MILKEN INSTITUTE

review

GORGEOUS BUT HAS A BIG DOWNSIDE SEE PAGE 68

THE MILKEN INSTITUTE REVIEW
FIRST QUARTER 2026

THE MILKEN INSTITUTE
Michael Milken, Chairman
Richard Ditizio, CEO

PUBLISHER
Conrad Kiechel

EDITOR IN CHIEF
Peter Passell

ART DIRECTION AND DESIGN
Leslie Noyes

MANAGING EDITOR
Larry Yu

CHARTS AND GRAPHS
Matthew DuBeau

ISSN 1523-4282

The Milken Institute Review is published quarterly by the Milken Institute to encourage discussion of current issues of public policy relating to economic growth, job creation and capital formation. Topics and authors are selected to represent a diversity of views. The opinions expressed are solely those of the authors and do not necessarily represent the views of the Institute.

The Milken Institute's mission is to improve lives around the world by advancing innovative economic and policy solutions that create jobs, widen access to capital and enhance health.

Send requests for additional copies to:
The Milken Institute
The Milken Institute Review
1250 Fourth Street, Second Floor
Santa Monica, CA 90401-1353
310-570-4600 telephone
310-570-4627 fax
info@milkeninstitute.org
www.milkeninstitute.org

COVER: Roberto Machado Noa/ LightRocket via Getty Images

SPINE: David Smith

With the dawning of 2026, let the celebrations begin. This year marks the 250th anniversary of one of the most important events in history, an event that marked our past and, we can hope, guide our future.

The Declaration of Independence and the founding of the United States of America? Sure, those are worthy of celebration and deservedly being cheered, loud and long. But 1776 also witnessed the first publication of *An Inquiry into the Nature and Causes of the Wealth of Nations*, by the Scottish moral philosopher Adam Smith. Known thereafter simply as *The Wealth of Nations*, the book both influenced the nascent field of economic thought and provided the intellectual foundation for free market capitalism.

In an era of *dirigisme*, mercantilism and state-directed economies, Smith showed by example and argument how an "invisible hand" of individuals responding to their economic self-interest will unwittingly but powerfully advance general prosperity. It immediately set an influential new paradigm for developing economic policies, an intellectual cornerstone for the increasing global prosperity of the past 250 years.

Unlike the esteemed editor of this journal, I am not an economist and will not pretend to have read the 900 pages and two volumes of Smith's monumental work (though I enjoyed the late P.J. O'Rourke's book on the masterpiece, which unlocked many of its insights with clarity and humor.) But a later British giant of economists who doubtless did was the 20th-century master John Maynard Keynes, who once wrote: "Practical men who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist."

Was Keynes slyly referring to Smith? Perhaps, but there is no doubt that the intellectual influence of Adam Smith has powerfully shaped the past quarter of a millennium, and for the better.

So, happy birthday America – and *The Wealth of Nations*.

Conrad Kiechel, Publisher

EDITOR'S NOTE

It was the best of times and worst of times. Well, maybe not the best, but an era in which technology, capital, savvy government and goodwill can still be mobilized to tackle the looming problems facing the global economy. I know, I know, I know – we economists tend toward optimism. But do read on.

Jan Mischke, **Chris Bradley** and **Olivia White** at the McKinsey Global Institute take a deep dive into the performance of the global economy and discover a striking, unintuitive reality: "If you think most productivity gains come from incremental improvements in efficiency across the broad swath of firms – or even from adopting new technologies like AI – think again," they write. "There's strong evidence that a small cadre of standout companies making bold, strategic moves drives national productivity growth."

China's massive commitment to education, everybody knows, is paying off big-time as Chinese students race ahead of their counterparts in the rich, developed economies. What you probably don't know, though, is that China's spectacular record is partly – arguably mostly – smoke and mirrors. "It is possible that China as a whole is outperforming other economies at its income level with respect to academic achievement," writes **Nick Eberstadt** of the American Enterprise Institute. "It is also possible that overall aptitude for students in China is similar to that of students in Turkey, a country at roughly China's level of socioeconomic development."

Gernot Wagner, the faculty director of Columbia Business School's Climate Knowledge Initiative, takes a deep dive into the economics and technology of the largest industrial emitter of greenhouse gases you probably never knew about. "All told," he writes, "global cement production is responsible for an astounding 5-8 percent of CO_2 emissions – a lot less than fossil fuel consumption, but a significant part of what is often viewed as especially hard to abate, and for good reason."

Now "the giants of the cement industry do have the financial resources and industrial know-how to scale new technologies fast. They even have internal venture capital shops seeking out new ideas." But getting from here to anything close to zero emissions with cement never looked easy – and it just got a lot harder thanks to the Trump administration's determination to withdraw support from the effort.

ADAM NIKLEWICZ

Magne Mogstad, **Kjell Salvanes** and **Gaute Torsvik**, professors of economics at the University of Chicago, the Norwegian School of Economics and the University of Oslo, respectively, explain why the puzzle of how Scandinavia managed to become immensely productive while sustaining enviable economic equality is really no puzzle at all.

Nordic countries, they note, all invest heavily in human capital, narrowing productivity differences at the metaphoric starting line of working life. Equally important, institutions for wage-setting bypass markets, effectively "cross-subsidizing" low-productivity wage earners with the fruits generated by higher-productivity workers. The real puzzle, then, is why the highest-productivity workers don't rebel – and that comes down to cultural cohesion.

America badly needs better roads – and most people, it is safe to say, think the owners of vehicles who use them should underwrite the effort to improve them with taxes at the pump. Trouble is, writes **Michael Gorman**, professor of operations management at the University of Dayton, this approach is becoming ever less practical. "The wear and tear done by vehicles increases exponentially with weight," he writes, "and fuel consumption is a very poor proxy for it – and getting worse all the time."

The best approach, he says, is to start afresh with a tax on trucks based on their weight and mileage. "In a country that demands higher-quality public services and doesn't want to pay for them, something has to give," he argues. "Vehicle-mile fees represent a timely opportunity for raising badly needed revenues without distorting markets."

Justin Kakeu (University of Prince Edward Island), along with **Brandon Holmes** and **Ethan Ziegler** (Resources for the Future), tackles a thorny problem in a source of pollution damage whose existence is just beginning to be recognized. "Governments regulate air quality as though each contaminant exists in isolation, when in reality people breathe in a complex cloud of pollutants," they explain. "And mounting evidence shows that assaying the damage caused by individual pollutants understates public health risk because many chemicals interact synergistically."

"The technical problem of getting a handle on these interactions is daunting, with literally millions of possible blends to consider." But it is no longer intractable: the researchers propose the creation of multipollutant cap-and-trade regulation that draws on advances in both environmental science and mathematical systems analysis.

Gene Steuerle, co-founder of the Urban-Brookings Tax Policy Center, is frustrated by the terms of the debate over inequality. "Government policies supported by both Democrats and Republicans have prioritized wealth accumulation for the affluent and consumption for the masses," he writes, "making it increasingly difficult for many Americans to build wealth and earn market income."

The disastrous consequence: "American children born before the start of World War II had a 92 percent chance of earning more than their parents, while those born when Ronald Reagan was re-elected had only a 50 percent chance. Indeed, if income growth had continued to be distributed as evenly as it was between the 1940s and 1970s, 70 percent of that decline in mobility would be reversed."

Want more? Check this excerpt from the new book *Shared Prosperity in a Fractured World*, **Dani Rodrik**'s ambitious effort to reenvision globalism that advances prosperity without forcing the middle class to bear the resulting insecurity.

Happy perusing. — *Peter Passell*

BY MAGNE MOGSTAD, KJELL G. SALVANES
AND GAUTE TORSVIK

The Nordic economies – Denmark, Norway, Sweden, Finland – continue to perplex economists and inspire policymakers. These countries are among the wealthiest in the world, and their workers are as productive, in some cases more productive, as their American counterparts. Yet their societies are far more equal in income than either the United States or much of the rest of Europe.

By conventional economic analysis, this shouldn't be possible. Standard textbooks portray inequality as an engine of prosperity. The reasoning is straightforward: when individuals see the possibility of getting ahead by working harder, innovating or investing wisely, they respond to the incentives. High rewards at the top encourage risk-taking, while the threat of falling behind disciplines workers and firms to be efficient.

Redistribution, by contrast, is supposed to inhibit ambition. Tax away too much of the upside or shield people too well from the downside and growth suffers. In this view, equality comes at the expense of dynamism and productivity growth.

Part of the answer to the Nordic puzzle may be that this standard analysis rests on a model in which equality is achieved through post-market redistribution of returns – the market generates income and the state redistributes it. But equality need not rely solely on post-market redistribution. It can also be created before the market by more equal distribution of human capital, or in the market itself by delinking wages and individual productivity. Widening the lens on equality thus raises the question: do residents of the Nordic countries end up with a more equal distribution of resources because they are born and raised in cultures that promote equality, because they are paid more equally, or because taxes generate more equality?

MATHIAS BERGELD/BILDBYRAN/SIPA USA/SIPA VIA AP IMAGES

SETTING THE STAGE

The Nordic countries are home to just 26 million people. Sweden, with 10 million people, is about twice the size of each of the others.

Demographically, they resemble the rest of

Europe: about 65 percent are of working age and, at 1.6 expected births per woman, their fertility rate is close to the OECD average. Contrary to the stereotype of ethnic homogeneity, in 2021 both Norway and Sweden had larger shares of foreign-born residents than the United Kingdom or the United States, with about half of the foreign-born from non-Western countries.

The populations are well educated and healthy, with life expectancy above 83 years in Sweden and Norway, 82 in Finland and 81.5 in Denmark (2019) – compared with 76.4 years in the United States. The Nordics also rank consistently near the top in global quality-of-life indices.

All four Nordic countries combine small, open economies with large public sectors and a heavy reliance on exports. Each has its specialties: machinery and paper in Finland, oil and fish in Norway, manufacturing in Sweden and pharmaceuticals in Denmark.

Incomes are high across the region. Norway's GDP per capita adjusted for purchasing power slightly exceeds that of the United States. Denmark and Sweden trail the U.S. by about 15 percent, but remain well above the OECD average. Finland, the least wealthy of the four, still outpaces the UK and the OECD as a whole.

High labor productivity is central to the Nordic economies' success. On an hourly basis, Denmark, Norway and Sweden match or exceed the United States by this metric, and all four Nordics outperform both the UK and the OECD average. The gap in average annual income between the Nordics and the U.S. mainly reflects differences in hours worked: Americans are on the job more than 200 hours a year longer than Nordic workers. Shorter workweeks – not lower employment – explain the difference. In fact, labor force participation, especially among women, is higher in the Nordics than in the United States, the United Kingdom or the OECD average.

It's important to note, however, that these outcomes are not explained by markets alone. They are closely tied to the institutions that underpin the Nordic welfare model.

MAGNE MOGSTAD is professor of economics at the University of Chicago. KJELL SALVANES is professor of economics at the Norwegian School of Economics in Bergen. GAUTE TORSVIK is professor of economics at the University of Oslo. This paper summarizes the conclusions of their more technical research survey.

FOUR PILLARS OF THE MODEL

The political scientist Gøsta Esping-Andersen developed a typology that distinguishes among three kinds of welfare regimes. The United States exemplifies the "liberal" model, in which benefits are limited and often means-tested, and markets play the central role in allocating resources. Much of continental Europe follows a "conservative-corporatist" model, where benefits are more generous but are linked to occupational status and family roles.

The Nordic countries fit the "social democratic" model. In this system, the state plays a larger role in promoting equality through universal programs and policies that support high labor force participation. Basic needs such as health care, education, childcare and pensions are financed through broad-based taxation and provided as rights of citizenship rather than as goods to be purchased in the market.

Esping-Andersen's typology captures only the welfare-state side of the economic model. In the Nordics, the design of the welfare model has been tightly interwoven with labor market policy. From the interwar rise of coordinated, tripartite wage bargaining to contemporary active labor market policies, unions and employer associations have co-

Multisensory stimulation song and play class for babies.

FREDRIK NAUMANN/PANOS/REDUX

governed wage formation and shaped the tax/benefit architecture. Wage compression – narrowing the range created by productivity differences – and broad bargaining coverage made universalism fiscally and politically sustainable, while universal services and social insurance, in turn, supported high employment and a broad contribution base. In short, the Nordic welfare state and its labor market institutions developed together as a mutually reinforcing system.

The foundations of this system were laid in the period between the world wars, when social democratic parties rose to power alongside strong labor movements and early versions of social insurance and health programs were introduced. The most significant expansion, however, occurred during the post-World War II era, the so-called Golden Age of organized labor in the 1950s and 1960s, when universal social security and health care were established across the region. In the same period, centralized wage bargaining between unions and employer associations became institutionalized, anchoring the aforementioned wage compression and supporting the financing of universal benefits.

The 1970s brought further reforms, expanding into family policies such as paid maternity leave and publicly subsidized day care, with near-universal availability achieved by the 1990s and 2000s. Education also broadened in scope, as access to secondary and higher education shifted from selective,

Kirkeristen Street in the Oslo, Norway, city center.

JORGE MANTILLA/NURPHOTO VIA GETTY IMAGES

means-tested systems to universal entitlements. Taken together, these developments gradually transformed earlier, fragmented arrangements into the comprehensive welfare system that characterizes the Nordic model today.

The contemporary Nordic model can thus be refined into four key pillars of economic organization:

- **Universal services:** Substantial public investment in family policies, education and health care, ensuring broad access to essentials.
- **Coordinated wage-setting:** Strong labor unions with bargaining that aligns wages across and within industries.
- **Comprehensive social insurance:** Programs that protect individuals against income losses from unemployment, disability and illness.
- **Progressive taxation:** High and progressive taxes on labor income, combined with subsidies for services that support employment.

Together, these pillars constitute a cradle-to-grave model of welfare provision influencing individuals' opportunities at multiple stages of life – before, at and after market income is earned.

Economist Gary Becker described the bundle of resources and circumstances passed from parents to children as a "family endowment." In more equal societies such as the Nordics, these endowments may be less dispersed than in countries with higher inequality. Universal access to health care and

education may further reduce disparities in early-life conditions, allowing individuals to enter the labor market with narrower productivity gaps. Within the labor market, coordinated wage-setting compresses the wage distribution by raising pay at the lower end and limiting dispersion at the top. Finally, progressive taxes and transfers reshape market incomes into more equal disposable incomes.

SEARCHING FOR THE SOURCE OF NORDIC EQUALITY

While all of these mechanisms plausibly play a role, their relative quantitative importance remains an open question – and one that our analysis seeks to address.

In tracing the origins of Nordic equality, we begin at the end and move backward. Start with the role of redistribution: to what extent do progressive taxes and transfers reduce inequality in disposable income, and how does this compare to countries such as the United States? From there, we turn to the pre-distribution of earnings – the degree of equality already present in market incomes before taxes and transfers. We then ask how much of this greater equality in the Nordics stems from narrower dispersion in skills versus the institutional compression of wages.

