

Doomslayer: Weekly Progress Roundup

Lab-grown diamonds flood the market, Japan begins moving on from Fukushima, a new technique prevents genetic diseases, and more.

MALCOLM COCHRAN
JUL 20, 2025

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Economics & Development

- A [recent national survey](#) of multidimensional child poverty in Rwanda, which took into account factors related to health, education, water, sanitation, and housing, found that **the share of Rwandan children aged 5 to 14 living in multidimensional poverty fell from 25 percent to 12 percent between 2017 and 2024.**
- According to the World Bank’s Global Findex 2025 report, **40 percent of adults in developing economies saved money in a financial account in 2024**, up from 24 percent just three years earlier.

Energy & Environment

Conservation and biodiversity

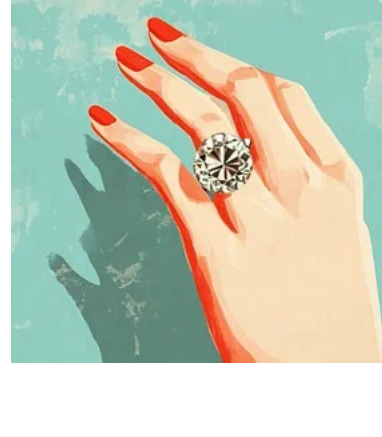
- For more than a century, **Germany’s Emscher river** carried sewage and industrial sludge through the Ruhr, earning a reputation as an open sewer. Now, after a massive cleanup, the river **is becoming a thriving ecosystem once again.**
- **5,765 hectares of new woodland** have been planted in England over the past year, 27 percent more than the year before.

Energy & Natural Resources

- Diamond mines are [floundering](#) as **lab-grown diamonds flood the market and prices plummet.** [One fifth](#) of all diamond jewelry sold worldwide is now made using synthetic stones, including most new engagement rings in the US.

From Silk Stockings to Synthetic Diamonds

MARIAN L TUPY • MAY 21



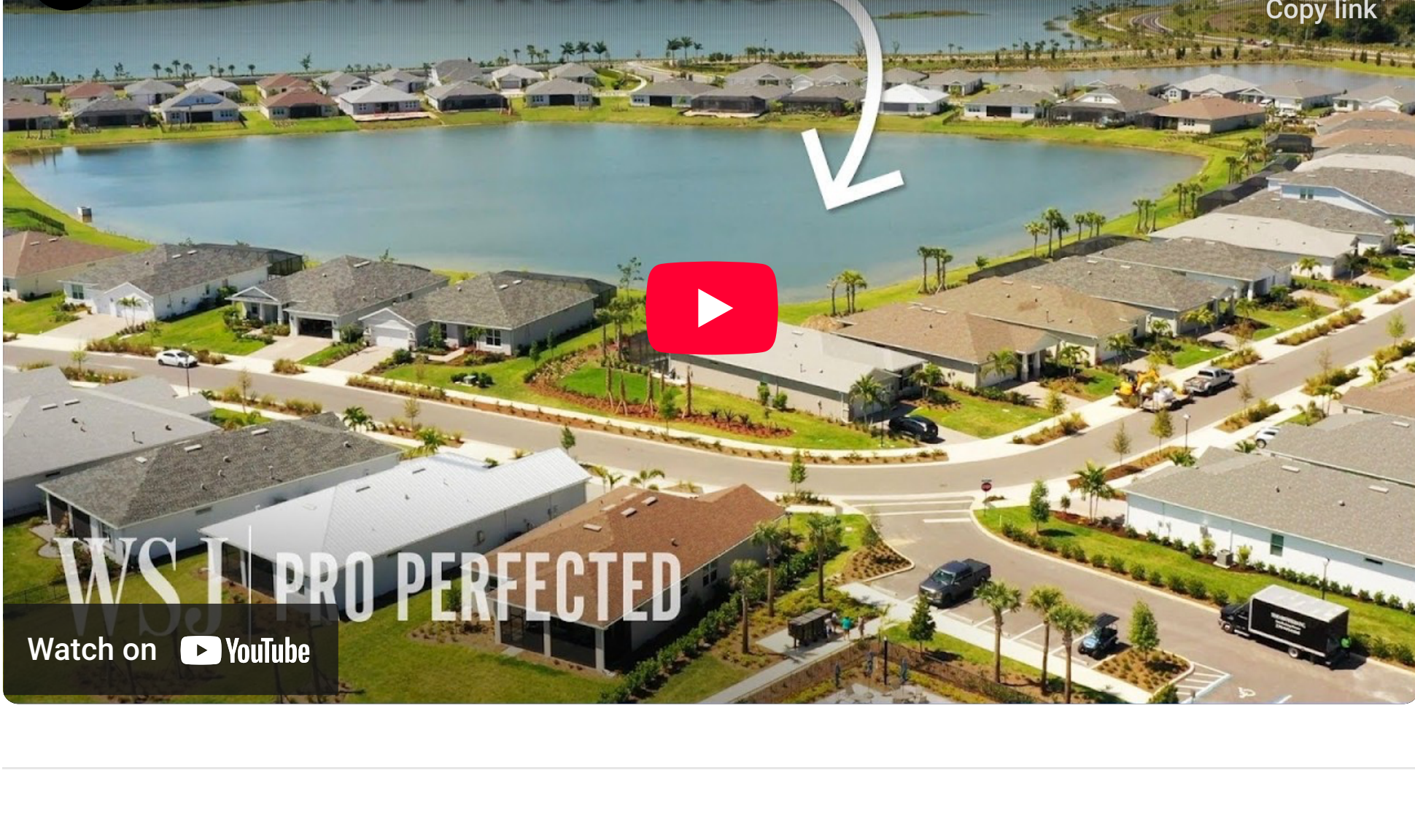
In his 1942 book *Capitalism, Socialism and Democracy*, the Austrian economist Joseph Schumpeter explained one of the most important characteristics of free market economies. He wrote:

