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THE WORLD IS RUNNING OUT OF…NOTHING

How Incentives and Innovation Make Long-Term Commodity Shortages Scarce

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During the spring of 2017, a series of headlines blared that the world's coffee supply faced imminent doom. A slew of weather-related hardships in prime coffee-growing countries – possibly connected to climate change – were not only stressing yields in the short-term, but providing a grim preview of coffee's long-term future.

From a market perspective, perhaps this headline from Investor's Business Daily encapsulated the hysteria best: "Brewing Coffee Shortage Could Fire Up Prices 800%."

Oh wait. That was a headline from 2014. Or was it 2011? Or perhaps 2005?

Point is, this type of terminal shortage narrative seems to dog many of our most familiar, if not essential, commodities.

For those of a certain age, who can forget peak oil and the energy crisis of the 1970s? Or $147 barrels of oil in 2008, as we approached decades-old predictions about when the world would turn the corner on its existing reserves?

More recently, similar fears about price-spiking shortages and monopolies have surfaced over commodities as diverse as the rare earth metals used in our smartphones to the bananas that adorn so many countertops and cafeteria shelves across the world.

Despite these serial hysterias, none of the forecast shortages have come to pass in the long term. In fact, none seem even close to materializing today. Why not?

They answer may lie in the dueling principles at play in a now-obscure – but enormously influential – wager between an ecologist and an economist in the 1980s.

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Scarcity, Ingenuity, and the Power of Incentive

Humankind has always battled scarcity in some form or other. The theoretical expression of the idea that a society's needs could outgrow the amount of resources available to meet them – to catastrophic effect – dates back to the work of Thomas Malthus in the late 1700s.

In the boom times that followed the Second World War, however, the notion that an industrialized society could simply run out of a commodity essential to its economy and way of life probably seemed as far-fetched as the science fiction movies flying out of Hollywood during that era. However, attitudes began to change in the late 1950s and early 1960s. Not only were populations – and industrial economies – across the world growing at unprecedented rates, but the negative effects of this growth were becoming increasingly evident in the natural environment.

In 1968, Stanford ecologist Paul R. Ehrlich and his wife and Anne gave voice to the rising alarm among some scientists and academics with the publication of "The Population Bomb." In it, the Ehrlichs predicted that hundreds of millions of people would die of starvation in the 1970s and 1980s due to food scarcity. In its simplest form, the argument asserts that the world's population, if left unchecked, will grow to the point where the earth's natural resources would become too depleted to meet the population's basic needs. The book sold millions of copies worldwide, and exerted enormous influence over debates about population control, economic growth and environmental conservation for most of the next decade.

Of course, the Ehrlichs' argument was informed by their ecology training. It viewed the Earth as a closed system with largely finite resources. If those resources aren't conserved or renewed at the same rate that they are consumed, then scarcity must ensue. Economists, on the other hand, view human activity through a different set of principles. While scarcity is certainly one of those principles, many economists were skeptical of The Population Bomb's prognostications.

Among the skeptics: Julian L. Simon, who was then a professor of economics at the University of Illinois. In stark contrast to the Ehrlichs, Simon viewed population growth and increased resource consumption as positive forces for humanity, believing that, in a market environment, 1) human ingenuity could solve any problem involving resource scarcity, and 2) that any scarcity resulting from population growth would provide the proportional economic incentives to find such solutions. This would create a virtuous circle of innovation, wealth creation and population growth wherein demand continually stimulates supply, as opposed to exhausting it. If a given resource began to run short, market forces would provide the incentive to resolve the problem before the point of critical shortage. The more valuable the resource, the greater the incentive. As evidence of his theory, he pointed to the fact that commodity prices had dropped significantly and continuously over history, while increasing wealth and technological innovation had consistently raised living standards.