This stepwise approach allows us to decompose the relative importance of redistribution, pre-distribution and wage-setting institutions in shaping overall equality. By rolling the story back from outcomes to their underlying drivers, we seek to clarify which mechanisms matter most for the distinctive egalitarianism of the Nordic model.

Lesson 1: Pre-distribution, not redistribution. A widely used yardstick for inequality is the Gini coefficient. Think of it this way: pick two people at random, look at the difference in their incomes and divide that difference by the sum of their incomes. If they earn the same amount, this number is zero; if one person has all the income, the number is one. The Gini coefficient is just the average of this calculation across all possible pairs.

According to OECD data from 2019, the Gini for disposable income is about 0.39 in the United States and 0.27 in the Nordic countries. That 12-point gap translates into about 30 percent less inequality in the Nordics. Put another way, cutting the Gini by 30 percent is roughly equivalent to imposing a 30 percent tax on all income and distributing the proceeds equally.

But how much of this difference reflects redistribution through taxes and transfers, and how much comes from a more equal distribution of incomes before taxes? Looking at market income, the gap narrows but remains substantial: 0.47 in the U.S. versus 0.39 in the Nordics. And when we focus on labor market earnings, the contrast is even starker: the Gini is about 15 percentage points lower in the Nordics.

Our evidence – especially on labor market earnings – points to a simple lesson: the Nordics are more equal than the U.S. not primarily because they redistribute more after the fact, but because market earnings are more equal to begin with. Taxes and transfers matter, and the Nordics do more of both than the U.S. But the real driver of their equality is the compressed distribution of pre-tax wages.

Lesson 2: Wage compression, not working-hour compression. To see why earnings inequality is so much lower in the Nordics than in the United States, we break the distribution into three parts: variation in hours worked, variation in hourly wages and the connection between hours and wages. The Nordic countries come out ahead on all three.

High rates of labor force participation, especially among women, mean fewer people

are left out of the labor market altogether. Among those employed, hours worked vary much less than in the U.S., where part-time work is more common and schedules more uneven. And while high-wage workers in the U.S. typically put in longer hours, thereby reinforcing income gaps, the link between wages and hours is weaker in the Nordics: better-paid workers do work more hours, but not dramatically more.

Gender differences also play a role, but not nearly as much as one might think. Nordic women earn more relative to men than their U.S. counterparts, which does help reduce inequality. Yet when we decompose the gap in earnings inequality, only about 2 percent can be traced to gender pay differences. The remaining 98 percent comes from the wider spread of wages within each gender group in the U.S.

The dominant factor explaining the U.S.-Nordic equality gap is the distribution of wages themselves. In the U.S., hourly wages are spread widely: a worker at the 90th percentile earns about five times as much as one at the 10th percentile. In the Nordics, the ratio is closer to two-to-one. This narrower wage spread shows up clearly in the statistical decomposition. More than 70 percent of the difference in earnings inequality between the Nordics and the U.S. can be attributed to the lower variance of hourly wages in the Nordics. High participation, steadier hours and smaller gender gaps all contribute, but the key fact is that hourly wages are distributed much more equally.

Lesson 3: Compression of skill premiums, not skills. The wage compression observed in the Nordic countries could, in principle, have two sources: either workers there are more similar in their skills/productivity, or the labor market puts less weight on skill differences when setting pay. Data from the OECD's PIAAC survey help distinguish between these explanations.

On average, skill levels in the Nordics are high, and inequality in skills is lower than in the United States. Measured by the coefficient of variation – a statistic that captures the spread of scores relative to their average – skill inequality is about 30 percent higher in the U.S. Although not negligible, this difference in skills is modest compared with the gap in wages: hourly wage inequality is nearly twice as high in the U.S. as in the Nordics. In other words, differences in measured skills are far too small to explain the much larger dispersion of wages.

Statistical regression analysis points to the real source. In the Nordics, moving one standard deviation up the skill distribution ladder is associated with a 10-12 percent increase in wages. In the U.S., the same skill difference translates into about a 24 percent increase – roughly twice as much. This larger "skill premium" in the U.S. means that pay rises much more steeply with ability. A formal decomposition analysis confirms the point: the much wider dispersion in hourly wages in the U.S. compared to the Nordics is largely driven by higher returns to skills in the U.S., while differences in the distribution of skills themselves play only a minor role.

It may seem surprising that the extensive pre-market support provided by the Nordic model – generous family policies and universal access to high-quality education and health services – does not account for more of the relative equality in pay. Indeed, research shows that expanding such programs can improve outcomes, often with the largest benefits for low-income families. But these effects are not large enough to explain the much greater equality of earnings in the Nordics relative to the U.S. The real difference is made in the labor market.

Crown Prince Haakon visits the ship M/S *GANN*, a private upper-secondary school.

NTB/ALAMY

HOW WAGE BARGAINING SHAPES EQUALITY

There may be several factors that contribute to wage compression in the Nordic countries. Progressive taxes may reduce the payoff to capturing very high wages, and free higher education may lower the salaries needed to attract skilled workers. But the most natural explanation is institutional. We believe that the compression of wages in the Nordic countries stems primarily from their distinctive wage-setting arrangements. While practices vary somewhat across countries, they share two features: high union representation and strong coordination in wage bargaining.

Over the past 40 years, most Western economies have seen sharp declines in both union membership and collective bargaining coverage. But here, the Nordics stand out, starting from high levels of unionization and coverage, and experiencing only modest declines.

Wage-setting in the Nordic economies typically follows a two-tier system: sectoral negotiations establish wage floors, which are then supplemented by local bargaining at the firm level. This structure promotes coordination and results in compressed wages both within industries and across the broader economy. Whether unions and collective bargaining necessarily produce a more equal wage distribution is not obvious in theory since it depends on which workers are covered and how bargaining is organized. But in practice, the Nordic experience shows that coordinated wage-setting has played a central role in compressing wages.

Deichman Bjørvika Public Library in Oslo, Norway.

SERGIO AZENHA/ALAMY

In these countries, wages are set through a two-tier system. Base wages are negotiated at the national or industry level, and then local bargaining can add a supplement (often tied to firm performance) on top. Downward adjustments are rare, which creates stability, while the local flexibility ensures that pay can still in part reflect productivity differences across firms. The overall result is a wage structure that is both compressed and flexible – a defining feature of the Nordic model.

CAN THE NORDIC MODEL TRAVEL?

One line of thought, associated with the "varieties of capitalism" literature, sees different systems as broadly self-sustaining. Liberal market economies like the United States rely more on competitive markets and tolerate greater inequality. Coordinated market economies, like the Nordics, are anchored by social insurance and wage compression. Both systems can deliver high incomes, but their institutional complementarities make it difficult to switch from one model to the other.

Others are (even) less optimistic about transplanting the Nordic approach. In a world of globalized innovation, the argument goes, egalitarian economies can thrive only because they benefit from technologies developed in more unequal, "cutthroat" systems. By this view, the Nordics succeed as adapters and implementers of innovations that origi-

nate elsewhere. Thus if the United States tried to adopt the Nordic model, the concern is that global innovation would slow, leaving everyone worse off.

But not all theories see equality and efficiency in conflict. The Rehn-Meidner framework, developed in Sweden after World War II, argued that wage compression could actually enhance growth by channeling labor and capital away from low-productivity firms and toward more advanced ones.

Later formal models showed that narrowing wage differences can accelerate structural change, push firms to invest in new technologies and create more high-quality jobs. Others suggest that generous social insurance encourages workers to adapt more readily to globalization and technological change, reducing resistance to economic restructuring that enhances productivity.

What does the evidence say? The verdict is still out. Some studies show that periods of wage compression in Sweden coincided with strong productivity growth. But whether one caused the other – or both were shaped by outside forces – remains uncertain. Most of the evidence rests on case studies, anecdotes and cross-country comparisons, which can miss important influences and blur the line between correlation and causation.

REMAINING PUZZLES

Our finding that much of Nordic equality reflects compressed wages sustained by coordinated bargaining implies that high-skill workers earn less than they would under a more decentralized wage-setting, and low-skill workers earn more. This arrangement raises several questions.

First, why hasn't compression inhibited education and skill formation? Standard theory predicts that when the wage payoff to schooling is modest, people will invest less in human capital. Yet the Nordics remain among the most highly educated societies in the world. Free higher education, reduced risks of failure and strong social norms may offset weaker financial incentives, but a more precise explanation is elusive.

Second, why haven't highly skilled workers left for greener pastures? In open economies, one might expect top professionals to migrate to where their skills command higher returns. But Nordic countries have not seen such an exodus. Here, the quality of life and generous family policies may be key to retaining talent.

The Nordic model also has unique attractions for entrepreneurs and investors: compressed wages mean skilled labor is cheaper, which can raise the returns to capital. One indication of this effect is Nordic economies' contrast between low labor market inequality and highly concentrated wealth and capital income – a greater contrast than in many OECD countries. This raises the possibility that by boosting profits, compressed wages may fuel wealth inequality even as they limit income inequality.

* * *

Our understanding of how and why the Nordic model works is still limited, and many causal links remain unclear. Yet the Nordic experience shows that equality and high levels of prosperity can coexist and, in some cases, reinforce each other. As former Swedish Prime Minister Göran Persson quipped, the Nordic model is like a bumblebee: by the laws of textbook economics, it shouldn't fly – and yet it does.

The real challenge is not simply to observe that the Nordics do fly, but to understand how wage-setting, skill formation, capital markets and migration interact to make flight possible, and whether those conditions can be replicated elsewhere.

The Real Story of Inequality

BY EUGENE STEUERLE

Even if we act to erase material poverty, there is another greater task, it is to confront the poverty of satisfaction – purpose and dignity – that afflicts us all.

— ROBERT F. KENNEDY

LEFT: RENATA TYBURCZY/ALAMY; RIGHT: A TEUFEN/CLASSICSTOCK/GETTY IMAGES

Everyone knows that the United States is a highly unequal country. But what does that really mean? Since the Occupy Wall Street protests of 2011 and a raft of books on inequality that began appearing as the Reagan Revolution unfolded, the conventional wisdom has been that the economic divide between the rich and everybody else has been inexorably widening. When Representative Alexandria Ocasio-Cortez wore a gown emblazoned with "Tax the Rich" at the super-elite 2021 Met Gala, *The New York Times*'s Maureen Dowd drily remarked that the self-styled radical was expressing an opinion already held by a solid majority of the public.

Once only the focus of left-wing activists and economists, inequality has emerged as a mainstream issue. Republicans have always struggled to gain electoral traction simply by appealing to business interests and arguing – correctly, when accurately expressed – that increased investment in the economy can and often does benefit many, not just the investors. Recently, they have gained office by capturing working-class voters through what is essentially an "inequality" appeal: that they have been left behind by the "elitist" Democrats.

However, talk about inequality is cheap and often superficial. Politicians, pundits and even researchers frequently only present the data that best supports their arguments. We must sift through the misdirection to clarify what we know and what we don't about different forms of inequality and why those differences matter.

Compared to many other periods in our nation's history, the years since 1980 have seen regression in the share of both societal wealth and income held by the poor, working class and middle class. This is particularly true for market wealth, such as stocks and homes, as well as market incomes, primarily cash wages.

In our Re-Gilded Age, the top 1 percent of U.S. households in 2022 could claim to hold nearly one-quarter of the nation's market wealth. Correspondingly, rising wealth and market income inequality have coincided with a decline in social mobility. Children from families with low or moderate wealth are less likely to exceed their parents' earnings and ascend the social ladder when compared to their ancestors a half-century ago – or to their counterparts in other wealthy nations.

Human capital involves not only the capacity to earn money from work but also the social, cognitive, teamwork, and empathy skills that typically lead to greater success in both school and the workplace.

These decades have also coincided with what labor economists, demographers, journalists, historians, evolutionary biologists and policy analysts describe as a multi-decade increase in low-wage, economically insecure jobs, a transition from a "we" to an "I" society, a focus on the individual and individualism, and growing stress within society.

People with even modest amounts of market wealth face much less risk in life. They have the means to ride through bad periods, whether accidental or not. Unemployment and lack of income are less of a threat. They are much less likely to borrow and get sucked into the high interest rates – not to mention the outrageous fees – lenders typically charge low-wealth, low-income borrowers.

While above-average market income can provide a steady source of support, a family with equity in a home of $400,000 typically will need about $20,000 less annually that would have gone to pay for renting an equivalent place. Put another way, the family will have $20,000 in extra "income" provided by that housing wealth.

That's a nice base on which to rely, a type of insurance that both adds to income and reduces the risk of getting evicted from a rental

GENE STEUERLE, a former deputy assistant secretary of the U.S. Treasury, is a co-founder of the Urban-Brookings Tax Policy Center. **This article is adapted from his new book, *Abandoned: How Republicans and Democrats Deserted Working Families, the Young, People of Color and the Pursuit of Wealth-Building and Opportunity for All*. Special thanks to Andrew Yarrow for his analytic assistance.**

when unemployed or facing humongous medical bills. The equity can also be tapped for emergency loans, starting a small business or supporting a better retirement. Moreover, affluence begets affluence. Individuals with above-average net worth or market income typically reside in neighborhoods with superior schools. They frequently associate with others who are aware of job or business opportunities that offer them further income gains. They can afford to take risks in moving to new jobs or choosing to retire early. They pass on their net worth and skills to their children, extending a cushion to the next generation.

MARKET VERSUS TOTAL WEALTH AND INCOME

Although effective policy design requires making crucial distinctions about various forms of inequality, progressives at times seem to suggest that anything that makes the income distribution more equal must be good policy. Rather than engage the issue, the second Trump administration has one-upped them and banned the discussion by penalizing civil servants and government contractors for even using terms like "equity."

In addition to market wealth or net worth – such as ownership of homes, retirement plans businesses and other assets – employers, social scientists and economists frequently emphasize the importance of another type of wealth: human capital.

This encompasses a broad range of abilities and opportunities that allow us to thrive and contribute more effectively in the market, community and at home. Human capital involves not only the capacity to earn money from work but also the social, cognitive, teamwork, and empathy skills that typically lead to greater success in both school and the workplace. Just as market returns from wealth, such as stocks and bank accounts, appear in the form of dividends, interest and capital gains, the market returns to human capital primarily manifest as wages and other types of labor compensation, including employer-provided health insurance.

I generally use the terms, "wealth" or "asset ownership" to refer to both market wealth and human capital. And for the most part, I consider wealth accumulation synonymous with the attainment of upward mobility and the creation of greater opportunity. There are no measures of this concept of total wealth per se. What we can examine, however, are both market wealth and market incomes. The former entails real and financial capital (excluding human capital), while the latter refers to the combined market returns from both market wealth and human capital.

Just as market wealth differs from (unmeasurable) total wealth, market income also differs from (measurable) total income. Total income equals market income plus income from government benefits, like Social Security, less taxes paid. Note that the degree of income inequality varies considerably depending on whether government transfers and taxes are included.