[Read full story](#) →

- Japan’s Kansai utility is planning to [start geological surveys](#) for a new nuclear reactor. If completed, it would be the **first reactor built in Japan since the Fukushima accident.**

Natural disasters

- To help mitigate future seismic disasters, **Japan has built a sprawling undersea earthquake-detection system** capable of providing up to 20 additional minutes of warning time before tsunamis hit coastal areas. During Fukushima, residents had just 10 minutes of warning.
- **Google is using motion sensors in over two billion Android phones to detect earthquakes.** Between 2021 and 2024, [their system](#) picked up more than 11,000 tremors and now provides early warnings in 98 countries, many of which lack traditional seismometer networks.
- *The Wall Street Journal* recently spotlighted a **housing development in Florida cleverly designed to minimize the risk of flooding.** An interesting watch.



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Health & Demographics

- **Eight babies have been born in the UK using DNA from three people to prevent a deadly inherited disease.** The technique replaces faulty mitochondria from the mother’s egg with healthy ones from a donor, while keeping the parents’ nuclear DNA intact.
- In 2024, **85 percent** of infants worldwide received a **full course of the diphtheria, tetanus, and pertussis vaccine**, a slight improvement over 2023.
- Senegal has [eliminated trachoma](#) as a public health problem.

Science & Technology

- **Uber and Baidu are teaming up to bring autonomous taxis to the world.** Baidu’s robotaxis, which have already logged more than [11 million rides](#) in China, will start appearing on Uber’s app later this year across Asia and the Middle East.
- **Netflix has used generative AI in an original series for the first time.** In the Argentine sci-fi show *El Eternauta*, the company [employed AI](#) to create a building-collapse scene, completing it 10 times faster and at a lower cost than traditional visual effects would allow.

Violence & Coercion

- **Every egg-laying chicken in Sweden is now cage-free** thanks to a multi-decade persuasion campaign—**no legal ban on cages required.**

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Progress Studies

The Roots of Progress announces an impressive cohort of progress writers.



The Roots of Progress

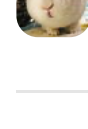
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Noah Smith comments on Javier Milei’s remarkable success in Argentina.



Noahpinion

Free-market economics is working surprisingly well

One area of seeming bipartisan consensus in America over the past decade is the idea that free-market economics — or “neoliberalism” — has failed, and that our economic system needs to be overhauled. Leftists have always believed this, of course, and in recent years they’ve been joined by more mainstream progr...

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Derek Thompson explores technology’s role in the baby boom.



Derek Thompson

What Caused the 'Baby Boom'? What Would It Take to Have Another?

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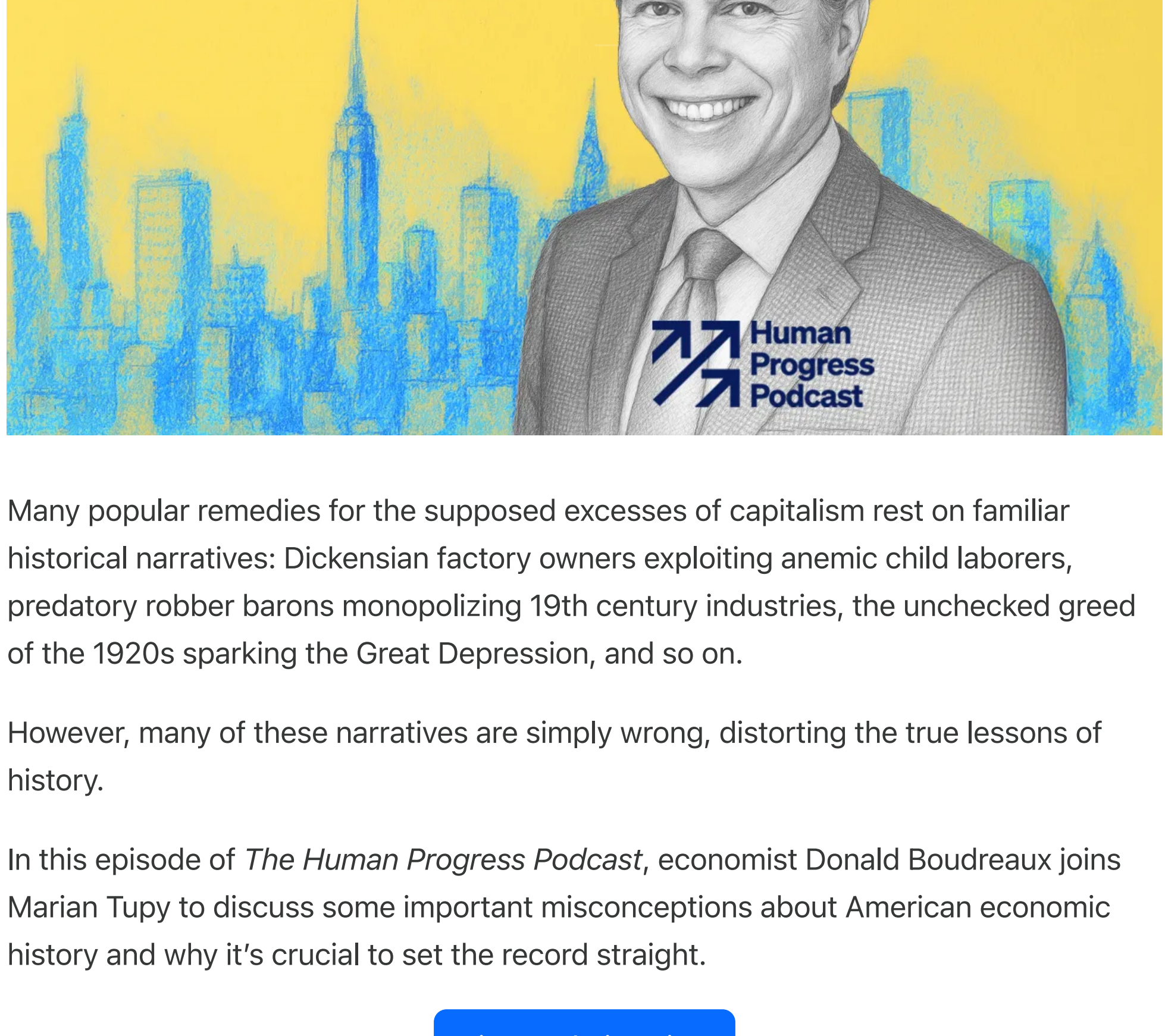
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The False History of American Capitalism