Looking forward, Simon believed that the twin drivers of incentive and innovation will always lead to solutions because they would spur or enable:

- The discovery of new reserves via new methods and technologies
- The development of more efficient production/extraction methods
- The discovery and/or development of substitutes
- More efficient technology on the user end
- Technology paradigm shifts that mitigate/obviate need

The competition between the contrasting views advocated by Simon and Ehrlich culminated in a public wager between the two in 1980. As part of the bet, Ehrlich was allowed to choose up to 10 commodities for which he believed prices would rise in the next decade. Simon would take the opposite side – that their prices would drop. Ehrlich selected copper, chromium, nickel, tin, and tungsten.

Simon won the bet – going away.

In each case, prices fell due to efficiency spurred by technological innovation or the incentive to find and use substitutes. Sound familiar?

WHY SIMON WON

- The price of tin went down because of an increased use of aluminum, a much more abundant, useful and inexpensive material.
- Better mining technologies allowed for the discovery of vast nickel lodes, which ended the near monopoly that was enjoyed on the market.
- Tungsten fell due to the rise of the use of ceramics in cookware.
- The price of chromium fell due to better smelting techniques.
- The price of copper began to fall due to the invention of fiber optic cable (which is derived from sand), which serves a number of the functions once reserved only for copper wire.

Source: https://en.wikipedia.org/wiki/Julian_Simon

The Green Revolution

While the tale of Simon and Ehrlich's bet provides a tidy frame for summarizing the competing arguments, it's important to note that Norman Borlaug, an American agronomist, had already spent the two decades prior to the wager effectively proving Simon's points.

Rewind to the mid-1960s, when some of the direst predictions about mass starvation due to overpopulation centered on India and Pakistan. Even Ehrlich, in the pages of The Population Bomb, asserted that India would fail to feed itself by 1970, and that the situation would be even worse by 1980.

By that time, Borlaug and his team had helped Mexico improve its food self-sufficiency by breeding innovative new strains of wheat that produced higher yields, resisted disease more effectively, and could grow in terrain within Mexico that existing varieties couldn't. Based on this success, Borlaug was invited to India and Pakistan to plant some of his new wheat varieties in 1965.

Despite a number of significant challenges – both agricultural and political – Borlaug's plantings produced yields higher than any seen previously in the region. In Pakistan, wheat yields grew from 4.6 million tons in 1965 to 7.3 million tons in 1970; yields topped 21 million tons by 2000.[1] In India, yields soared from 12.3 million tons in 1965 to 131 million tons in 1978-79.[2] By the 1980s, both countries were self-sufficient in wheat production – with India subsequently becoming a major exporter going forward.

In 1970, Borlaug won the Nobel Peace Prize for his work, and subsequently, the Presidential Medal of Freedom and the Congressional Gold Medal. It's fair to say that this "yield" surpasses the $576 dollars Simon collected from Ehrlich for winning their wager.

Borlaug's innovative, high-yield methods – so dependent on ingenuity – became known subsequently as the Green Revolution. His work has also given rise to what some have dubbed the Borlaug hypothesis: "that increasing the productivity of agriculture on the best farmland can help control deforestation by reducing the demand for new farmland." According to some estimates: the use of high-yield farming in India may have prevented an estimated 100 million acres of "virgin land from being converted into farmland—an area about the size of California, or 13.6% of the total area of India."[3]

[1] http://www.pakistaneconomist.com/issue2000/issue48/i&e1.htm
[2] http://www.indiaonestop.com/Greenrevolution.htm
[3] http://www.businessinsider.com/coffee-shortage-climate-change-2016-8

Norman, Meet Joe…

Can the principles behind Simon's Ultimate Resource and Borlaug's Green Revolution apply to the current predictions over coffee? You bet.

In fact, some of the parallels are eerily similar – starting with the notion that spiraling demand will exhaust supplies, rather than stimulate their increase.