WHERE IS INEQUALITY MOST PRONOUNCED?

If you conduct a quick review of news coverage on inequality, you will observe that Democrats cite measures of growth in any sort of economic inequality as a justification for a larger government, while Republicans defend the status quo by praising alternative measures that suggest inequality has increased less, if at all. Even academics debate over who has measured the growth in inequality most accurately. The question, however, should not be, "What is the right measure?" A more pertinent question is, "What are the implications

BEN HASTY/MEDIANEWS GROUP/READING EAGLE VIA GETTY IMAGES

of the alternative measures for individual well-being and policy?"

To clarify matters:

• *Net worth* or *market wealth* usually refers to holdings of financial and real assets, less debt.

• *Market income* refers to labor income plus the returns to market wealth. Note that federal income tax returns capture wages, dividends, interest and other items of market income, but still exclude a number of other items such as employer-provided benefits and the implicit returns (rents) to owner-occupied housing. Because gains from assets are hard to measure, most measures include only gains realized when assets are sold.

• *Labor income* refers to earnings from work. (Another confusion here is that much business income includes returns to both labor and capital, both of which are captured in measures of total income even if they can't easily be separated.)

• *Wages* refers to cash wages.

• *Total income* refers to the combination of market incomes from labor and capital, plus transfers less taxes from the government. It excludes benefits from public goods like defense and toll-free roads.

• *Consumption* refers to measures of goods and services that people consume.

I've organized this list hierarchically according to the degree of measured inequality, ranging from highest to lowest. Net worth inequality is significantly greater than inequality in market income, labor income or wages, and all measures of market income show greater inequality than measures of total income inequality that include government transfers and taxes. Consumption inequality can be useful in some contexts, such as determining whether individuals have adequate food and shelter. It sometimes receives support from economists who further assume –

AL SEIB/LOS ANGELES TIMES VIA GETTY IMAGES

and it is entirely an assumption – that individuals' well-being can be approximated solely by their consumption.

Yes, the rich and the poor likely add the same amount of milk to their cereal. High-income Americans are more prone to pay for it with after-tax earnings, while low-income Americans are more inclined to use Supplemental Nutrition Assistance Program benefits. However, when comparing the houses for sale in East Hampton or Montecito to those in rural Kentucky or North St. Louis, or examining the clientele of Sotheby's versus that of Dollar General, one can see the limitations of this perspective in assessing social mobility and opportunity. Though President Jimmy Carter faced ridicule for his speech in 1979 on national malaise, he was not incorrect when he stated that "consuming things does not satisfy our longing for meaning."

MARKET WEALTH INEQUALITY AND ITS GROWTH

Almost all studies of generational mobility concentrate on market wealth and income, not consumption. No one assesses upward mobility by evaluating whether we receive more government-provided food stamps, health care or years of retirement support than our parents did. Consumption also does not fully capture the opportunities available to individuals. The influence of Warren Buffett is hardly measurable by his consumption – he lives the lifestyle of his upper-middle-class neighbors in Omaha.

Data on net worth and wealth inequality derived from the Federal Reserve's Survey of Consumer Finances every three years from 1983 to 2022 provide perhaps the best comparative snapshots of how wealth has grown for different classes of the population over recent decades. Families in the bottom 25 percent of

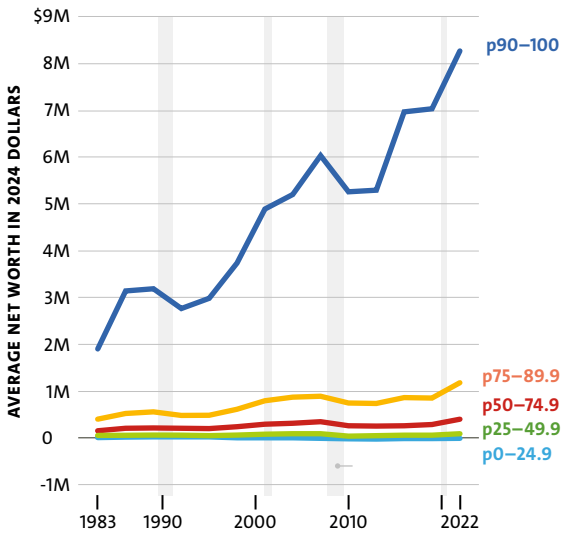
the wealth distribution had an average net worth that was negative in 1989 and thereafter. The net worth of the next two quartiles did roughly double from 1983 to 2022. Still, even in the second-highest quartile, average net worth had increased to only about $400,000 in 2022. Meanwhile, the net worth of those between the 75th and 90th percentiles nearly tripled, while those in the 90th to 100th percentiles saw their average net worth more than quadruple to over $8 million.

The growth and concentration of net worth within the top quintile conceal the degree to which it is concentrated at the very top. Using a slightly more comprehensive measure than the SCF, Jesse Bricker and his colleagues at the Federal Reserve found that the wealthiest 1 percent of Americans held about one-third of the country's wealth in 2019, up from roughly one-quarter in 1989. In contrast, the top 1 percent in Japan held about 11 percent of that country's wealth, while the comparable figure for Germany's top 1 percent was around 19 percent in the mid-2010s.

Surveys indicate that about half of Americans lack sufficient liquid assets to cover three months of expenses. In addition to the negative net worth of the lowest-income quintile mentioned above, over one-fourth of households were either unable to pay their monthly bills or were just one $400 financial setback away from being unable to pay them in full.

The data can mislead depending on the periods over which comparisons are made (the 1983 figures also use a slightly different methodology than those from 1989 to 2022). Additionally, from around 1990 to the end of 2021, the nation experienced an extraordinary bubble in the valuation of market wealth well beyond the creation of more wealth for more people in the form of equipment, housing and other capital. As of this writing, the bubble has remained inflated, despite a couple of small and brief sags. The long-term impact of this bubble remains uncertain.

RICHEST PERCENTILES DOMINATE



SOURCE: Author's estimates based on *Survey of Consumer Finances*

INCOME INEQUALITY

Measures of income inequality can be more confusing than those of wealth inequality. Even esteemed researchers disagree on what is included and how to measure it. A prime focus within the income inequality debate is over whether total income inequality has grown as much as often asserted.

The changes in market income are what matter here for two key reasons. First, these market measures are essential for assessing the decline in upward mobility within society, an area where public policy has largely faltered. Second, the rise in market income inequality, regardless of gains in transfers of government health and Social Security benefits, helps explain the modern rebellion among many working-class individuals (regardless of race or ethnicity,) and the young.

My income analysis is based on Congres-

MATTHEW DUBEAU

sional Budget Office data, a notably impartial and authoritative source, but I believe my conclusions would not differ significantly from those drawn from other sources. These data reveal that individuals in households within the bottom 20 percent of the market income distribution earned only 2 percent of total market income in 2021 – a slight decline from 1979. Every other income group, except for the top quintile (i.e., fifth), whose share rose from 48 percent to 63 percent, experienced a significant drop in their share. One caveat: 2021 was a Covid-19 year, and the share of the top group still increased by 10 percentage points from 1979 to 2019.

Another way to illustrate this dramatic change is to look at the decline in the shares of quintiles other than the top and bottom ones. For instance, the middle quintile (between the 40th and 60th percentiles) witnessed a drop of 4.4 percentage points from a base of 16.1 percent, indicating a 30 percent decline in its share of total market income.

Although wages dominate market incomes, health insurance, 401(k) plans and other employer-provided benefits change the dynamics for many. These benefits significantly enhance the compensation of the top three quintiles of the workforce.

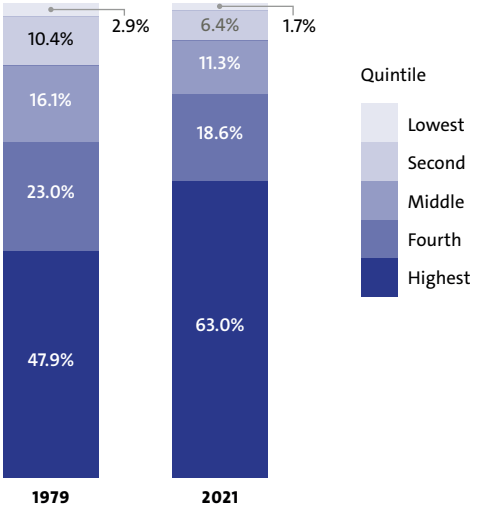
While some lower-wage workers are fortunate enough to secure jobs with employers that offer such perks, many lower-income and part-time workers do not receive employee benefits from what was once colloquially known as America's "private welfare state."

Furthermore, the rapidly rising dollar value of employer-provided health insurance – where a decent family policy can cost an employer well over $20,000 – does not improve workers' perceptions of their compensation. Anne Case and Angus Deaton, who documented the increasing numbers of deaths of despair related to drugs, alcohol abuse and suicide, attribute these issues partly to how "the U.S. healthcare system… is needlessly eroding workers' wages" while failing to provide preventive care. Meanwhile, Sylvester Schieber, a former chair of the Social Security Advisory Board, provides numerous examples illustrating how an employer-provided insurance policy that costs $20,000 or more can significantly limit the growth in cash earnings available to workers at nearly all earning levels, except for the very top.

At the same time, market income is an incomplete measure of total income because higher-income individuals pay a significant share of taxes and many receive transfers from a host of sources – indeed, lower-income and older individuals often receive transfers exceeding their market income. While what I call the "three Santas" of easy money – Democratic spending, Republican tax cuts and often zero borrowing costs – have likely alleviated a portion of the growth

HIGHEST QUINTILE'S SHARE OF TOTAL INCOME ROSE 15% FROM 1979 TO 2021

SHARE OF TOTAL HOUSEHOLD INCOME PER QUINTILE



SOURCE: Author's estimates based on Congressional Budget Office, *The Distribution of Household Income in 2012*

MATTHEW DUBEAU

The Tenuous Focus on Income

The focus on inequality in income terms is itself a relatively modern idea. For most of history, wealth or property and status received more attention. Two decades before the Declaration of Independence, Jean-Jacques Rousseau wrote in his *Discourse on Inequality* that beyond natural or physical differences among people, civil society is characterized by differences in "wealth, nobility or rank, power and personal merit."

A few years later, Adam Smith also presented inequality in terms that knitted together social status, wealth, and moral favor. Distinctions of rank are maintained by a "disposition to admire, and almost to worship, the rich and the powerful, and to despise, or, at least, to neglect, persons of poor and mean condition," Smith wrote in his *Theory of Moral Sentiments*.

Income inequality became a sharper focus in the 19th century, as the great British economist David Ricardo saw distribution between "rent, profit and wage" as the fundamental problem of political economy. Karl Marx, who juxtaposed the owners of the means of production and those who only owned their labor power, viewed inequality in terms of property and social class. For most economists, politicians, and activists even into the middle of the 20th century, the primary focus was on the conflict between owners and workers, not the broader economic distribution of income among individuals of different income and social classes.

The concept of human capital was expressed by Max Weber, the German social theorist, when he argued that power is based not only on the ownership of land and capital but also on status, physical strength, and knowledge – a concept that French social theorist Pierre Bourdieu expanded to include "cultural capital."

Inequalities in education and health, along with different forms of human capital, also contribute to economic inequality. Similarly, the enduring legacy of past discrimination helps explain issues such as the significantly larger wealth gap than income gap between Black and white Americans, as well as how our retirement systems provide the most years of support to those with the highest incomes. Does anyone fail to see how the anger and attacks on elite colleges by individuals with privileged edu-

in inequality in *total* income, they've also contributed to increasing inequality in *market* income and wealth by increasing household reliance on government.

WORK

Work, not just income, matters to individual well-being and how the historical debate over inequality has evolved from wealth to income. In particular, one cause of modern income inequality is the increasing divide between those with stable employment and those who have precarious work or are not working at all.

Changes in the unemployment rate tell us less and less over time about the impact of work on income and opportunity distribution. The most visible calculation of the unemployment rate – the number reported every first Friday of the month – only includes individuals actively seeking jobs during the previous four weeks. However, most nonworking Americans are not searching for

TOP: ANDREW LICHTENSTEIN/CORBIS VIA GETTY IMAGES;
BOTTOM: BENJAMIN C. TANKERSLEY/FOR THE WASHINGTON POST VIA GETTY IMAGES

cations, like Vice President JD Vance, correlate with the findings of Harvard economists Raj Chetty, John Friedman and others, showing that 38 elite colleges have more students from the highest-income 1 percent of families than from the bottom 50 percent?

Social reformers from Charles Dickens to Jane Addams, Michael Harrington and more recently, Michael Desmond, cared more about fighting poverty than inequality. When Harrington's *The Other America* was published in 1962, progressive social critic Dwight Macdonald even stated, "Inequality of wealth is not necessarily a major social problem per se; poverty is." Most War on Poverty initiatives under President Lyndon Johnson focused on alleviating poverty through government transfers.

There is a significant danger here, especially if poverty is defined merely in income terms. Means-tested programs aimed at the poor are relatively inexpensive, representing only a modest portion of total social welfare spending. An excessive focus on poverty often justifies neglecting how well the government serves all citizens. Some wealthy individuals prefer supporting research institutions that combine arguments for low tax rates with a government narrowly focused on poverty relief and a few public goods, such as defense.

To top it off, in the U.S., the official measure of poverty has not been adjusted since the early 1960s for growth in real income. The poverty level for an individual has decreased to about one-quarter of what a full-time worker at the median wage would earn. It continues to decline further in relative terms as per capita real income grows. Means-tested, annually appropriated programs aimed at alleviating poverty tend to fail politically compared to programs such as Social Security that grow automatically and without appropriations as fast as or faster than per capita real incomes.

jobs. Between 1950 and 2024, working-age male participation has almost continually declined from 86 to 68 percent, while female participation rose from 34 to 58 percent. Focusing only on the period from 2000 to 2024, the male participation rate dropped by six percentage points and the female by two percentage points. The United States, which likes to view itself as a nation of hard workers, has often lagged behind many other G7 countries.

So, who makes up America's large non-working class, what do they do and how do they get by? Setting aside the elderly, non-work has increased sharply since the 1970s among men with less than a four-year college degree. While some look for work or become active "house husbands," time-use studies find that many spend no more time caring for their children or doing housework than men with full-time jobs. TV and the internet, drugs and alcohol loom large. Department of Defense surveys find that 77

percent of 17-to-24-year-olds cannot qualify to be Army recruits.

The major reasons? Outside of ever-expanding lives in retirement (mainly for those already well-off), ill health, drug dependencies, police records and a lack of high school education loom large. When it comes to making ends meet, record numbers of younger men (read: well into their 30s) and a smaller number of women live with their parents or other family members. Some are supported by spouses or partners, some drift in and out of the workforce and others rely on government benefits. However, most members of this modern-day alienated proletariat aren't doing well by any measure, and their sizable ranks contribute to socioeconomic inequality and a rebellion against society that Richard Reeves and the American Institute for Boys and Men, and, earlier, Andrew Yarrow, so well document.