Donald Boudreaux joins Marian Tupy to address some important misconceptions about American economic history.

HUMAN PROGRESS
JUL 19, 2025

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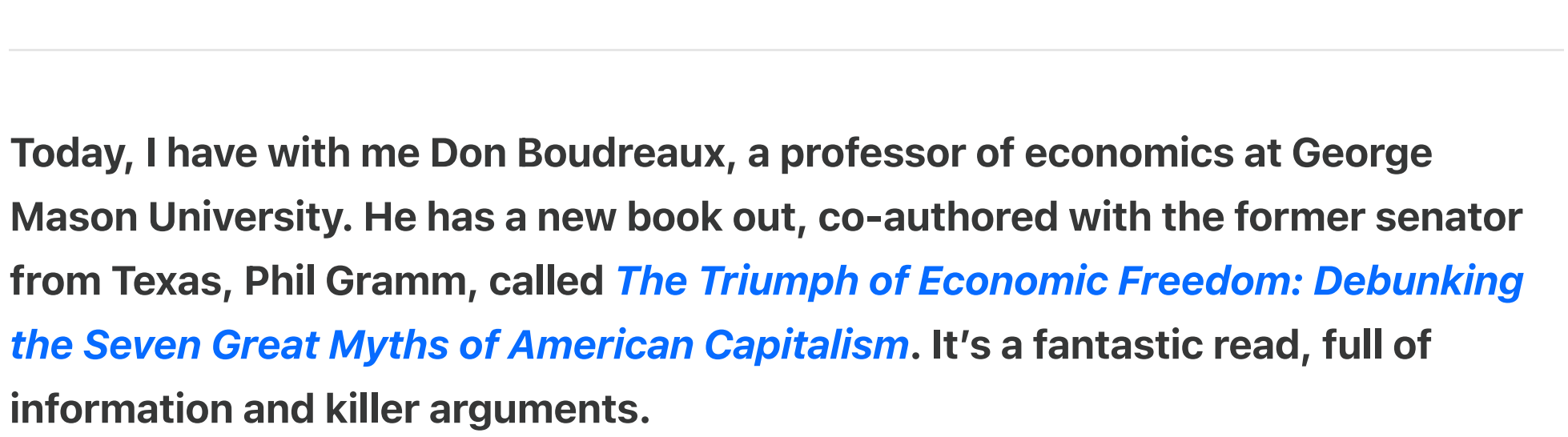


Many popular remedies for the supposed excesses of capitalism rest on familiar historical narratives: Dickensian factory owners exploiting anemic child laborers, predatory robber barons monopolizing 19th century industries, the unchecked greed of the 1920s sparking the Great Depression, and so on.

However, many of these narratives are simply wrong, distorting the true lessons of history.

In this episode of *The Human Progress Podcast*, economist Donald Boudreaux joins Marian Tupy to discuss some important misconceptions about American economic history and why it's crucial to set the record straight.

Listen to the interview



Below is an edited and abridged transcript featuring some highlights from the interview.

Today, I have with me Don Boudreaux, a professor of economics at George Mason University. He has a new book out, co-authored with the former senator from Texas, Phil Gramm, called *The Triumph of Economic Freedom: Debunking the Seven Great Myths of American Capitalism*. It's a fantastic read, full of information and killer arguments.

We're going to discuss that book today. But first, Don, why is the study of economic history important?

What we think we know about the past determines how we assess the present.