Let's start by examining the narrative. A broad-based belief has emerged among many in the coffee market that escalating demand and the creeping effects of climate change pose an imminent and existential threat to coffee as we know it. An article published in Bloomberg Business frames the dilemma rather succinctly:

> *"Coffee crops are under siege from deforestation, abnormally high temperatures, a lack of precipitation, and disease…At the same time, global demand for the beloved beverage is expected to reach an all-time high this year, led by demand from younger American consumers. Production will need to increase at least 50 percent by the middle of this century to keep pace with the demand…"*[4]

Worse, this increase in production will need to occur during exactly the same time that 50 percent of the land that offers the requisite bioclimatic traits for growing coffee could be lost to the effects of climate change, according to a report issued in 2017 by the Climate Institute of Australia.[5] This is especially problematic for coffee because the primary varieties grown today (Arabica and Robusta) can only thrive in very specific climatological conditions.

OPTIMAL CONDITIONS FOR GROWING THE WORLD'S MOST IMPORTANT COFFEE VARIETIES

VARIETY	TEMPERATURE	ANNUAL RAINFALL	ALTITUDE
Arabica	15°C - 24°C	1500mm – 2000mm	1000m - 2000m
Robusta	22°C - 26°C	~2,000mm	0m - 800m

[4] https://www.bloomberg.com/news/articles/2017-04-28/the-scientists-fighting-to-save-us-from-a-world-without-coffee
[5] http://www.businessinsider.com/coffee-shortage-climate-change-2016-8

Unlike with wheat, for example, farmers have not had the need or incentive to develop genetic varietals that can survive in different conditions. This same lack of genetic diversity also makes coffee plants more susceptible to new diseases and pests now being given life and license by changes in climate within the current growing regions.

While the possible loss of nearly 50 percent of the world's suitable coffee land to climate change may sound astounding, there are some potentially mitigating factors. For example, only 2 percent of such land is actually dedicated to coffee production today. The remainder is largely covered by forest.[6] This suggests that even with a massive loss of territory, there might still be suitable land left to accommodate the expansion of production. However, this land may not be as productive as current areas, especially if the climate continues to warm. It's also possible that the optimal growing zones may shift upward in altitude, and that producers may be able to migrate with them. In both potential scenarios – expanding into still-suitable untapped lands and moving "upslope" into newly favorable lands - environmental groups have raised fears of mass deforestation, which in turn could accelerate climate change even more.[7]

It's also worth noting that it's not just academics and environmentalists sounding the alarm. In recent years, high-ranking officials at Starbucks,[8] LaVazza[9] and IllyCafe have publicly expressed their concerns regarding climate change's perceived threat to coffee.

These factors seem to foretell a dire future for the global supply of coffee. So, to paraphrase (and repurpose) The Population Bomb's infamous opening, is the battle to fill all of humanity's coffee mugs over? Are hundreds of millions of people doomed to muddle through each day, listless and irritable, despite any crash programs embarked upon now? At this late date, can nothing can prevent a substantial increase in the world misery rate?

Hardly.

Why? Again, the answer lies in the very demand that so many analysts and reporters are ringing their hands over. And once again, the cures are incentive and innovation.

Let's start with incentive. The global value of coffee production from 2010 to 2017 is estimated at $1.28 trillion.[10] In the U.S. alone, the total economic impact of the coffee industry in 2015 was $225.2 billion. Coffee-related economic activity comprises approximately 1.6% of the total U.S. gross domestic product. Consumers spent $74.2 billion on coffee in 2015.[11] In Brazil alone, the production value of the country's coffee crop was estimated at more than $6 billion. As demand grows, so does the opportunity associated with meeting it.