This is not a dismissal of the character of those left behind, but rather yet a further critique of how Republicans and Democrats uphold policies that fail to adapt to contemporary needs and conditions.

UNEQUAL OPPORTUNITY AND THE AMERICAN DREAM

The shortcomings of previous efforts to enhance the distribution of wealth and market income should motivate all parties to explore better methods for ensuring that each individual gains what the Nobel economist Amartya Sen describes as "capabilities" to attain a form of personal freedom.

In a sense, this has embodied the American Dream, which, while defined in many ways, has consistently focused on the belief that anyone, regardless of their birth circumstances, can achieve success through hard work. This concept, alongside freedom, has arguably represented the most defining characteristic of the United States in the eyes of the world. Visitors like Lafayette and de Tocqueville, along

WIRESTOCK CREATORS/SHUTTERSTOCK

JOHN LEYBA/THE DENVER POST VIA GETTY IMAGES

with early American leaders such as Benjamin Franklin, celebrated the strength of the middle class and the absence of pretentious European social hierarchies.

Although Horatio Alger's rags-to-riches stories were popular in the late 19th century, it was after World War II that strong, broad-based economic growth and an egalitarian, middle-class culture made the American Dream a spectacular reality. Most segments of society, including those not going to college and even Black Americans living under the legal racism of Jim Crow, achieved an increase in intergenerational social mobility.

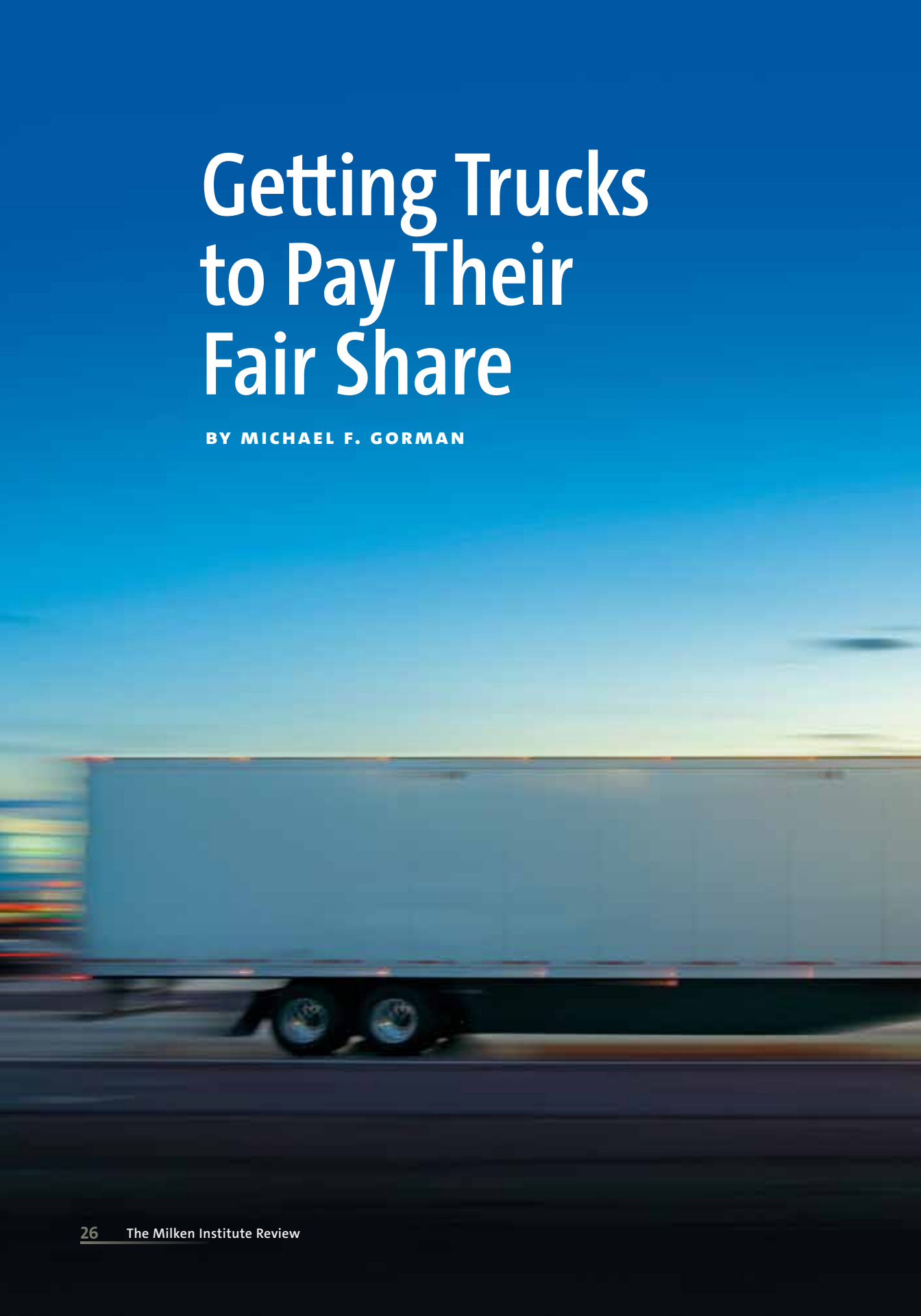
We all know what has transpired since, both here and abroad. For American children born in the 1980s – the Millennials – the likelihood of surpassing their parents' success by age 30 has decreased significantly. As MIT's Raj Chetty and colleagues have noted, kids born at the start of World War II had a 92 percent chance of earning more than their parents, while those born when Ronald Reagan was re-elected had only a 50 percent chance. Similarly, if income growth had continued to be distributed as evenly as it was between the 1940s and 1970s, 70 percent of that decline in mobility would be reversed.

* * *

So much for the land of opportunity. Government policies, supported by both parties, have predominantly prioritized wealth accumulation for the affluent and consumption for the masses, making it increasingly difficult for many Americans to build wealth and earn market income. I don't claim these are the only factors at play – racial discrimination and anticompetitive policies also require attention. Nor do I deny that various market forces, such as a more global economy, contribute to this issue. Rather, I'm convinced that government policy could have channeled those forces better to the benefit of the many.

Getting Trucks to Pay Their Fair Share

BY MICHAEL F. GORMAN



WHEN YOU FILL UP AT THE PUMP, there's always a sign showing how much of the price consists of dedicated state and federal road taxes. Well, that's okay, you say. Somebody has to pay for the roads ... who better than the folks who use them? ¶ Indeed. But it isn't nearly as simple as that. The wear and tear done by vehicles increases exponentially with weight, and fuel consumption is a very poor proxy for it – and getting worse all the time. Then there's the reality that fuel tax revenues cover only a fraction of the federal government's share of maintenance, leaving Congress to pony up from other sources. Here, I suggest a path toward syncing charges to users with the damage they do, beginning with trucks.

PAGES 26-27: THE PALMER/GETTY IMAGES

THE ORIGIN STORY

The Highway Revenue Act of 1956 created the U.S. Highway Trust Fund to pay for the Interstate Highway System, the most ambitious public works program in U.S. history. The idea was to ensure that adequate funds were available to maintain and expand the U.S. roadways to make the system sustainable, and to divide the cost in a way that seemed fair in a rough and ready way.

The HTF is funded primarily through fuel taxes at a flat rate per quantity purchased, which Congress increased slowly from its inception to 18.4 cents per gallon for gasoline and 24.4 cents per gallon of diesel in 1993.

MICHAEL GORMAN is the Niehaus Chair in Business Analytics at the University of Dayton.

RANDY DUCHAINE/ALAMY

But it has not risen since, in part due to trucking industry lobbying, in part to bipartisan political sensitivity to pump prices as a bellwether of inflation. As a result, the fund has been in deficit for nearly two decades. Currently HTF revenues are just half its expenses, and the gap is growing. That's why the Congressional Budget Office projects a cumulative deficit of $209 billion in 2034.

To keep the HTF solvent, Congress has periodically injected cash from the general fund. For example, in 2015 the Fixing America's Surface Transportation (FAST) Act allocated $70 billion to the HTF. Then the JOBS Act in 2022 allocated $550 billion to help revive the nation's transportation infrastructure, with $350 billion allocated to roads.

The federal government has been effectively subsidizing heavy users of the roadway system at the expense of light users and non-users. These subsidies of the road network have treated the network as a public good like, say, national defense, rather than one funded by the people or businesses that directly benefit.

Now, economists have long argued that the resulting inefficiency in pricing creates what is commonly referred to as the tragedy of the commons. The tragedy here is that a shared resource (roads) will be overutilized in the sense that users at the margin will add more to maintenance costs than they pay. Individually rational users pursuing their own interests thus do so at the expense of the greater good, and the common pool resource is overutilized. This is surely the case with the U.S. highway network, which is plagued by congestion and substandard road conditions.

The problem has grown along with the need for public subsidy, with highway users paying a shrinking fraction of the total usage cost. The fact that vehicles have both become more fuel-efficient and are increasingly being powered by electricity (allowing EV owners to escape payment altogether) has added to the inefficiency and the revenue shortfall.

That's where an alternative approach, the vehicle-mileage-traveled fee, fits in. The VMT is hardly a new idea: the economist Edward Manson put forth the notion in 1906 when just 33,000 cars were sold in the U.S., making reference to the fact that even the Romans implemented a usage-based road fee.

TRUCKING'S FAIR SHARE

Much more recently (2009), the congressionally mandated National Surface Transportation Infrastructure Financing Commission recommended a VMT as a means of financing road infrastructure that would eventually replace the fuel tax. The CBO recommended a similar funding structure in an independent report that emphasized the disproportionate damage caused by trucks. (More on the latter below.)

Given the magnitude of the funding shortfall and the inherent inadequacy of the gasoline tax base, it's plain that an alternative to paying at the pump needs to be found. I think the place to begin is to apply a VMT fee to trucks.

Starting with trucks makes sense for three reasons, all of which relate to the objections commonly raised to a VMT fee. First, although a healthy transportation network has some of the characteristics of a classic public good – society as a whole receives large benefits from the enhanced mobility it engenders – much of the savings from good roads accrue to the trucking industry and its business customers, which are, of course, profit-seeking private entities.

Second, because trucking is a commercial undertaking, the often-stated concern that the tracking of vehicles with electronic transponders needed to make a VMT viable would raise privacy issues doesn't seem applicable. Commercial entities are subject to an entirely different set of privacy standards. Besides, the tracking and reporting of truck movements is already commonplace throughout the industry.

Third, beginning with trucks creates the most revenue with the lowest tracking cost. The trucking industry would be the most logical source to start recouping costs with a VMT fee since trucks do far more damage to pavement per vehicle-mile than cars. There is already an extensive system in place to track the movement of trucks – owners need the information in real time to manage efficient routes and loads while toll roads already use transponders to collect electronically – making the implementation of a VMT fee quite tractable. Finally, there are far fewer large trucks than passenger vehicles, allowing for much lower administrative costs per dollar of potential fee revenue.

THE COST OF INACTION

Both drivers and engineers agree that the state of road infrastructure in the U.S. leaves some-

VITALIY BORUSHKO/ALAMY

thing to be desired. The American Society of Civil Engineers provides an annual report card on the condition of U.S. roadways, finding that 43 percent of all roads are in mediocre or poor condition. With a backlog in maintenance and expansion projects approaching $800 billion, current spending levels would need to be increased by about 30 percent just to prevent the maintenance gap from growing.

Consider, too, that roadway safety has grown worse, with a 60 percent increase in fatalities from 2011 to 2021 in spite of increases in mandated auto safety features like lane-change warnings and automatic emergency braking. And while road conditions are only partly to blame, better infrastructure would make roads more forgiving of careless and aggressive driving. While we're at it, don't forget climate change: extreme weather is inexorably adding to road maintenance needs.

Of course, all this is taking place in the context of the growth in vehicle use. The Bureau of Transportation Statistics reports overall highway road mileage has increased 7 percent and highway lane-miles 10 percent since 1993, when the tax was last increased. More importantly, truck miles have increased by some 75 percent – that's right, at least

seven times as much as total road mileage.

Of course, the mismatch of supply and demand for road capacity has resulted in significantly more congestion. The American Society of Civil Engineers notes that congestion delays increased more than 25 percent between 2014 and 2021, and it estimates that congestion costs the nation $166 billion each year, or $1,000 annually in wasted time and fuel for the average auto commuter – not to mention adding to smog and greenhouse emissions, and reducing safety.

TRUCKS' SHARE OF THE COSTS

The damage done by a vehicle to the road increases exponentially with weight – that is, other things equal, a 6,000-pound Cadillac Escalade exacts far more than twice the toll in road wear as a 3,000-pound Toyota Corolla. Indeed, in a now-famous, four-year study in the 1950s, the American Association of State Highway and Transportation Officials estimated that a 40-ton truck causes an astonishing 9,600 times more damage to pavement than a then-standard two-ton vehicle.

The external costs of trucking – that is, costs beyond drivers' time, vehicle depreciation, maintenance and fuel – are fourfold: pavement damage, environmental degradation, congestion effects and the safety of other drivers. The Federal Highway Administration estimated that these external costs add up to as much as 70 cents per mile (no typo) for the heaviest trucks. Trucks account for 40 percent of federal highway costs, but provide only one-third of the Highway Trust Fund's revenues.

TRUCKING REVENUE SHORTFALL TO THE HIGHWAY TRUST FUND ($ BILLIONS)

	HIGHWAY TRUST FUND (HTF) OUTLAYS 2023	TOTAL	TRUCK-TRAILER COMBINATIONS	SINGLE-UNIT TRUCKS
a	U.S. Dept. of Transportation HTF Outlays (not including mass transit)	$ 69.0		
b	Percent of HTF Outlays for Truck-caused Damage	40 %	29 %	11 %
c	HTF Outlays for Truck-caused Damage	**$ 27.6**	**$ 20.0**	**$ 7.6**
	TRUCK TAX REVENUE 2023			
d	Diesel Fuel Taxes	$ 10.8		
e	Heavy Vehicle Sales, Use and Tire Taxes	$ 6.2		
f	Total Current Truck Tax Revenue	**$ 17.0**		
	TRUCK TAX REVENUE SHORTFALL			
g	Truck Highway Miles Traveled 2022	229	158	71
h	Percent of Total Truck Miles	100 %	69 %	31 %
i	Current Truck Tax Revenue Attributable to Miles Traveled	$ 17.0	$ 11.7	$ 5.3
j	Shortfall to Balance HTF Outlays for Truck-Caused Damage	**$ 10.6**	**$ 8.3**	**$ 2.3**
	VEHICLE MILES TRAVELED (VMT) TAX TO COVER SHORTFALL	**BLENDED**		
k	VMT Tax Per Mile With Current Taxes in Place (j ÷ g)	**$ 0.046**	**$ 0.053**	**$ 0.032**
l	VMT Tax Per Mile With No Other Taxes (c ÷ g)	**$ 0.120**	**$ 0.127**	**$ 0.106**

SOURCE: a – U.S. Department of Transportation, 2023; b – Federal Highway Administration, 2000; d, e – Urban-Brookings Tax Policy Center, 2023; g – U.S. Department of Transportation, Vehicle Miles Traveled, 2022; c, f, i, j, k, l – author's calculation

MATTHEW DUBEAU

A gap, though perhaps not as great as you expected? Remember that federal and state trust funds cover only a fraction of road depreciation and maintenance costs. All told, David Forkenbrock of the University of Iowa estimated back in 1999 that in order for trucks to compensate for all of the externalities imposed by the trucking industry, the fees they pay would need to triple.