For example, if we think that in the past, a certain monetary policy did this or did that, that's going to affect how we think monetary policy should be conducted today. So, in order to make good decisions in the present, we have to do our best to understand how various policies worked out in the past. That's what we try to do in the book.

Let's jump in and tackle trusts, or as we call them today, monopolies. We often hear about the power of monopolies in today's America, but let's go back to the 19th century. What was the trust problem, and what was the solution meant to address?

Some of the first original research I did as a young scholar was looking into the Sherman Antitrust Act of 1890. I had a colleague, Tom DiLorenzo, who, in 1985, published a wonderful paper on the origins of the Sherman Act, 95 years after its enactment. Astonishingly, no one in that near century-long period had ever bothered to check what had actually happened to the prices and outputs of the industries that were supposedly monopolized. So, Tom looked at these data and adjusted them for deflation—there was a deflationary period from the end of the Civil War until the early 20th century—and found that in the decade leading up to the Sherman Antitrust Act, the prices of the outputs of these allegedly monopolized industries fell faster than prices in the economy as a whole. Likewise, the outputs of these industries rose faster, and in most cases, multiple times faster than the output of the overall economy.

This is inconsistent with the monopoly story. Monopolies are supposed to raise prices, not cut prices. In reality, there was no monopoly problem in the 1880s; there was a competition problem. We had, for the first time, a fully transcontinental economy, thanks to the railroads and the telegraph, and soon thereafter, the telephone. So, a lot of firms could now take advantage of economies of scale. John D. Rockefeller in petroleum refining, Gustavus Swift in meat slaughtering, James Buchanan in tobacco manufacturing, and so on. And these firms did grow large, but “large” is not an appropriate definition of a monopoly. A monopoly is a firm that can suppress competition, raise prices, and suppress output. These firms did the opposite. They grew big, but they grew big precisely by being so efficient that they could lower their prices and expand their output.

Now, whenever this happens, other producers complain. And in the 19th century, the complaints came disproportionately from local butchers and local cattle raisers. Before the railroad and refrigeration, slaughtering took place locally. So, when the first meat packers set up shop in Chicago and began centrally slaughtering livestock and shipping the meat out across the nation by refrigerated railroad car, they destroyed an age-old line of work. These local butchers and independent cattlemen raised hell, and local politicians listened to them, villainized these firms, and attacked them with antitrust statutes.

Frankly, these early antitrust statutes, and the subsequent ones, were not intended to address what was truly perceived as a problem of monopoly. They were aimed at placating disgruntled producers who had been outcompeted by larger, more efficient, and more entrepreneurial rivals.

You mentioned the D word, “destruction.” The destruction of local butchers by big, centralized butchers. Is that a good thing?

Well, economic growth requires that resources move from where they are less productive to where they are more productive, so change is inevitable if you want economic growth.

Some people might naively say, “Well, look, we've had enough growth, let's just stop now,” and try to freeze everything in place. Now, I'm sure almost everyone alive today is very happy that our ancestors did not settle for the level of economic activity that existed when they were alive. You and I would not be talking over Zoom, and web designers would have eight legs.

However, even if we all agreed to settle for our current level of prosperity, we would still need to allow economic change, because some things are beyond human control. Supplies of raw materials can dry up. Natural disasters can destroy factories. So, we always need people to be able to adjust to the facts on the ground. That flexibility, that entrepreneurial alertness and creativity, is inseparable from capitalism. If you try to freeze our economy in its current pattern, you'll collapse it. We can either continue to move forward and embrace creative destruction, or we can collapse into destitution.

Yeah, that's fundamental. There are, in Donald Rumsfeld's famous words, “unknown unknowns,” and we want to be as rich and as technologically sophisticated as possible when those challenges arise.

Okay, on to the big one, the granddaddy of them all, the Great Depression. Can you steelman the anti-market position about what happened in 1929? What went wrong?

Yes. In the 1920s, a fundamental contradiction of capitalism reached its peak. The rich were getting richer relative to the poor, and rich people spend a smaller portion of their incomes than poorer people. By the late 1920s, you had an increasingly unequal distribution of income, and a smaller portion of that income was being spent. As a result, America's factories were producing more than America's factories could sell, and a terrible spiral took place. The factories started laying off workers, which further reduced the income of factory workers, who responded by reducing their spending, which further reduced economic output and employment.

All of this happened when Herbert Hoover was president. And as everyone knows, Hoover was a staunch advocate of laissez-faire. He was a do-nothing president. The Depression happened, and Herbert Hoover just sat in the White House and twiddled his thumbs, hoping this recession would go away. Then, of course, it got worse. By 1932 and 1933, unemployment in America hit 25 percent. Fortunately, the American people elected Franklin Roosevelt, who came to office with a whole bunch of really good ideas and smart advisors. They developed the New Deal, a system of relief programs, and we were able to start recovering. Finally, World War II comes along, there's more government spending, and we get out of the Depression. That's the myth.

That's what a lot of American kids learn at school. But I suspect that you don't quite agree with that interpretation of the Great Depression.

No, I don't. Let's start with the easy one: Hoover was not a do-nothing president or an advocate of laissez-faire. Hoover was the president who signed the Smoot-Hawley Tariff Act. He created the Reconstruction Finance Corporation. Hoover spent at a deficit during every year of his administration. In fact, one of Franklin Roosevelt's campaign platforms was that Hoover was too big a spender. Hoover's administration was the first time, really, that any sitting American president did much to combat an economic downturn. So that's a complete fallacy.