[6] https://insideclimatenews.org/news/12052017/coffee-risk-climate-change-study-forests-puerto-rico
[7] https://insideclimatenews.org/news/12052017/coffee-risk-climate-change-study-forests-puerto-rico
[8] https://www.theguardian.com/business/2011/oct/13/starbucks-coffee-climate-change-threat
[9] https://www.foodwinetravel.com.au/food/food-features/coffee-and-climate-change/
[10] World Coffee Research: The First Five Years 2012-2017
[11] http://www.ncausa.org/Industry-Resources/Economic-Impact

Where there's opportunity, innovation typically isn't far behind. Already, a number of organizations and corporations are working hard to address the potential challenges posed to future supply by climate change. And they appear to be taking their cues directly from the Green Revolution playbook.

The rise of Vietnam as a major global coffee producer is a prime example. Once barely a blip on the global scene with a modest 6,000 pounds of output in 1975, the country has grown into the second largest producer in the world in recent years, with a total of more than 3.6 billion pounds in 2016.[12] The 2018-2019 crop is expected to jump to 31 million bags, which at roughly 132 pounds apiece, would total approximately 4.1 billion pounds. The major factor driving Vietnam's ascent is its production of Robusta beans, which have gained favor among major coffee companies as a cheaper substitute for Arabica beans. Robusta beans can be grown at lower altitudes, and while they don't make for a very tasty brew on their own, they can be mixed into commercial blends with Arabica beans without notice by consumers. The ratio of production between Arabica and Robusta globally is now approximately 60 to 40.

If Vietnam embodies the Simon principles at the country level, World Coffee Research does so at the institutional level. An international coalition of scientists, research institutions, trade associations and coffee businesses (including Starbucks and IllyCafe), WCR has launched an aggressive effort to find and cross-breed plants that can thrive in more diverse environments, and put those plants in the hands of farmers on a wide scale. Working across 21 countries, WCR scientists had created 60 crosses by 2017. Part of WCR's stated goal is "to help nurseries ensure healthy and genetically pure plants, and enable the wider distribution of the best varieties."

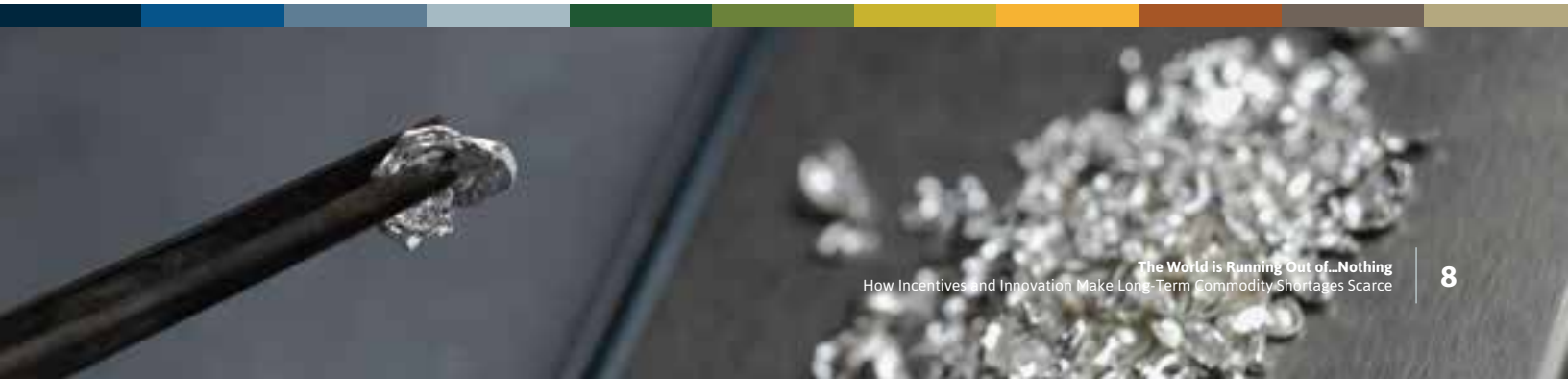
One key to achieving the goals above is to work closely with producers at the local level, according to Kraig Kraft, WCR's global programs director.

