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We Will Never Run Out of Resources

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The world's population has increased eightfold since 1800, and standards of living have never been higher. Despite increases in consumption, and contrary to the prophecies of generations of Malthusians, the world hasn't run out of a single metal or mineral. In fact, resources have generally grown cheaper relative to income over the past two centuries. Even on the largest cosmic scale, resources may well be limitless.

How can a growing population expand resource abundance? Some of the ways are well known. Consider increased supply. When the price of a resource increases, people have an incentive to find new sources of it. Geologists have surveyed only a fraction of the Earth's crust, let alone the ocean floor. As surveying and extracting technologies improve, geologists and engineers will go deeper, faster, cheaper and cleaner to reach hitherto untouched minerals.

Efficiency gains also contribute to resource abundance. In the late 1950s an aluminum can weighed close to 3 ounces. Today it weighs less than half an ounce. That smaller mass represents considerable environmental, energy and raw-material savings. Market incentives motivated people to search for opportunities or new knowledge to reduce the cost of an input (aluminum) to produce a cheaper output (a Coca-Cola can). Technological improvement drives a continual process whereby we can produce more from less.

Innovation creates opportunities for substitution. For centuries spermaceti, a waxy substance found in the heads of sperm whales, was used to make the candles that provided light in people's homes. Long before the whales might have run out, we switched to electricity. Are you worried about having enough lithium to power all those electric vehicles on the road? Quick-charging sodium-ion batteries are already on the horizon. There is far more sodium than lithium on or near the surface of the Earth.

We're living in an era of dematerialization. Not long ago, every hotel room in the U.S. was equipped with a thick blue copper cable to connect the guest's laptop to the internet. Nowadays guests use Wi-Fi—no cables necessary. Likewise, the smartphone has minimized, if not eliminated, the need for paper calendars, maps, dictionaries and encyclopedias as well as for metal or plastic radios, cameras, telephones, stereos, alarm clocks and more.

Perhaps less appreciated is that apart from a minuscule amount of aluminum and titanium that we have shot into outer space, all of our material resources are still here on Earth. Vast quantities of steel may have been "used" to build our skyscrapers, and copper in power cables, but all that metal could be recovered and reassigned. During World War II, 14,000 tons of silver in the U.S. Treasury's West Point Bullion Depository were made into silver wire for electromagnets as part of the Manhattan Project. Virtually all of it was eventually returned.

Common sense implies that since no physical resource is infinite, the cupboard will eventually grow bare. Given ever-increasing consumption, we will reach a level where all useful atoms are physically incorporated into objects that make life enjoyable. Won't economic growth plateau or reverse course entirely at that point? You can't have unlimited growth on a planet with a finite number of atoms. Or can you?

This argument has no bearing on any real resource issue. It invokes a hypothetical future when we are mining the Earth's very core for rare elements and draining its oceans to sustain billions of thirsty humans. This is so far in the future as not to be relevant to any present-day policies or planning. Today, the bottleneck isn't physical resources but knowledge of how to use them to our benefit. Not just theoretical knowledge but down-to-earth, practical engineering knowledge. We need to improve that as fast as we can.

For millennia, learned people and charlatans dreamed of transmuting elements. In 1919 physicist Ernest Rutherford achieved the first artificial transmutation by turning nitrogen into oxygen. Today, transmutation is all around us. Smoke detectors contain americium, an artificial element produced by transmutation. Nuclear physicists achieved the transmutation of lead into gold decades ago, though the process requires far too much energy to be a viable alternative to mining.

But the cost of energy is bound to fall. The sun is effectively a nuclear fusion reactor converting millions of tons of mass into energy every second. Someday soon we will be able to capture as much of that energy as we like via super-efficient solar panels. The difficulty won't be harvesting that energy but getting rid of waste heat by radiating it into space. We may find it more convenient to make our own fusion reactors. All the elements found on Earth other than hydrogen and helium were made by transmutation in various kinds of stars. In the distant future, we could use artificial fusion not only for energy but for artificial transmutation, to make whatever elements we like. All we need is abundant energy and hydrogen, which is plentiful in the water that covers most of the Earth's surface and is the most common element in the universe.

Long before humans have extracted all the useful atoms in the Earth's crust and oceans, we will develop the technological sophistication to obtain vastly more atoms and energy from asteroids, planets and beyond. In that future, just as has always been the case, the only bottleneck will be the rate at which new knowledge can be created. And nothing prevents us from improving that rate too. Knowledge is the ultimate resource and there are no limits on creating it.

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