The industry warns that if trucks were forced to pay more to use the nation's roads, the costs would be passed through in the prices of myriad goods carried by the vehicles. But this is an oddly limited argument: the cost is now borne by taxpayers or just added to the accumulation in deferred road maintenance. Is that somehow better?

Moreover, this is not a zero-sum game in which a dollar of subsidy reduces consumer costs by a dollar. In a world in which trucks fully covered the external costs they generated, the relative cost of shipping by truck would rise, making it more attractive for long-haul shippers to switch to far more efficient rail. In a 2015 study, the Congressional Budget Office estimated that adding the unpriced external costs to the rates charged by both rail and truck – i.e., leveling the playing field – would shift 15 percent of truck freight to rail.

FOLLOW THE STATES

In an effort to reallocate the tax burden more fairly and to supplement the shrinking fuel tax base, several states have experimented with VMT fees, and a handful have applied them to heavy trucks.

- Oregon instituted a weight-mile fee to commercial operations on public roads for vehicles above 13 tons, with the fees ranging from 7 cents to 24 cents per mile.
- Kentucky charges a 2.8 cent per mile fee for all vehicles above 30 tons.
- New Mexico's VMT fee begins at 13 tons at 1 cent per mile and grows to a maximum of 4.5 cents per mile for the heaviest trucks. The revenue, by the way, is nothing to sneeze at: the VMT fee constitutes 21 percent of the New Mexico State Road Fund's revenue.

A balanced approach to structuring a federal VMT fee for trucking could be tailored to varying objectives related to which external costs of trucking you want to internalize: it could, for example, be limited to pavement damage or include everything from greenhouse gas emissions to road congestion. The objective of Congress might simply be to put the Highway Trust Fund in the black or to incentivize production of low (or no) emission trucks by tying the fee to tailpipe effluent.

It's worth noting that if the goal is to speed the transition to low-carbon energy, fuel taxes would remain the efficient and direct means. So, in a multi-goal scenario in which the objective is to internalize several different externalities of truck usage, a mix of fuel taxes and VMT fees would make the most sense.

That said, I propose a VMT fee structure that both closes the highway funding gap and makes shipping more efficient by capturing the damages associated with distance, tonnage and the number of axles. The latter must be included because more axles distribute the weight to more surface points, which reduces the damage from a given total vehicle weight.

There are legal constraints that vary by state on the minimum number of axles allowable for trucks of various weights. But the most common policy is to allow two axles to bear up to 33,000 pounds, five axles (in tandem trucks, aka semi-trucks) from 33,000 to 80,000 pounds and six axles (tridem trucks) above 80,000 pounds.

The table on page 32 shows key data with basic VMT fee calculations. Walking through the calculation for combination trucks:

Total outlays in 2023 for the HTF (omitting mass transit) were $69 billion (line a).

Truck-trailer combination trucks – what people refer to as semi-trucks – are responsible for about 29 percent of the damage-related outlays for highway maintenance and expansion expense (line b), which adds up to $20 billion (line c).

Total federal truck taxes in 2023 (diesel fuel and excise taxes) amounted to $17 billion (line f) with 59 percent of that coming from combination trucks, implying that the big trucks paid $10 billion less than their damage-related share.

In 2022 combination-truck miles in the U.S. totaled 157 billion (line g). This implies a 5.3 cent per mile shortfall between damage costs and heavy truck taxes (line k).

Applying the same methodology to smaller single-unit trucks yields a 3.2 cents per mile damage-revenue gap. Blending the two truck types leads to an overall average revenue gap of 4.6 cents per mile. So a VMT fee of 5.3 cents per mile for heavy trucks and 3.2 cents for lighter ones (to supplement the current fuel tax) would go a long way toward making federal highway funding sustainable without dipping into general revenues.

One caveat to this calculation: the appropriate tax per mile may be understated because the Federal Highway Administration has not conducted an analysis on road damage attributable to trucks since 1999. In the intervening years, average truck weight has grown by 15 percent. Meanwhile, as noted above, engineering studies show that the damage done to highway pavement by vehicles rises sharply and disproportionately with weight. In fact, it has been found that damage increases with the fourth power of weight. So doubling the load per axle increases damages 32-fold!

This implies that the efficient VMT fee would be far higher than our calculations. In any event, the table is based only on truck-miles and omits any direct consideration of truck weight, while an efficient user fee would be a function of axle weight. Given that combination trucks over 34,000 pounds generally operate on five axles, we assume that fewer axles are used at lower weights to reduce the acquisition, fuel and operating costs faced by the trucking industry.

Now, the Federal Highway Administration last reported on the weight distribution of trucks back in 2002. Assuming (quite plausibly) that the distribution of truck weight hasn't changed drastically, we can integrate these weight distributions into the VMT calculations to create a charge per axle-ton-mile.

For single-unit trucks, this fee ranges from 0.1 cent to 18 cents per mile. For combination trucks, the VMT fee ranges from 1.4 to 20 cents. The single unit trucks' fee increases by about 5.1 cents per 1,000 pounds, while the five-axle combination trucks' fee increases by about 2.9 cents per 1,000 pounds.

The result of the analysis is a truck VMT fee that offsets the truck-deficit portion of the Highway Trust Fund in the future, preserving its economic viability. But, do remember that it doesn't necessarily represent the full cost of the road damage done by heavy vehicles.

WHY NOW?

It almost goes without saying that the U.S. highway network is essential to the quality of life of Americans and to the health of the economy. But that could have been (and was) said about the United States 20 or 30 or 40 years ago to justify a VMT fee. What's different?

Start with the fact that the highway maintenance gap continues to grow. Add the fact that paying for the system by the gallon of

WATCHARA PHOMICINDA/MEDIANEWS GROUP/THE PRESS-ENTERPRISE VIA GETTY IMAGES

fuel sold is dependent on a shrinking tax base as fossil-fuel engines become more efficient and EVs offer the opportunity to avoid fuel taxes entirely.

Add, too, the fact that the idea of fees calibrated to the users of the services delivered (as opposed to new taxes) ought to appeal to a Congress controlled by conservatives.

Now factor in some political realities. First, a handful of states in desperate need of revenue have already broken the ice, overcoming trucking lobbies to impose VMT fees. Second, the federal cupboard is even barer than usual, with Washington running budget deficits of wartime proportions in a period of nearly full employment. And while the ultimate distributional burden of paying for roads with fees on trucks is not entirely clear, a VMT fee would sting less at this political moment than a broader-based increase in the fuel tax.

Well, if trucks are to be subject to fees, why not SUVs and cars? The mechanisms for collecting mileage fees from commercial trucks are proven and relatively cheap to administer, while generating substantial revenue per vehicle. The same can't be said for the hundreds of millions of other vehicles on the road. In any event, trying to broaden the base to include lighter vehicles would make the VMT fee an even harder political lift, yet generate relatively small sums.

* * *

In a country that demands higher-quality public services and doesn't want to pay for them with taxes, something has to give. VMT fees represent a timely opportunity for raising badly needed revenues without distorting markets by charging the direct beneficiaries. Anybody have a better idea?

Air Pollution Is Worse Than We Thought

The Case for a Multipollutant Cap-and-Trade

BY JUSTIN JOHNSON KAKEU, BRANDON HOLMES AND ETHAN ZIEGLER

In 2013, nine-year-old London resident Ella Adoo-Kissi-Debrah died after a severe asthma attack. Having suffered from a long history of respiratory illness, a public inquest ruled that air pollution exposure was a major contributing factor to her death. This unprecedented announcement marked the first time that air pollution was explicitly listed as a cause of death, prompting Ella's mother to take highly publicized legal action against the British government and to start a foundation for spreading awareness about the overlooked threats posed to children by toxic air. ¶ Why weren't existing regulations enough to protect people like Ella? One reason is that environmental regulation often gives short shrift to a relatively small number of places that bear the heaviest load of pollutants – typically places where poor people and victims of racial discrimination live.

NICK MOORE/ALAMY

London under a shroud of air pollution.

Indeed, questions of environmental justice have only recently become high priorities. Ella's case galvanized an ongoing cross-party initiative in the UK Parliament to establish clean air as a human right in what would be a groundbreaking acknowledgement of distributional environmental inequities.

But there is another widely overlooked reason why air pollution is more dangerous than generally understood. Governments continue to regulate air quality as though each contaminant exists in isolation, when in reality people breathe in a complex cloud of pollutants. And mounting evidence shows that assaying the damage caused by individual pollutants understates public health risk because many chemicals interact synergistically. So single-substance rules can miss damage only evident when exposures are combined.

To address the mismatch between law and lived experience, we propose a shift toward a multipollutant cap-and-trade regime that treats air pollution as a cumulative public health burden and aims to reduce it more holistically.

LIMITS OF ONE POLLUTANT AT A TIME

In the 16th century, the Swiss physician Paracelsus famously declared, "The dose makes the poison." And that principle has provided a powerful framework for assessing risk that informed generations of environmental and public health regulation.

By the 1970s, the proliferation of industrial chemicals and urban air contaminants led governments to codify the historic dose principle in law. In the United States, the separate National Ambient Air Quality Standards for each "criteria pollutant" – small particulate matter, ground-level ozone, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and lead – include maximum permissible load for each enforced independently.

These pollutant-specific limits were intended to simplify compliance and enforcement, but they had the drawback of cementing fragmented regulation. Regulators could declare "attainment" for ozone, for example, even if particulate matter or nitrogen dioxide levels remained dangerously high in the same community.

Other statutes carved out responsibility for

JUSTIN JOHNSON KAKEU teaches economics at the University of Prince Edward Island in Canada. BRANDON HOLMES and ETHAN ZIEGLER are research analysts at Resources for the Future, the environmental think tank in Washington.

Air pollution in New Delhi.

AMARJEET KUMAR SINGH/ANADOLU VIA GETTY IMAGES

distinct chemical categories such as the 1947 Federal Insecticide, Fungicide, and Rodenticide Act for pesticides, the 1976 Toxic Substances Control Act for industrial chemicals, the 1976 Resource Conservation and Recovery Act for hazardous waste and the 1974 Safe Drinking Water Act for waterborne contaminants. Each of these frameworks evolved in isolation, overseen by different offices within the EPA or other federal agencies, creating what experts now call "regulatory silos."

The patchwork allows little institutional space for addressing how pollutants interact in real-world environments. For instance, communities near major highways are simultaneously exposed to fine particulates, nitrogen oxides, and volatile organic compounds from vehicle exhaust, with each still judged against its own threshold without regard for their combined cardiovascular or respiratory effects.

In water systems, a community's supply might test below the legal limits for arsenic, nitrates and per- and polyfluoroalkyl substances (PFAS) individually, but the toxic load of these contaminants together can still pose significant risks to human health.

Occasional early warnings about gaps in public health coverage did emerge. In the 1960s, Rachel Carson's *Silent Spring* raised

Wildfire air pollution near Chita, Russia.

alarms about pesticide mixing, but such concerns were sidelined for decades. Technical challenges made testing every possible chemical combination impractical, and institutional inertia favored the simplicity of one-pollutant rules.

Market-based environmental policies that effectively put a price on pollution, while often more flexible and cost-effective than prescriptive regulation, have so far done little to address these cumulative risks. Current emissions trading systems that incentivize reductions, such as the federal SO_2 trading program, regional NO_2 trading markets and global CO_2 cap-and-trade schemes, are designed for single pollutants. They often succeed in lowering the targeted pollutant but can inadvertently worsen conditions for vulnerable communities if other co-pollutants remain uncontrolled. For example, a power plant might reduce its CO_2 output through fuel-switching but increase local pollution of particulate matter or toxic metals.

Regulators in Europe and the United States have begun exploring ways to integrate cumulative risk considerations into environmental policy. Yet progress remains slow. And closing the gaps left by fragmented and single-pollutant rules requires more than administrative reform. It demands a reckoning with the science itself. Below, we dig a bit into these issues, offering evidence that pollutants combine in real-world settings to produce harms far greater than the sum of their parts

EVGENY YEPANCHINTSEV/SPUTNIK VIA AP

– and why this makes it impossible for one-pollutant safety limits to ever fully protect communities.

THE SCIENCE OF MIXTURES AND WHY IT'S TIME TO RETHINK THE MODEL

Modern toxicology is moving decisively beyond the old assumption that chemicals act independently. When substances co-occur, they can combine their effects additively – each contributing to a growing burden on the same biological pathway – or interact synergistically so that the combined harm exceeds the collective individual total.

A useful analogy is medicine: two mild drugs taken together can produce side effects far worse than either alone. The same logic applies to tiny amounts of disparate pollutants that converge on the same hormone system or cellular 9oprocess. For example, laboratory reconstructions of maternal blood composition have shown that low-dose mixtures can disrupt thyroid signaling in developing neural tissue – outcomes that no single chemical's profile would have predicted. Epidemiological cohorts increasingly tie routine, low-level mixtures to higher risks of certain cancers, endocrine dysfunction and neurodevelopmental impairments even though each constituent sits below its regulatory limit.

The technical problem of getting a handle on these interactions is daunting, with thousands of chemicals and millions of possible blends to consider. But it is no longer intractable: high-throughput bioassays (laboratory tests that expose living cells or tissues to chemicals to measure biological responses such as toxicity, hormone disruption or DNA damage), mass-spectrometry imaging (which maps chemicals inside tissues) and computational models now let scientists triage which combinations are most likely to be hazardous and therefore worthy of regulatory attention. Indeed, policymakers can now see that additive and synergistic effects are common enough to change how we set standards.

Drinking water illustrates the gap between law and reality. Utilities routinely meet contaminant-by-contaminant standards while delivering blends of arsenic, nitrates, pesticides, disinfectant byproducts and PFAS to households every day. The 2014 Flint, Michigan, water crisis painfully demonstrated how lead exposure in conjunction with corrosive treatment chemistry and disinfectant byproducts produced health outcomes no single standard predicted.

For regulators, the lessons are strong: drinking water rules must require cumulative-risk assessment, utilities must model and

Industrial air pollution during a visit to the Forbidden City, Beijing.

ANDREA VERDELLI/GETTY IMAGES

report combined exposures, and remediation funding and legal-technical support should be prioritized for overburdened watersheds and communities.