"Increased knowledge is the best tool we can put in the hands of farmers," he explains. "There may be varieties of coffee available to grow that suit a farmer's needs better than what he or she is growing now. A certain variety may be more resilient to heat or drought, grow better at the farm's altitude, or have higher potential for quality. No farmer is going to plant these varieties if he's not aware they exist, let alone understand the traits that may make them more profitable than his current crop."

To this end, WCR has complied a global catalogue of coffee varieties that aims to help farmers make more informed decisions about what to grow in the future.

Enlarging coffee's possible bioclimatic footprint through a combination of genetic innovation and producer support is one way to protect and increase coffee supply. Using innovative fertilizers and new farming techniques that incorporate them to increase yields – wherever coffee ends up growing – is emerging quickly as another. One of the companies leading this effort (perhaps not surprisingly) is the world's largest fertilizer company, Yara International. In recent years, the company has leveraged its R&D resources, partnerships and field expertise to build a coffee "innovation platform" focused on "helping coffee farmers to both increase profitability through higher yields and improve quality, while at the same

[12] https://www.worldatlas.com/articles/top-coffee-producing-countries.html



time limiting the negative environmental impact."[13] The company's agronomists work directly with family farmers in Vietnam, Tanzania, Colombia and Mexico, to understand the needs of the soil on each farm and instruct the farmers how to use their products and methods both effectively and judiciously. In Vietnam, for example, a Yara program helped farmers increase their yields and profits by 10%, while at the same time enabling them to reduce their fertilizer use by 20%.[14] In addition, program participants were able to reduce their carbon footprints by more than 50% and water usage by 40%. Thus, through widespread and efficient use of innovative fertilizer products, it would appear that coffee farmers may be able to protect their livelihoods and increase yields on their existing farms– while helping to stave off deforestation in the process. Sound familiar?

From one "black gold" to another

For those still jittery over the future of their morning fix, comfort may come from the recent saga of another ubiquitous, everyday commodity: oil.

Focus on the notion that the world may someday run out of oil began in the late 1930s thanks U.S. geologist M. King Hubbert and his concept of Peak Oil. Hubbert defined Peak Oil as the point at which half of the crude oil in the world's conventional reserves has been extracted. From here, production could only decline – even as demand from a growing population and increasingly developed global society would continue to rise. Sound familiar?

By the 1970s, it seemed like Peak Oil and its ugly aftermath were inevitable. U.S. oil production had seemed to peak in 1970 (almost to the year that Hubbert predicted it would), and the oil crisis of 1973 appeared to foretell a grim future of runaway prices, rationing and economic recession. In the following decades, anxiety about a final shortage seemed to rise with every spike in prices – even as late as 2008, when prices reached $147 a barrel. (Using Hubbert's method, economists believed that the world crude oil supply would peak around 2010.[15])

What few people realized during these tumultuous times is that the innovations required to find new reserves and extract their oil were already under development. And that all of the high prices and fears of scarcity were providing precisely the sort of incentives required to make them economically feasible and expedite their development and adoption.

Chief among these was the ability to find and extract oil and natural gas from shale deposits via hydraulic fracturing, or fracking. This innovation significantly increased world supply. Ironically, Hubbert himself had pointed the way for oil companies on how they might extract from these deposits as early as 1953. By the early 2000s, the technology and methodology were ready for broad use. "Oil prices had been about $100/bbl for several years running up to 2014," explains writer James Conca in his analysis of Peak Oil published

[13] https://www.yara.com/knowledge-grows/
[14] https://www.yara.com/news-and-media/news/archive/2014/tackling-the-coffee-challenge-in-vietnam/
[15] https://www.forbes.com/sites/jamesconca/2017/03/02/no-peak-oil-for-america-or-the-world/#4ad8348f4220

by Forbes.com in 2017. "But as shale oil began flooding the global market, the price began to fall in 2014."[16] In fact, OPEC saw this new and abundant source of oil as enough of a threat to its market domination that it increased its own production in order to drive prices down to $30/bbl – below the break-even point for American frackers. While this removed the incentive to work these new reserves in the short term, it has not removed the reserves themselves – or our ability to tap them should we need them in the future.