There are other problems too. In the 1920s—and this is from research done by Simon Kuznets, a Nobel Prize-winning, very respectable economist—the distribution of income did not grow more heavily toward upper-income Americans. In fact, it became a little bit flatter in the 1920s. In terms of spending, the mythical theory says that there just wasn't enough spending to buy what the factories were producing. But if you look at the data on consumer spending in the 1920s, it was off the charts. It was a boom time for Americans.

What actually happened, and here I'm quite conventional, was bad monetary policy. The Fed was created in 1913 to serve as a lender of last resort. Before the Fed was created, whenever banking crises would happen, they had private arrangements where bank clearing houses would get together and channel liquidity to the parts of the banking system that needed money. And these panics, as they were called, were quickly undone. But after the panic of 1907, people said, “Well, we can't have this. Let's get the government to take over this process.” And they created the Federal Reserve.

When the downturn began in August of 1929, the Fed should have stepped in to prevent the money supply from contracting. But the Fed just stood by, and from 1929 to 1933, the money supply contracted by over 30 percent. That is huge. Then, on top of that, you have the hyperactive Hoover, who administered a historically unique level of economic intervention. And then it gets worse under FDR.

The big problem was what the economic historian Bob Higgs calls regime uncertainty. Hoover and Roosevelt became increasingly hostile to businesses and investors throughout the 1930s. Basically, they scared investors off. Well, if you want economic recovery, you can't scare investors off. You can't threaten their property rights. You can't threaten to tax away their earnings. You can't threaten to control prices. All of this was being done. Roosevelt became a little more friendly to businesses when he needed them to cooperate in the war effort, but there was still concern that after the war, Roosevelt would return to his increasingly anti-capitalist stance. But of course, Roosevelt died in April of 1945, and Truman, for all of his imperfections, was a businessman, and he was perceived, quite rightly, as much less radical than Roosevelt.

Higgs dates the end of the Great Depression as immediately after the war, 1946 or 1947. The war years, we can't say much about. You're conscripting people into a military, so unemployment looks low, but that's not the result of an improved market economy. Prices are controlled. Wages are controlled. Certainly, the standard of living of ordinary Americans back home was falling. So, if you define the end of the Depression as a return to high and rising living standards for ordinary people, you don't get any evidence of that until the years immediately following the end of World War II. So, the New Deal didn't cure the Great Depression. If anything, it extended the Great Depression throughout the 1930s. If we're going to actually rely on data, we must say that the Depression only ended after the end of World War II.

Now on to the final topic, the Great Recession.

The mainstream explanation is that financial deregulation created the housing crisis. Greedy, mustache-twisting bankers lent money to people who they knew couldn't repay the mortgage loans, which anybody with common sense would know is not a good banking strategy.

In fact, what happened is that starting in the early 1990s, the government became intent on increasing the rate of home ownership. So, the government wanted banks to extend mortgage lending to people that they otherwise wouldn't lend to, but the banks didn't want to lend money to people who were unlikely to pay them back. So, the federal government said, look, Fannie and Freddie, increasingly large shares of your portfolio have to be made up of subprime mortgages, or we're going to do all kinds of nasty things to you.

Say you're a bank in Omaha, Nebraska, and someone comes to you to borrow money to buy a house. In the past, you'd say, “Sorry, you don't have 20 percent to put down, and you don't have a high enough income. I'm not going to lend you the money.” But now, Freddie comes by and says, “I really want to buy some subprime loans from you, so if you make some subprime loans, I'll buy them from you and relieve you of the risk.” So, when that same borrower comes back, you lend them the money and sell the mortgage to a government-backed firm. Now you're off the hook, but that bad loan is still out there. The result was that increasingly large numbers of house mortgages were held by people who couldn't afford to repay them, and so any decline in economic activity, and certainly any decline in housing prices, would put a lot of the homeowners under water, and that is what eventually happened. The house of cards collapsed.

One final question: Why don't bad ideas die?

There are at least two reasons.

First, if you show me a bad economic idea, I will show you a special interest group that benefits from it. This is what Bruce Yandle called the “Bootleggers and Baptists” idea: when you have a sincere but mistaken belief backed by venal interest groups who stand to gain materially by the maintenance of those beliefs, those beliefs become entrenched.

The second reason is that bad ideas are usually easier to grasp than good ideas. Good ideas tend to involve one or two steps of reasoning beyond the bad idea. And so, to push out bad ideas and replace them with good ideas requires good education. So, all the things that we're doing, all the blogging and podcasting and tweeting.

It's a struggle to present good ideas, but we have no choice. We have to keep doing it. And history shows that, if you're effective at it, you can sometimes push bad ideas aside and replace them with good ideas. But it's a never-ending battle. It's not like the bad idea is defeated and then it goes away forever. It'll always lurk. So, we always have to be at the ready to challenge it with good ideas. And we have to be very patient.