The stakes are highest for the very young and very old. Fetuses and infants are exposed to maternal chemical mixtures – phthalates, bisphenols, flame retardants and numerous other compounds – that readily cross the placenta and act on precisely timed development pathways. Laboratory reconstructions of real-world maternal mixes have disrupted thyroid-mediated neurodevelopment at concentrations commonly found in pregnant women, and longitudinal human studies link higher combined prenatal loads to lower IQ, increased ADHD risk and other persistent deficits.

With the elderly, multipollutant exposure further increases already elevated base risks of respiratory and cardiovascular issues in addition to geriatric neurological conditions like Alzheimer's disease. Because these effects accumulate during narrow windows, regulating chemicals one by one fails to protect the most vulnerable: a dozen individually "safe" exposures together can alter developmental trajectories in irreversible ways. It thus makes sense to require mixture-based testing for chemicals that cross the placenta and to build on our knowledge with long-term birth-cohort studies that measure combined exposures and life-course outcomes.

Urban air is the paradigmatic cocktail. A single breath in a city can deliver fine particulates laced with metals and organics, nitrogen oxides from traffic, ozone produced in sunlight, sulfur compounds from industry and a cloud of volatile organic compounds. Epidemiology shows that days with elevated multipollutant burdens produce larger spikes in asthma attacks, heart attacks and hospital visits than single-pollutant metrics predict. Research has shown that particulates act as carriers, ferrying adsorbed toxins deep into the lung and into systemic circulation.

In practice, pivoting means embedding the assessment of mixtures into standard-setting:

• Introducing conservative mixtures assessment factors where co-exposure is likely

• Redesigning economic tools so pollution externality taxes and tradable allowances reflect cumulative toxicity rather than single-pollutant volume

• Creating multipollutant cap-and-trade systems that reward reductions in broadly defined toxic portfolios

It also means upgrading monitoring systems, so air, water, product and biomonitoring data are interoperable and discoverable across agencies that require manufacturers and registrants to submit mixture-toxicity modeling or testing when products are authorized – not to mention reforming statutes and interagency cooperation to permit cross-program action. The next step is to consider how these scientific insights can be translated into a market design that creates efficient incentives to cut the entire portfolio of emissions.

THE CASE FOR MULTIPOLLUTANT CAP-AND-TRADE

How do we bend market incentives so firms reduce the mix of pollutants that do the most harm? A multipollutant cap-and-trade system answers that question by converting the single-permit market into a bundled-permit system that manages firms' pollutant portfolios rather than regulating isolated emissions.

Before going into the details, it helps to recall the logic of conventional cap-and-trade so the contrast is clear. A traditional cap-and-trade program sets a hard limit – an overall cap – on emissions of a single pollutant, then distributes allowances up to that cap, and lets firms buy and sell those allowances so the pollution control is undertaken by emitters who can manage the process at least cost. The multipollutant variant, by contrast, bundles rights across several pollutants into a single permit and is explicitly grounded in mixture toxicology and health-impact evidence.

Regulators set an aggregate cap informed by those scientific and public health priorities, issue a fixed number of bundled permits and allow firms to trade those multipollutant permits. A company that reduces its portfolio of emissions below its allotment can sell unused permits to other firms or perhaps sell them back to the regulator. When the regulator permanently cancels a returned multipollutant permit, the supply shrinks and the overall cap tightens.

Because each permit covers multiple pollutants and prices embed health-weighted values, the market rewards investments that reduce several harmful emissions at once. An important design point here is firm heterogeneity: firms differ dramatically in the pollutants they emit. A coal-fired power plant typically releases SO_2, NO_2 and PM2.5 (ultra-small particulates), while a metal smelter emits toxic metals and PM2.5, and a chemical plant releases volatile organics. So a one-size-fits-all bundled permit would not be efficient in achieving public health goals informed by the science of chemical mixture.

Instead, regulators should design several types of bundled permits that reflect the market's mix of firm profiles and dominant emissions portfolios. A heterogeneity-aware permit structure allows a matching mechanism to allocate bundles that fit firms' technical capabilities and abatement costs, improving allocative efficiency and nudging capital toward holistic abatement technologies that cut the chemical mixtures that matter most for health.

Yes, this isn't simple, but practical building blocks already exist. Integrated multipollutant management programs and multipollutant monitoring networks offer the data backbone needed for designing bundled markets. Additionally, a Resources for the Future

policy brief lays out concrete schematics for institutional relationships and permit structures that are directly usable in pilot settings.

Several factors make the design especially attractive. First, it preserves market flexibility: firms retain the ability to choose the lowest-cost path to compliance. But now that choice must account for the health impacts of the whole emissions mix. Second, it channels investment toward holistic abatement technologies – filters and process changes that cut particulates, toxic metals and volatile organics together – because such technologies earn greater returns in a market that values pollutant portfolios. Third, the approach can be tailored to equity goals: permits can be weighted or phased so that reductions concentrate in neighborhoods with the highest cumulative exposures rather than only where abatement is least expensive.

There are positive dynamic effects at work here, too. Bundled-permit markets could reshape incentives so firms innovate broadly to cut the total health burden of their emissions. Unlike narrow single-pollutant programs that encourage end-of-pipe fixes, multipollutant markets reward system-level solutions – advanced catalytic systems, integrated biofilters and process redesigns. Those market signals accelerate the development and deployment of technologies that reduce multiple harms at once, delivering larger and more durable public health gains.

Equally important, bundled markets can spur cross-firm partnerships and industrial redesigns that treat pollution as a collaborative design challenge. For example, if neighboring plants each emit elements of the same harmful mixture, they can co-finance a shared technology – say, a centralized filtration unit or a heat-recovery system – that reduces several pollutants at once and lowers permit exposure for both. By adjusting the permit limits in a constructive manner, these market-based approaches create a self-perpetuating scheme that continues to improve air quality over time while fostering key industrial innovations that reshape the energy and manufacturing sectors.

All that said, implementation requires careful sequencing and interdisciplinary work. Constructing bundles requires toxicological and epidemiological inputs so the market price genuinely reflects health harms. Monitoring and verification systems must be robust so trades correspond to real reductions, and additional oversight will likely be needed to ensure the effectiveness of the bundles. Market design must explicitly prevent volatility

Canadian wildfire air pollution in New York City.

ANGELA WEISS/AFP VIA GETTY IMAGES

and perverse incentives – and agencies would likely need new statutory authority to issue bundled permits and coordinate across jurisdictions. An RFF working paper formalizes much of this architecture, drawing on mathematical economics tools to match heterogeneous firms to permit bundles in a way that maximizes social welfare while meeting environmental goals.

How to begin? A pragmatic rollout is the sensible path. Start with pilots in well-bounded sectors or regions – an industrial cluster, a power-generation region or a metropolitan airshed – where monitoring is already strong and the mix of pollutants is well understood. Pair pilots with independent evaluation, transparent data sharing and direct engagement with affected communities so adjustments are based on evidence and equity, not conjecture. Funding interdisciplinary teams that link economists, toxicologists and public health experts would help translate pollutant reductions into health gains and use those health metrics to set permit weights and price signals.

Multipollutant cap-and-trade is not a silver bullet, but it is a realistic mechanism to bring market discipline to the messy consequences of the chemical brews generated by modern economies. Policymakers have the opportunity to move from idea to evidence by funding pilots, building up monitoring capacity and commissioning the interdisciplinary research needed to design permit bundles that reflect real public health stakes.

FROM CONCEPT TO IMPLEMENTATION

The shift from single-pollutant to multipollutant regulation requires more than a technical adjustment. It represents a structural change in the way governments conceive of environmental risk. Existing regulatory systems were built around pollutant-by-pollutant statutes and agency divisions, and this fragmented architecture resists reform. As multipollutant research leaders George Hidy and William Pennell argued in 2010, reform requires not only technical expertise but also explicit statutory direction – legal mandates that acknowledge multipollutant assessments must be conducted as a matter of course, rather than as exceptions.

Even with strong political will, multipollutant regulation confronts the inherent difficulty of measuring and modeling chemical mixtures. Science has advanced dramatically in recent years. Epidemiological evidence now shows that mixtures drive health outcomes that no single-pollutant assessment would predict. New statistical and computational tools help make sense of this complexity. Artificial neural networks – machine learning systems designed to capture nonlinear relationships – have been applied to pollution datasets in São Paulo, Brazil, to improve predictions of mortality risk under multipollutant exposures. Quantile-based g-computation, pioneered in recent epidemiological work, enables researchers to assess how incremental changes across multiple pollutants affect health, even when the changes in a variety of pollutants are statistically correlated. Both methods represent a leap beyond traditional statistical regression analysis, which falters in the face of collinearity and synergy.

Yet these advances highlight the need for robust infrastructure. The new modeling techniques demand high-frequency monitoring data, large sample sizes and computing capacity that many agencies still lack. Multipollutant regulation will thus require scaling up monitoring networks like the EPA's NCore stations, expanding coverage to disadvantaged neighborhoods and ensuring data interoperability across agencies. Without this empirical backbone, even the most sophisticated models cannot reliably guide policy.

Industry, too, faces uncertainty regarding multipollutant reform. Firms are accustomed to pollutant-specific regulations: a carbon price here, an SO_2 allowance there. A bundled-permit system that prices pollutant portfolios is unfamiliar terrain. And from a corporate perspective, uncertainty about future compliance costs can deter investment in abatement or clean technology. For example, a company considering retrofitting a refinery must know whether multipollutant reductions will be rewarded in future markets or if only carbon emissions savings will count.

Evidence from prior cap-and-trade programs shows that stable and credible regulatory signals are critical. Without them, firms delay investment or focus on short-term, pollutant-specific fixes. A 2007 Georgia case study found that clear multipollutant frameworks enabled firms to adopt technologies that reduced both particulates and chemical precursors to ozone, an outcome unlikely under fragmented rules. For industry, the challenge is not a lack of capacity, but a lack of predictable incentives.

Policymakers can take immediate steps that do not require a wholesale rewrite of environmental law. Governments can adopt multipollutant health-based indices like China's proposed health-risk-based air quality index, which integrates multiple pollutants into a single measure of risk. Doing so improves communication with the public and

Wildfire air pollution engulfing Los Angeles.

CITIZEN OF THE PLANET/EDUCATION IMAGES/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

ensures that regulators evaluate progress against health outcomes, not arbitrary pollutant-by-pollutant thresholds. Multipollutant cap-and-trade systems could bundle existing permits across pollutants, ensuring firms are able to profit the most from holistic abatement strategies. Regulators can further tailor these markets to equity goals by weighing permits toward pollutants disproportionately affecting vulnerable communities.

The path forward will not be easy. Institutional inertia, scientific complexity and industry uncertainty are real obstacles. In the United States, moreover, environmentalists and environmental science are facing a potent political backlash fed by special interest opposition.

But pollution and its health consequences aren't going away on their own, and it's hard to imagine a long-term equilibrium in which the political constituency for clean air and water is unable to reassert its clout. When it does, it is immensely important to recognize that the tools now exist to overcome the technological, administrative and economic challenges to multipollutant management, including advanced models that capture mixture risks, monitoring systems that measure multiple pollutants and policy designs that align financial incentives with health outcomes.

The signs are there for policymakers, industry leaders, scientists and the public to recognize air pollution as a holistic health crisis demanding integrated solutions. If Ella's legacy teaches us anything, it is that the price of delay is great and that a cleaner, fairer future is possible if we make it a priority.


002
001
001
003
002
001
003
792
217
921

In Praise of PRODUCTIVITY BURSTS

BY JAN MISCHKE, CHRIS BRADLEY AND OLIVIA WHITE

ILLUSTRATIONS BY SAM PEET

After powering U.S. prosperity for over a century, labor productivity growth has languished for most of the past two decades. But a recent surge presents a critical question: can the United States turn its latest productivity gains into a period of sustained growth? The answer will determine the nation's future competitiveness, especially in light of the promise of artificial intelligence against converging challenges like an aging population, geopolitical tensions, the push to reshore manufacturing, rising debt levels and broad economic uncertainty. ¶ For companies, productivity growth is the primary tool with which to face competition, and the only sustainable way to elevate profits, please customers, and raise employee compensation at the same time. For countries, it pays for increasingly critical demands from defense to the energy transition by expanding the pie and thus countering zero-sum thinking as well as political polarization. ¶ The challenge, by the way, is not confined to the United States. Since 2000, labor productivity growth has languished in most advanced economies, with many posting even smaller gains than the United States.

PRODUCTIVITY BURSTS

But if you think most productivity gains come from incremental improvements in efficiency across the broad swath of firms – or even from adopting new technologies like AI – think again. The reality is both more sporadic and more inspiring: there's strong evidence that a small cadre of standout companies making bold, strategic moves drive national productivity growth. This conclusion, drawn from a detailed analysis of thousands of firms, flies in the face of conventional wisdom and suggests the need for fresh thinking on the part of both business leaders and policymakers.

Today all eyes are on AI. Pundits debate how much breakthroughs in large language models and their widespread applications across traditional businesses will matter. But our research points to a different point of leverage for country-wide productivity gains: how will ambitious large or fast-growing firms use technology at scale to create new value through new business models, new customer value propositions or sweeping operational transformations?

THE STUDY

In our latest productivity research, we zoom in on firm-level contributions to productivity growth in four sectors (retail, automotive and aerospace, travel and logistics, and computers and electronics) for the United States as well as Germany and the United Kingdom. With detailed data for each country's companies, we measured the contributions that individual firms made to total productivity. We used the period 2011 to 2019, but also cross-checked conclusions with data through 2023. The study allows us to see how productivity accrues firm by firm, and even worker by worker.

JAN MISCHKE is a partner at the McKinsey Global Institute, McKinsey & Company's business and economics research arm. CHRIS BRADLEY and OLIVIA WHITE are directors and senior partners at MGI. This article is adapted from a new MGI report available at the McKinsey Global Institute website.

PRODUCTIVITY STANDOUTS

The results were striking. From our total sample of 8,300 firms, fewer than 100 – a group that we dub "standouts" – accounted for approximately two-thirds of the total productivity gains in the three countries. Numbers were even as striking in the United States. There, roughly 5 percent of firms powered 78 percent of the country's productivity growth.

U.S. standouts included household names like Amazon, Delta Air Lines and The Home Depot. Between 2011 and 2019, U.S. productivity growth in our sample of firms averaged 2.1 percent annually, far outpacing 0.2 percent growth in our German sample and virtually zero growth in the British sample. U.S. firms enjoy broad structural advantages including a less fragmented domestic market, more innovation- and investment-friendly regulation and a mature risk-capital ecosystem.

