorbed the work ethic. On top of this we have added the growth ethic. Both are now deeply embedded in our mores. ■

NOTES

1 Computations checked by Dr. John W. Legge, Chairman of the Mathematics Department at Blackburn College.
2 Robert E. Heilbroner, *Business Civilization in Decline*, New York: W.W. Norton, 1976, p.103.
3 Albert Bartlett, "Forgotten Fundamentals of the Energy Crisis," *Journal of Geological Education*, 28, 9, (1980).
4 Earl Cook in *The Sustainable Society*, Dennis Pirages, ed., New York: Praeger, 1977, p.31.
5 Jack Parsons, *The Economic Transition*, London: Conservation Trust, 1975, p.11.