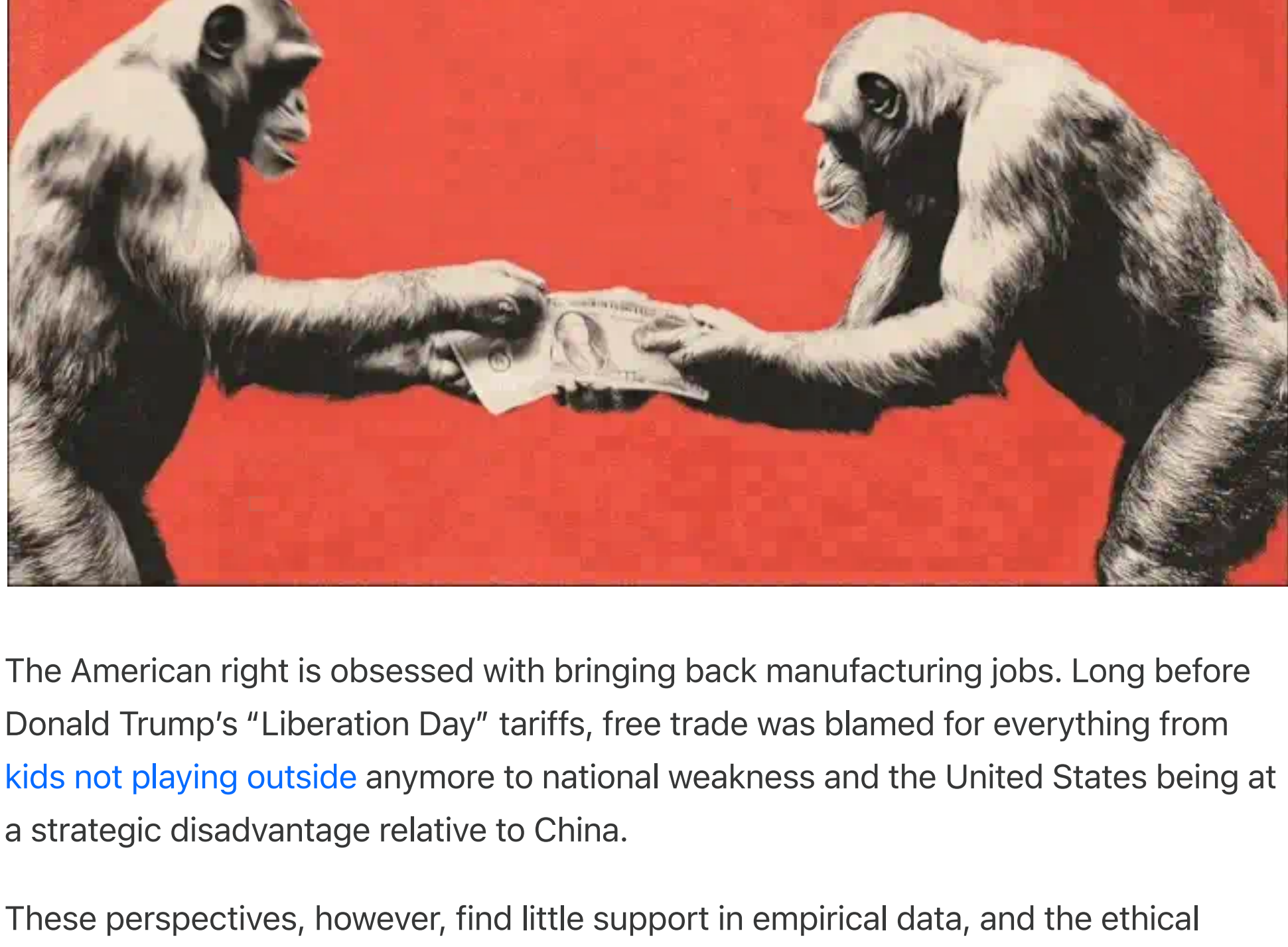
Read the full transcript

How Evolutionary Psychology Explains Opposition to Trade

Without developed market economies, outsiders could gain something from your tribe only at your tribe's expense.

RICHARD HANANIA
JUL 18, 2025

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The American right is obsessed with bringing back manufacturing jobs. Long before Donald Trump's "Liberation Day" tariffs, free trade was blamed for everything from [kids not playing outside](#) anymore to national weakness and the United States being at a strategic disadvantage relative to China.

These perspectives, however, find little support in empirical data, and the ethical arguments underlying protectionism range from underdeveloped to downright odd.

The fact that poor arguments against trade persist despite common sense and the overwhelming consensus of economists is a sign that we need to understand support for protecting manufacturing jobs against foreign competition as being rooted in evolutionary psychology.

Protectionism is a preference that can be found where two very strong emotions intersect: hostility toward outgroups and an aesthetic preference for work that involves producing tangible objects.

Chris Caldwell has recently [criticized trade](#) on the grounds that the idea of the "country as a whole" is a myth. "The same policy could be perceived by one group as a windfall and by the other as a catastrophe. Trade made you the ally of certain foreigners and the rival of certain fellow Americans." Similarly, in *Conservatism: A Rediscovery*, Yoram Hazony argues that free trade leaves workers feeling betrayed by leaders in government and business, thus "bursting the bonds of mutual loyalty."

These arguments are difficult to justify upon reflection. With regard to Caldwell's view that trade puts you on the same team as foreigners against Americans, one may ask:

Doesn't restricting trade do the same? If I want to buy a widget from a Chinese manufacturer at a cheaper price, aren't the protectionists within my own country thwarting me in that goal if they prevent me from doing so? Caldwell's perspective treats a world without cross-border trade as the natural default, with the movement of goods across borders "creating" a situation in which Americans are pitted against one another.