The upshot for consumers: not only were shortages no longer imminent, but prices had fallen to around half of the $100/bbl they had been accustomed to in the prior years.

Prior to the advances in extraction technology exerting significant force on the market, however, economic incentives were driving the search for innovation and substitutes on the user end, in classic Simon style. Engineers developed more fuel-efficient automobile technologies, including electric cars and hybrids. Many companies began converting their heavy truck fleets to run on liquefied natural gas, which is cheaper and burns cleaner than gasoline.

Should we pay attention to scarcity scares?

So, if history tells us that dire predictions of long-term commodity shortages almost never come to pass. And economics tells us that markets will always provide compelling (and perfectly proportionate) incentives to solve any potential shortage of the commodities we need. Then do we really need to pay any attention at all to the next shortage scare?

The short answer is "Yes," according to Arlan Suderman, chief commodities economist with INTL FCStone Financial Inc. That's because shortage narratives do have the power to impact prices in the short term.

"Markets are more responsive to shortage scares than ever before," explains Suderman, "and that's mostly because there is simply so much speculative money in the markets today. Speculators need an edge to make money, and they are looking farther and farther out into the future to find it."

Thus, if a report comes out forecasting a significant future shortage, and it seems credible enough, speculators will take positions against it today. This, in turn, impacts prices – today – regardless of what the current fundamentals are. And changes in prices affect everyone in a given commodity chain.

The crude oil market provides a clear example of how even the hint of a shortage can quickly lead to higher prices for end users. For consumers, how many times in the last three decades has flaring political strife in the Middle East lead to higher prices at the pump just days later? Granted, these potential shortages are not due to impending resource depletion, but they demonstrate the extent to which speculative money can swing markets in the short term.

[16] https://www.forbes.com/sites/jamesconca/2017/03/02/no-peak-oil-for-america-or-the-world/#4ad8348f4220

Consumers aren't the only losers in such scenarios. In the coffee market, producers are the most vulnerable to the effects of dubious supply information, says Albert Scalla, SVP of Trading at INTL FCStone Financial Inc.

"Brazilian exporters have agronomists on the ground who can provide accurate supply info to them. Roasters get accurate reports. And so do the commodity funds in investment community," Scalla explains. "Everyone has experts on their side but the producers, who are mostly small farmers. They are basically at the mercy of the information and forecasts contained in government and industry-group reports – and by extension, what is reported by the media."

In Scalla's experience, governments tend to under-report supply. "They think that by doing so, they will boost prices and help their home-grown producers, when the opposite is true – and everyone else in the market knows it," he explains. "Worse, this erroneous data becomes the basis of studies by academics, reports by industry groups, and news stories – which amplifies its effect.

This is important because producers use this information to decide how much coffee to produce two and three years down the line. (Newly planted coffee bushes take two-three years to yield berries.) If producers believe that a shortage is looming in the near future, and that prices will rise, they are incentivized to plant more crops. If the shortage fails to materialize, or its prospects were dubious to begin with, the market will end up being oversupplied, and prices for producers will fall – not rise.

The ill-effects of continued surpluses fall heaviest on the smallest and poorest farmers, according to WCR's Kraig Kraft. "When you have producing countries misrepresenting supply on a global scale, that has ramifications for everyone – but small farmers bear the brunt of low prices more than anyone. That's why WCR is trying to help these farmers make more informed choices now about what to grow beyond the two- to three-year crop cycle."

Scalla takes it a step further: "Absolutely, producers need better information. But the reality is that it's even better to be ignorant than to make decisions based on bad information. But more often than not, that's what producers are doing."