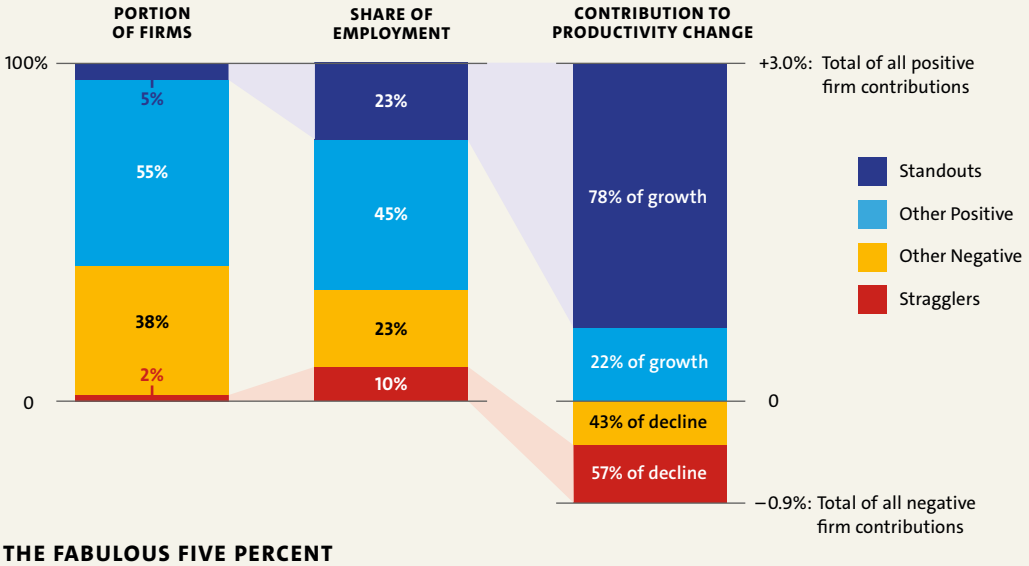
To give a sense of how important a single standout can be, consider that in the United States, adding another 30 standout companies of comparable size could have doubled aggregate productivity growth. That is the power of the top productivity contributors.

On the flip side, the firms that were responsible for the largest drag on productivity – we call them stragglers – formed a smaller group that also had outsized impact. In the United States, under 2 percent of firms in our sample were stragglers, but they were responsible for 57 percent of negative productivity growth.

WHERE TO FIND STANDOUTS

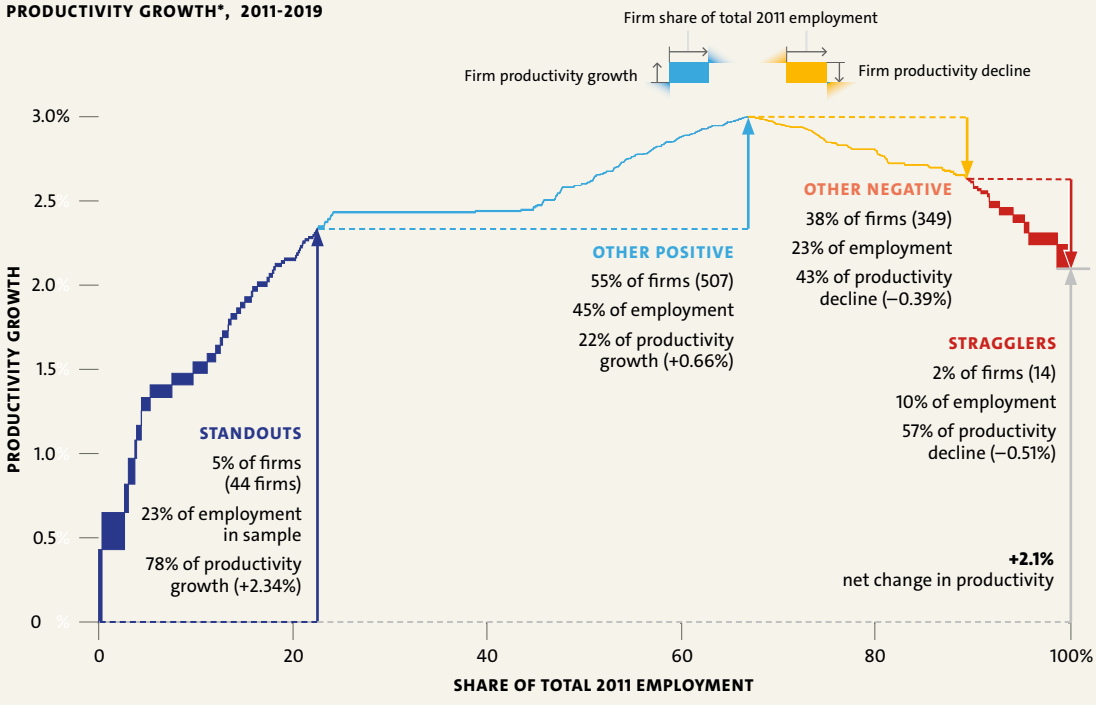
Standouts drove the bulk of gains in almost all subsectors that experienced rapid produc-

JUST A HANDFUL OF U.S. FIRMS* DRIVE PRODUCTIVITY CHANGE



THE FABULOUS FIVE PERCENT

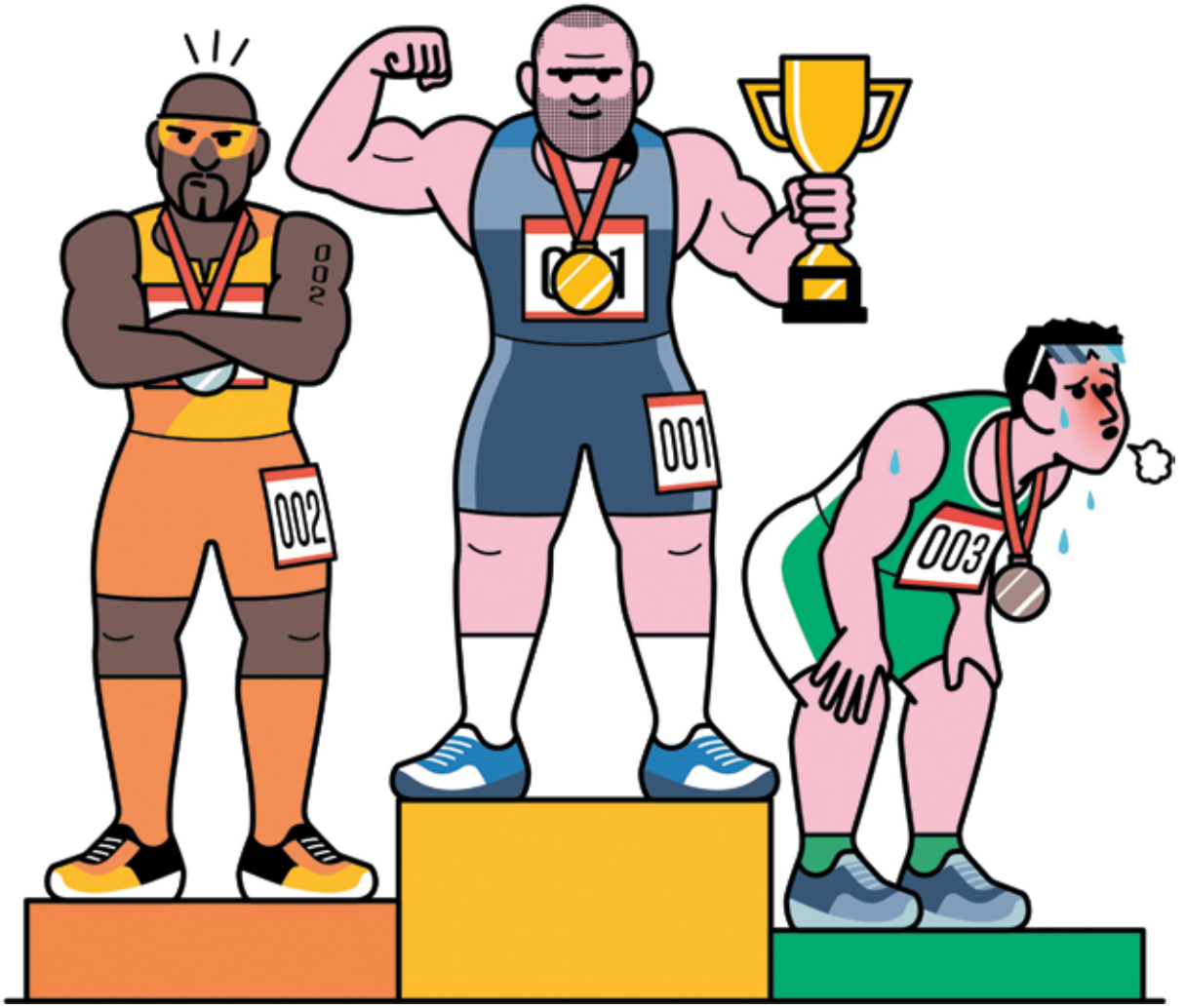
DISTRIBUTION OF CONTRIBUTORS TO U.S. PRODUCTIVITY GROWTH*, 2011-2019



* From a representative sample of 914 U.S. Firms

SOURCE: Moody's Investor Services, 2025; EU KLEMS; U.S. Bureau of Labor Statistics; Capital IQ; McKinsey Global Institute analysis

MATTHEW DUBEAU



tivity growth (defined as at least 2 percent per year). The relationship between standouts and sector growth is a symbiotic one. Standouts drive growth, but some sectors also have more promising conditions in terms of their market dynamics, technology, regulation and competitive settings to breed more standouts.

We found greater numbers of standout firms in sectors where participants could create new customer value and scale new business models than we did in sectors where success was largely driven by cost-cuts. To that point, across four sectors in our sample, about half of U.S. standout firms were in computers, semiconductors and electronic equipment.

CREATIVE DESTRUCTION REDEFINED

We found that much of the United States' productivity edge was driven by its dynamic reallocation of labor. Productive firms scaled up more rapidly, while underperformers shrank or exited faster. Among U.S. standouts, we see both high-productivity firms that expanded their workforces – like Apple and Amazon – as well as low-productivity firms that improved national productivity by shedding jobs or exiting altogether like Sears. In contrast, both Germany and the United Kingdom held on to their underperforming firms as stragglers, with fewer exits and limited workforce shifts.

This dynamism mattered. In the United States, the combined effect of firm scaling and exiting added 0.9 percentage points to productivity growth – nearly half the 2.1-percent total in the sample. In Germany and the United Kingdom, by contrast, labor reallocation made almost no contribution to growth.

U.S. policymakers and researchers have long recognized the importance of creative destruction. But too often, tracked statistics and investigations focus on the rate of firm entries and exits. In fact, new entrants do not do much for macroeconomic productivity: they remain too small and unproductive for too long to move the needle. Instead, the upside is measurable among leading firms that scale up ever further. Note, too, that the exits of low-productivity firms – especially larger ones with business models that are no longer viable – also contribute significantly.

WHO ARE THE STANDOUTS?

To better grasp what makes a standout in our analysis, we grouped firms according to how they drove productivity in their sector. At the top of the list, "improvers" were large firms that made bold moves to advance their productivity levels (per worker) for many workers. Most standouts in our study are in this group, especially large incumbents like United Airlines that made meaningful improvements by changing business strategies, value-added portfolios and scale.

Next, "scalers" started out above their sector's average productivity levels and then hired more people, thereby driving national productivity growth mostly via employment reallocation. In our study, about 20 percent are counted as scalers; Amazon and Apple are notable among them.

Almost the mirror image of scalers, "restructurers" are less productive firms that made a positive contribution by reducing their employment share or exiting the market altogether – like Sears in retail. Finally, "disruptors" grew productivity and share very rapidly, but actually made the smallest quantitative contributions when we crunched the numbers. About 10 percent of standouts started 2011 as smaller disruptors. Examples are varied, ranging from Germany's e-commerce player Zalando to Nvidia in the U.S.

Standouts with the most muscle to move the productivity needle for an entire economy are generally bigger incumbents. In fact, in the United States, the youngest firm in our eight-year sample was 11 years old and the average age was 60 – similar to the age distributions in the global sample. While younger, smaller and more niche-based firms may raise productivity at a faster pace, it takes time to develop the scale needed to make a dent in national productivity.

But while being large helps, size alone does not make a standout. In fact, while large firms are more likely than small ones to be standouts, they are also much more likely to be stragglers.

By the same token, while some standouts remain as top productivity contributors for many years, numerous ones drop in and out of the elite group over time. About two-thirds of all our 2011-19 standout firms (and nearly three-quarters of those in the U.S. sample) remained top contributors in the 2019-23 period. The other fraction fell back, with new firms taking their places. The story of productivity is bound closely to the story of flexibility and change.

THE MAKINGS OF A STANDOUT

Standout firms have little in common, at least at first glance. Their shared trait is not superior efficiency but a penchant for doing things differently and doing different things. Decision makers, take note.

PRODUCTIVITY BURSTS

Detailed case studies of standouts across all four sectors – retail, automotive and aerospace, travel and logistics, and computers and electronics – reveal a pattern. Standout firms tend to mainly rely on five strategic moves, often in combination.

Scaling more productive business models or technologies. For example, Apple shaped the mobile internet wave, rolling out its core iPhone business with new services, including Apple Music, iCloud and the App Store. As Apple was shaping mobile, Amazon was doing something similar for retail with e-commerce.

Shifting toward the most productive geographies and product lines. Standouts Apple and Broadcom moved into higher-margin services, General Motors withdrew from underperforming regional markets and Amazon branched into cloud-computing via Amazon Web Services.

Recasting customer value propositions. This strategy applies across markets – from mass to high-end niche – and it often comes in response to trends or competitive attack. For instance, The Home Depot improved both its physical stores and online integration to appeal to customers. Nvidia built a winning value proposition for graphics processing units and scaled it up.

Building scale and network effects. Examples of firms expanding scale include U.S. airlines, with their M&A activities that helped them improve route networks and aircraft capacity utilization, and Amazon, which broadened access to its fulfilment infrastructure to benefit both shoppers and partner retailers.

Transforming operations to make them more efficient and cut external costs. While this is the efficiency most commonly associated with productivity growth – at least among businesses – it was rarely the most important one in our case studies. This does not mean it doesn't matter, though. Almost all firms try to improve their efficiency and work to reduce costs constantly, and rightly so. But a focus on efficiency is rarely enough to become a productivity standout, except via large transformational programs.

These strategic moves often spark chain reactions, bursts of productivity that trigger more actions and responses. For instance, the success of Amazon in U.S. retail not only directly boosted productivity but also prompted responses from other firms. The Home Depot, in response to the e-commerce trend, reshaped value propositions in its own ways with online shopping and pick-up-in-store concepts, as well as closer customer proximity with a denser store network.

REVISITING PRODUCTIVITY POLICY

Policymakers would do well to take productivity seriously – not as an abstract macroeconomic metric but as a national imperative. Though often overshadowed by top-line growth and bottom-line profits at the company level, productivity is the rare force that benefits employees, consumers, shareholders and economies alike. Here are five important thrusts for decision makers to consider, some new and some evergreen, that warrant renewed emphasis.