In fact, a world without trade can come about only through heavy-handed government action, with the state intervening on the side of some Americans against others.

Hazony's argument likewise presents a strange view of ethics. When members of a group sacrifice, it's usually to help the whole. For instance, a soldier might die in war to keep his nation from being conquered. The "moral" argument against trade flips this idea on its head. The majority, and the well-being of the whole, must be sacrificed for the sake of the few.

Even if we accept the desirability of redistribution, this argument could make sense only if the pro-trade position involved a transfer from the poor to the rich. Those who have a lot might sacrifice to help the poorest among us. The problem with this view is that tariffs function as a [regressive tax](#), especially on goods that make up a larger share of low-income budgets, such as clothing, food, and appliances. A 25 percent duty on imported washing machines raises prices for everyone, but the cost is a greater burden for a minimum-wage household than for a wealthy one. A study of Trump's 2018 tariffs found an annual cost of [\\$419](#) per household. High earners might not notice such a cost, but it takes a big chunk out of the disposable income of the working poor.

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While protectionists focus on jobs their policies save, they ignore the much larger harms inflicted on the rest of society. Steel tariffs imposed by the Bush administration in 2002–2003 [were found](#) to have cost 168,000 jobs in industries that have steel as inputs, more than the total number of jobs in the entire steel industry. The first Trump administration's washing machine tariffs [created](#) 1,800 jobs, at the cost to consumers of \$820,000 for each job.

None of that should be surprising given the nature of the American economy. Protectionists seem to imagine that manufacturing makes up a massive portion of the national workforce. Yet only 8 percent of the [nonfarm labor force](#) works in manufacturing, half of what it was in the early 1990s. Even if you focus on the less educated, such jobs do not represent anywhere near a majority. As of 2015, [only 16 percent of men](#) without a bachelor's degree worked in manufacturing, down from 37 percent in 1960. Thus, even if you ignore women and everyone in the country who completed higher education, most people do not actually have the kinds of jobs that opponents of free trade seek to protect and cultivate.

On what basis, then, should national policy be geared toward helping a very small minority of the public, and even a minority of the working class, at the expense of everyone else? What is odd about antitrade conservatives is that they rarely focus on other sacrifices the rich could make on behalf of the poor. The most straightforward way for them to do so would be to call for higher taxes on the wealthy and more redistribution. That way, instead of taxing everyone (with a disproportionate effect on the poor) to help a small minority of the population, one could focus on those who can most afford to pay. This is not to argue for redistribution, but rather to say that if that is your goal, putting restrictions on trade is not the way to achieve it.

Given what the empirical data overwhelmingly show about the effects of tariffs, and given the existing structure of the American economy, there must be a psychological reason for the strong attachment many have to protectionist policies. Evolutionary psychology provides an answer. First of all, we evolved in a world of zero-sum competition between individuals and groups. Without developed market economies, outsiders could gain something from your tribe only at your tribe's expense.

President Trump makes this view explicit when he says that a trade deficit [means](#) we are "losing" money to foreign countries. This, of course, makes no sense. When I buy something from a store, it is because both parties decided it was in their interest to engage in a voluntary transaction. It's telling that conservative intellectuals, and Americans more generally, rarely have opinions nearly this strong in economic domains outside of trade and immigration. Shouldn't every situation where there's a buyer and a seller be some sort of scam, according to Trump's worldview? The fact that almost nobody understands economics this way indicates that the presence of foreigners in an interaction changes the nature of how individuals perceive it.

In addition to zero-sum thinking, another aspect of evolutionary psychology that is relevant here is how we perceive the nature of work. As alluded to earlier, protectionists tend to value manufacturing jobs higher than other forms of work, while also implicitly overestimating the extent to which our economy depends on them. But why, exactly, does someone going from working in a factory to becoming a hairdresser or driving an Uber seem like a loss, even if their new job might pay more? Why do protectionists in America seem envious of nations like China and Vietnam, which have a higher percentage of their workforces involved in manufacturing but are much poorer than we are?

Once again, the answer must be found in the distant past and how it shaped our contemporary brains. As hunter-gatherers and later farmers, we could see that someone who erected a dwelling or made a fishing spear was clearly contributing to society. Manufacturing workers are the modern equivalents, producing goods that individuals can see and touch.

The rise of the service economy is a recent phenomenon. For most of human history, nearly all labor was tied to survival—hunting, gathering, farming, or crafting tools. Even through the early industrial period, most workers made things. But in the past century, advanced economies have shifted dramatically. Today, the vast majority of workers in countries like the United States are employed in services, including sectors such as health care, education, finance, hospitality, and software development. These roles often involve abstract forms of productivity, making their social value harder for most people to grasp.

Note that like manufacturing, agriculture is often romanticized and protected from foreign competition, likely because it has premodern equivalents. Just like factories, farms evoke images of hard physical labor, sustenance, and independence. To find such work aesthetically appealing is deeply wired into our collective psychology. In truth, however, the structure of modern work has moved on. Manufacturing and farming make up only a fraction of the economies of advanced nations.

Most Americans today do not make things. They provide care, solve problems, create knowledge, or facilitate transactions. These jobs are no less real or valuable than factory work, but they lack the visceral, visible outputs our minds were shaped to recognize as valuable. The nostalgia for manufacturing, then, is rooted not in economic logic or ethical clarity, but in an instinctive bias toward forms of labor that resemble those in our ancestral past.