The right perspective

If commodity scarcity narratives can be neither trusted nor completely ignored, how should market participants approach them? Suderman has some advice:

"I see hundreds of stories and reports like this a year," he acknowledges, "and in my role, I have to give them all at least a glance. When I do come across something that I think may have some true data or market dynamics behind it, I go right to the source to evaluate its credibility and its methodology."

Specifically, Suderman considers the possible motivations that the source would have in disseminating the information, and then looks for any evidence that the conclusion was reverse-engineered to suit those motivations. Of the two facets, the methodology is more important.

"You can have a vested interest in a forecast or outcome," he says, "but still employ a sound process and produce a credible analysis. They're not mutually exclusive."

In other cases, the data and market trends underlying the analysis may be accurate, but the conclusions can be either faulty or skewed.

Scalla also focuses on methodology, and often finds it lacking.

"With coffee, you cannot just take today's production and extrapolate it out symmetrically for the next two or three years," he insists. "But that's exactly what some of these forecasts seem to do."

Of course, not everyone with commodity market exposure is a trained economist like Suderman, or a seasoned trader like Scalla. But that doesn't mean laymen can't bring a discerning eye to shortage narratives that come along. Here again, Simon's basic tenets can come in handy – in the form of questions. Specifically, does the analysis take into account the current progress toward, or the possibility of:

- The discovery of new reserves via new methods and technologies?
- The development of more efficient production/extraction methods?
- The discovery and/or development of substitutes?
- More efficient technology on the user end?
- Technology paradigm shifts that mitigate/obviate need?

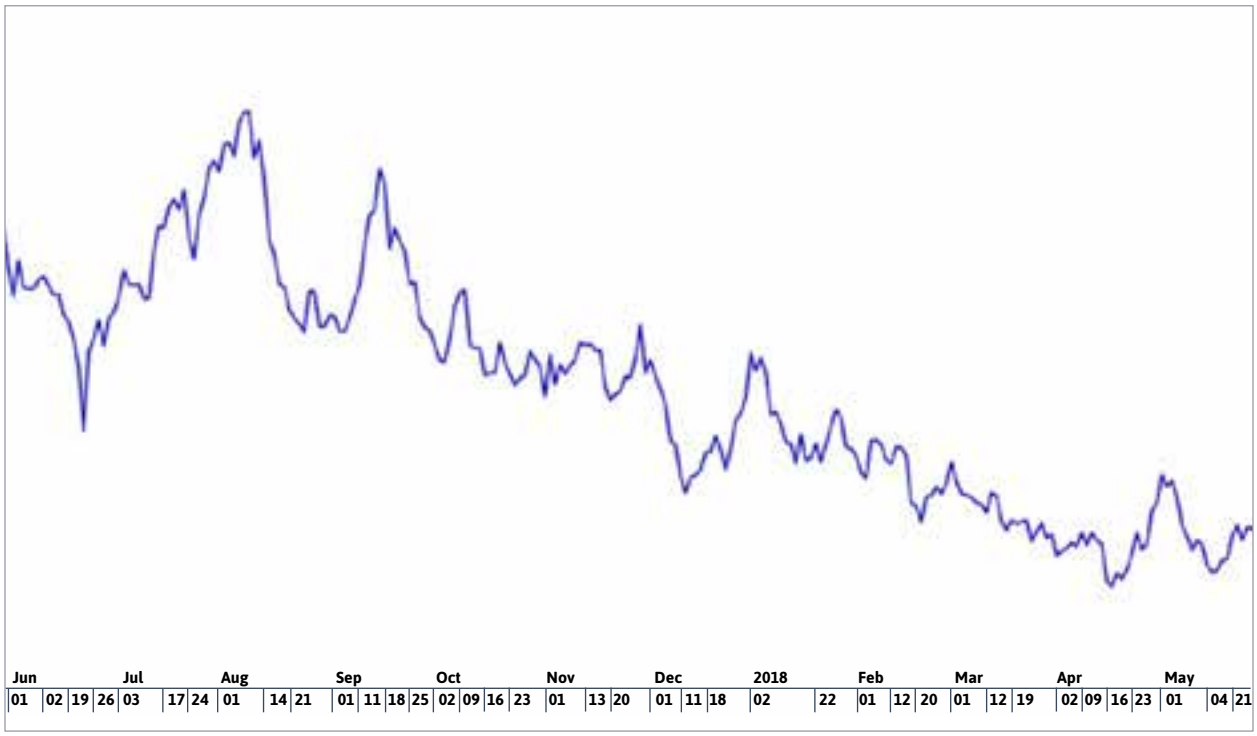
If not, then it may not be time to panic just yet.