Of course feelings matter in politics. Nonetheless, it is important to understand when we are being motivated by psychological illusions. One might argue that the path to happiness is to indulge in our natural instincts and have a closed economy in which more people make tangible things, even if it causes our living standards to collapse. Yet protectionists practically never make a case like this—and for good reason. Once you understand the nature of these biases and how irrational they are, the case against trade falls apart.

This is why protectionists instead argue that their preferred policies will make their country better off economically, or at the very least transfer wealth from the rich to the poor. The proper response here is that their assumptions are simply not true. Instead of throwing up barriers to trade or trying to resurrect a long-gone employment landscape, we should ask how best to support workers as they are, not as we imagine them to be. That means supporting things like flexible labor markets, higher-quality training and education, and the removal of arbitrary barriers to making a living such as occupational licensing regimes.

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Microscopic to Astronomic Knowledge Discovery

Compared to the unaided eye, humans see 100 million times more with microscopes and 375.5 billion times more with telescopes.

GALE POOLEY
JUL 15, 2025

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Limitations in our sense of vision have driven us to invent and share new instruments of knowledge discovery. The unaided human eye can see a 100 micrometer (μm) object, about half the diameter of a human hair. Naked-eye stargazers can see a sufficiently bright celestial object up to 2.5 million light-years away. This was the extent of our vision until around 1600, when glassmakers in the Netherlands started to experiment with shaping lenses. The results of their experiments have given us the astonishing power to see millions and even billions of times more.

Microscopes

Zacharias Janssen developed the first microscope in 1595. It could magnify objects 3 to 10 times their size. By the 1800s, magnification had improved to 1,000 times. A significant advancement occurred in 1931 with the use of the transmission electron microscope (TEM), which could magnify up to 1 million times. TEMs range in cost from \$100,000 to \$10 million or more, depending on their features. The most advanced TEM, located at Lawrence Berkeley National Laboratory, costs \$27 million. This microscope can achieve a resolution of half the width of a hydrogen atom, making it the most powerful microscope in existence.

The scanning electron microscope (SEM), developed in 1937, had lower magnification (approximately 100,000 times) but could produce three-dimensional images. From the 1980s to the present, cryo-electron microscopy (cryo-EM) has increased magnification up to 5 million times; scanning probe microscopes—using methods such as atomic force microscopy (AFM) and scanning tunneling microscopy (STM)—have increased magnification up to about 100 million times.

However, magnification is only marginally meaningful unless paired with resolution, since empty magnification yields no useful details. For true improvement, resolution is critical.

The light microscopes of the 1800s could see 500 times more, at 0.2 μm . In the 1930s, electron microscopes improved resolution to 0.05 nanometers (nm), an increase to 2 million times magnification. Today's cryo-EM/atomic microscopes have a resolution of 0.001 nm, which is *100 million times* that of the unaided human eye.

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Telescopes

Hans Lippershey is credited as the inventor of the first telescope, created in 1608. His instrument could magnify 3 times. After learning of the innovation the following year, Galileo built his own version and increased magnification to 30 times, yielding a 10 times improvement in one year. Telescopes have continued to improve in light-gathering power and resolution. In the 1700s and 1800s, innovations by Isaac Newton and others improved both of these factors. The Herschel reflecting telescope, produced in 1789, had 20 times better resolution and over 1,000 times better light-gathering power than the Galileo design. The Great Dorpat Refractor, built by Joseph Fraunhofer and completed in 1824, was the first modern, achromatic, refracting telescope. While the Herschel had a larger aperture, the Dorpat had much higher-quality lenses, yielding sharper and more measurable images.

The Hooker telescope was built in 1917 and offered 3 times resolution and 105 times improvement in light-gathering power over the Dorpat. The next major advancement was the creation of the Hubble telescope in 1990. As a space-based telescope 340 miles above the Earth's atmosphere, it was 10 times sharper and more stable than its Earth-based counterparts. The James Webb Space Telescope (JWST), launched in 2021, has a much larger mirror (6.5 meter vs. 2.4 meter), giving it vastly greater light-gathering power, and it is optimized for the infrared spectrum.

The Extremely Large Telescope (ELT) is scheduled to go online in 2030. Compared to the JWST, the ELT is 6 times larger, giving it dramatically higher light-gathering power for ground-based observations. The ELT will achieve 14 times sharper resolution (0.005 arcsec vs. JWST's 0.07 arcsec), especially when using adaptive optics. The JWST retains the edge in overall precision due to its space-based stability and optimized infrared systems, but the ELT will surpass it in spectroscopy, exoplanet imaging, and capturing the detailed structures of distant galaxies.

From the unaided human eye to the ELT, angular resolution will be 12,000 times better and light-gathering power will be 31 million times better. This gives the ELT a combined observational capability approximately *372.5 billion* times greater than the unaided human eye. This staggering difference reflects advances in both resolution and light-gathering power, enabling us to study the universe in ways that were unimaginable just a few centuries ago.

Microscopes and telescopes are instruments of knowledge discovery. There has never been a better time to be alive if you want to zoom in and look at an individual 0.05 nm atom or zoom out and look at the edge of the universe, some 46.5 billion light-years away from Earth.

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