Which brings us back to the brewing "coffee apocalypse" outlined at the top of this paper. Are we still on the precipice?

Global supplies of coffee did fall short of demand in 2014 and 2015,[17] the timeframe directly preceding the rise of the latest shortage narratives. However, supply rebounded in 2016 and 2017 – even in the face of adverse growing conditions, possibly linked to climate change, in Brazil – leading to surpluses for both years. Projections for 2018 and 2019 supply and demand also call for surpluses. And prices? Through the first half of 2018, prices are down.

[17] Annual Review 2016/2017. International Coffee Organization.

COFFEE PRICES: JUNE 2017 – MAY 2018



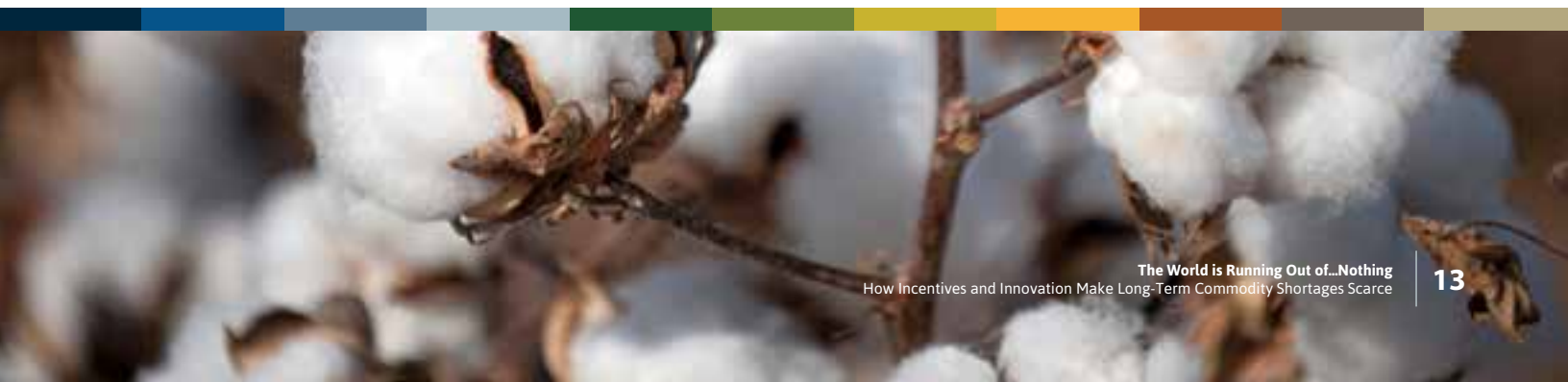
And for the other commodities mentioned above? Peak oil seems like a distant memory.

For those worried about rare earth metals, researchers recently discovered reserves that they categorized as "semi-infinite" near a small island off the coast of Japan.[18] Yes, extraction would be difficult and expensive today, but they're there for when incentive and innovation are ready to come for them.

And finally, global banana production remains robust.

All of these developments seem to suggest that, for the moment, at least, the only commodity the world is truly running out of is credible shortage scares.

[18] https://www.cnn.com/2018/04/16/asia/japan-rare-earth-metals-find-china-economy-trnd/index.html



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