Let leading innovators respond to scale incentives. Promising firms should have room to run to drive productivity growth. That doesn't mean giving monopolists a free pass – anticompetitive behavior should, of course, be curtailed to keep the market dynamic. Standouts and stragglers change over time, and they need to continue to do so. But competition policy should aim to maximize firms' contributions to productivity, and that includes leaders' ability to increase scale. Great economies are built with great enterprises.

Focus innovation and industrial policy on creating standouts. Industrial policy is often fixated on supporting "national champions" without serious consideration of whether these firms are (or are in the process of becoming) standouts or stragglers. On top of that, innovation policy tends to be spread thinly across millions of small and young firms. Only a handful of startups will have the ambition and ability to grow and generate meaningful gains at scale. With innovation policy, there's good reason to start with a very wide funnel. But there's also good reason to discipline access promptly in order to better fund the most productive and ambitious firms on a national level.

Don't prop up ailing incumbents. The reallocation of labor and resources away from low-productivity firms toward higher-performing ones has long been recognized by academic researchers as a driver of medium-term productivity gains. Comparisons with the EU and UK make clear that without a steady dose of creative destruction, economies risk forfeiting half of their productivity potential.

Our research offers new evidence to underscore the importance of letting ailing firms restructure or exit. And it shows the particular importance of steering larger stragglers to change or exit for the sake of national productivity spikes. Yes, these transitions are painful, especially for the workers and communities involved. But instead of trying to prop up poor performers, it would be better to provide resources to facilitate turnarounds or nurture new standouts.

Make input markets more dynamic. Factor markets are where businesses get the resources they need – labor, raw materials, land and capital. Training assistance and the offer of portable benefits can help make it easier for workers to find new jobs. Moreover, flexibility must not stop with labor. How flexible, for instance, are urban land markets? What product market regulations and permitting red tape stand in the way of leaders' growth? Policy adjustments can help businesses get the resources they need to thrive.

Look at the micro as well as the macro picture. Standard economic indicators often fail to capture the more granular sources of productivity growth on the ground. A refined approach would track the contributions of individual firms to aggregate productivity. Governments might task national statistics offices or economic councils with developing annual micro-to-macro productivity models – tools that could illuminate which firms, sectors and regions are truly driving progress. Companies themselves should put their productivity metric front and center.

* * *

For too long, the link between firm-level dynamics and aggregate growth has been blocked in a black box. Cracking open the box can yield actionable insights – and a more targeted playbook for both business and policymakers. To sustain the U.S.'s recent productivity acceleration, our research suggests it makes sense to identify which firms are positioned to contribute the most as they further scale and improve. Standout firms don't just tweak operations. They reshape whole industries, scale innovative business models and leverage technologies like AI in transformative ways.

Are China's Students Really Number One?

A Statistical Riddle

BY NICHOLAS N. EBERSTADT

In 2019, the world's leading authority on testing and comparing international educational performance announced stunning results from its latest round of examinations of 15-year-olds: China was number one across the board. ¶ PISA (the Programme for International Student Assessment, run under the auspices of the OECD) was so struck by the outcome that it introduced its five-volume report as follows:

> Students in the four provinces/municipalities of China that participated in the study outperformed by a large margin their peers from all of the other 78 participating education systems in mathematics and science. Moreover, the 10 percent most disadvantaged students … showed better reading skills than those of the average student in OECD countries.

China's test-takers outscored the average Western student by the equivalent of well over two grades of schooling. Even Singapore, long the global model child for stellar student achievement, was left in the dust.

VCG/VCG VIA GETTY IMAGES


静

CHINESE STUDENTS

More recent PISA scores for China are not yet publicly available. China did participate in the 2022 testing, but did not release those results. We do know, though, that Singapore's 2022 PISA numbers fell even further behind China's 2018 scores. China thus almost certainly remains in a class of its own.

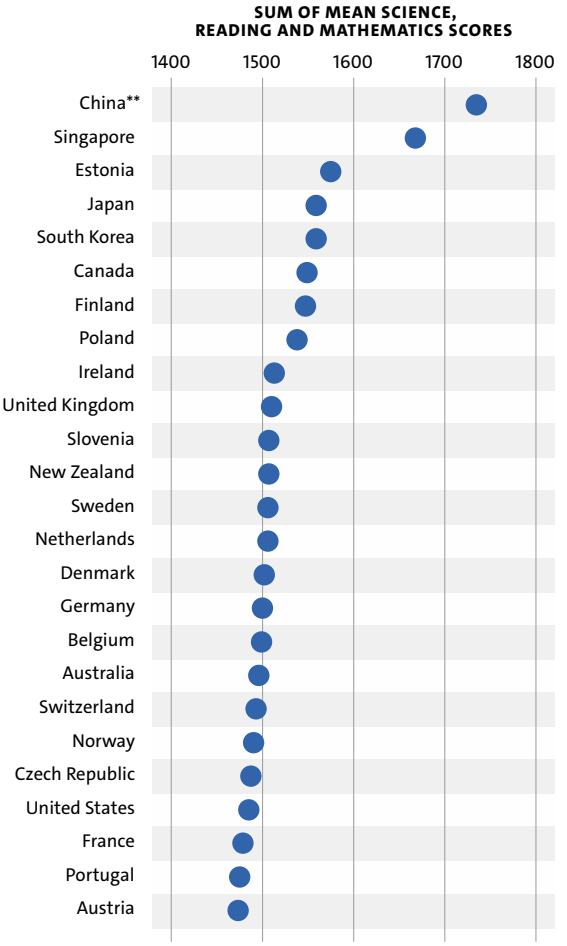
That ranking is more than just a point of national pride. "The quality of their schools today," the PISA report underscored, "will feed into the strength of their economies tomorrow." That conclusion comports with research by economists Eric Hanushek (Stanford) and Ludger Woessmann (University of Munich), who highlight the critical role in national economic performance of what they call "knowledge capital" – the knowledge obtained from education as opposed to sheer numbers of years in school. Simply put, better student learning today makes for greater workforce potential tomorrow.

My own research suggests that, after holding socioeconomic factors constant, a 100-point difference in mean PISA scores could make for a productivity difference of around 25 percent a decade hence, and of nearly 60 percent in 20 years if the gap remains constant. Thus China's seemingly spectacular student achievement would not only augur favorably for the country's continued rapid economic development, but also tilt geopolitical forces sharply in Beijing's favor.

But are China's test results too good to be true? Answering this question – the subject of this article – turns out to be much more complicated than one might think.

NICK EBERSTADT holds the Henry Wendt Chair in Political Economy at the American Enterprise Institute. **The author is grateful for the contributions of Patrick Norrick, Radek Sabatka and Peter Van Ness to this article.**

PISA* 2018: TOP 25 COUNTRIES



* Programme for International Student Assessment

** Beijing, Shanghai, Jiangsu and Zhejiang only

SOURCE: Organization for Economic Cooperation and Development

OPAQUE AND IRREPRODUCIBLE

While China's stunning PISA tests scores have raised some eyebrows abroad, they have been repeatedly defended by PISA administrators. Does that not mean they are beyond scrutiny?

Not quite. For one thing, PISA administrators and their partners at the Chinese Ministry of Education do not attempt to cover the entirety of China with their achievement testing. Instead, they have experimented with a

MATTHEW DUBEAU

shifting constellation of smaller, more limited geographical configurations in representing "China," as seen in the table below.

Even a quick perusal of these headline figures raises questions. PISA's 2018 sample, for example, earned higher scores than those recorded in 2009 for Shanghai alone – even though Shanghai is the country's most developed province and accounted for barely an eighth of PISA 2018's tested "China" agglomeration. Further, between PISA's 2015 and 2018 rounds of testing, "China" students reported an overall leap in mean scores of 65 points – approximately the same gap in scores as that separating the Netherlands from Mexico in PISA 2018.

Neither China nor PISA permits outsiders to work with the raw data, or even to see the test scores except on an aggregated basis of all four provinces. So it is impossible to compare test performance for, say, Beijing province in 2015 and 2018. Likewise, it is impossible to chart longer-term performance for Shanghai between 2009 and 2018, even though that municipality was tested in each wave.

Note, moreover, the peculiar changes to the roster of provinces representing China between 2015 and 2018. By swapping out Guangdong (the country's most populous province) for Zhejiang (a richer and much smaller province), PISA and the Ministry of Education opted for a smaller, less representative set of Chinese provinces for 2018 than the already unrepresentative one it had been working with in 2015. Why?

Although PISA 2018 ostensibly covered a swath of China accounting for more than 180 million persons, in actuality the sample involved just 361 schools and 12,000 students – about 33 students per school. We do not know the process by which those schools were selected, much less the identities of the schools or the protocols observed in the tests.

Even without better access to China's student aptitude data, though, a number of anomalies and curiosities from the reported results practically scream for closer attention. Consider a comparison between PISA's sample of China and that of Massachusetts, America's top-scoring state.

In 2015, Massachusetts' mean scores exceeded China's in reading and science. By 2018, however, a redefined China sample vaulted ahead of Massachusetts. Where Massachusetts's scores did not change dramatically over the short time span under consideration, China's surged. And between 2015 and 2018 China's share of low-performing students plummeted from 43 percent to 19 percent in reading, from 32 percent to 9 percent in math and from 38 percent to 10 percent in science. Nothing like these gyrations have been recorded elsewhere in PISA – ever.

Then there is the matter of performance for socioeconomic subcomponents of population. PISA allows analysis (at the overall "national" level for China) of testing differences by socioeconomic strata and household wealth. What occurred between 2015 and 2018 was most remarkable. In the course of just three years, the performance of students

PISA SCORES OVER TIME IN CHINA

TEST YEAR	MEAN SCORE	PROVINCES TESTED	% OF POPULATION IN TESTED PROVINCES
2009	577	Shanghai	1.7%
2012	588	Shanghai	1.7%
2015	514	Beijing, Shanghai, Jiangsu, Guangdong (B-S-J-G)	18.1%
2018	579	Beijing, Shanghai, Jiangsu, Zhejiang (B-S-J-Z)	13.8%

NOTE: B-S-J-Z participated in PISA 2022, but tests were not conducted due to COVID-19 school lockdowns.

SOURCE: Organization for Economic Cooperation and Development, author's analysis

MATTHEW DUBEAU

Prep class for the "gaokao," the Chinese college entrance exam.

CHEN BIN/VCG VIA GETTY IMAGES

from the lowest wealth quintile soared. In fact, by 2018 there was virtually no difference between test results for the poorest and the richest of test-takers in the sample.

The same was true for socioeconomic status – witness the leap for the least advantaged in reported China data. Here, too, the least-advantaged have come to perform like the most advantaged in just three miraculous years!

We compared these patterns of sudden social equity in pupil achievement with evidence from a variety of other countries including Brazil (another country with vast geographic expanses and some widely discussed socioeconomic differentials) and Vietnam (a poor Asian country that continues to perform far above socioeconomic expectations in PISA). But nothing quite like China's implied social revolution between 2015 and 2018 shows up in those other countries with more transparent data.

What to make of all this? We are inclined to believe that the Confucian tradition places a premium on study and academic excellence. We are prepared to believe that overall academic achievement could thus appear more favorable for China than our own statistical analysis based only on a country's socioeconomic indicators might predict. (That fits Vietnam.) But some of the results strain credulity. And it does not help that they are unverifiable.

TEST-CHEATING AND TEST-BEATING

Any investigation of test performance in China that does not acknowledge the extraordinary role of cheating is going to be missing an important aspect of what I call meritocracy with Chinese characteristics.

Inseparable from China's ancient tradition of merit-based examinations is the tradition of gaming tests for personal advantage. Widespread cheating on the Imperial examination for civil service jobs goes back centuries – tiny cheat sheets with tens of thousands of characters have survived from the Ming and Qing dynasties. And from at least the Song dynasty (AD 960-1279), which saw the advent of moveable type printing and thus something like mass publishing in China, Imperial examiners were preoccupied with preventing cheating.

Widespread test-cheating remains a fact of life in China today, practiced by enterprising students on an individual basis but sometimes involving large rings of teachers and high officials. Even when not technically cheating, gaming the system to perform better on tests has been worked to a fine science, and appears at times to be not only tolerated but admired.

Of course, China is far from the only country in which test-cheating is widespread: India and Indonesia are also among the numerous national competitors for this distinction. The point here is not that China is unique, rather that drawing inferences about "knowledge capital" from exam results in China risks appearing naïve if one ignores the cheat factor.

The PISA test may just be an example of an academic exercise in which officialdom in China is highly incentivized to "over-perform" – not to break the rules of PISA testing outright, but to bend them as far as possible in the service of harvesting higher scores than

students would have otherwise earned. Anecdotal reports about local schools in China that massaged the rules so students might "do their best" are not unknown. I personally was told about a 15-year-old in Shanghai who happened to be selected for PISA testing. As recounted, the school spent weeks "teaching to the test." The classroom was reportedly even favored with a visit from Shanghai's deputy mayor, who emphasized to the children how important this test was.

Another source flagged the possibility of test-beating selection bias, raising the possibility that PISA's results come not only from students within the most affluent provinces, but from a nonrandom sample of students chosen to paint the country in the best possible light. We cannot know how much test-beating affected the PISA results. However, there are clues that can help us appreciate the general magnitude of the distortion.

Consider parallel example, the test prep industry in the United States – the tutors who help high school juniors and seniors earn better scores in the SAT tests for college admission. Test-prep tutors do not know what will be on the upcoming rounds of SAT tests. But they have mastered the art of SAT test-taking, and they earn their pay because they can reliably raise tutees' scores. The Kaplan Test Prep company, for example, reportedly promises that it can raise tutees' total SAT scores by half a standard deviation, which is roughly equivalent to closing 50 of the 60-point difference in PISA scores between Massachusetts in 2015 and China in 2018.

It could well be that, absent test-beating, China's students from its most privileged provinces would perform capably, even impressively, against their OECD counterparts. But more faithfully administered test results for the provinces of China included in the PISA scores would almost certainly have shown much lower scores than those officially recorded.

If their performance represented rural China, then rural China was performing behind not only all Western countries tested but also all tested developing countries including Indonesia and Morocco.

EDUCATIONAL REALITIES IN CHINA'S HINTERLANDS

We cannot know just how well PISA protocols represented the less advantaged rural population in the four provinces tested in 2018. What we do know is that the billion-plus population of the provinces where PISA did not test in 2018 includes a vast contingent of poorer Chinese.

Despite long-standing efforts to uplift the hinterlands and to reduce rural poverty, official policy in China still discriminates against farmers and peasants in myriad fashions. Working with Chinese researchers, Stanford University economist Scott Rozelle and his colleagues at the Rural Education Action Program (REAP) detailed analyses of conditions for rural China's children that have surprised both Western and Chinese audiences.

In a particularly arresting 2017 study, Rozelle et al. conducted the PIRLS exam (a standardized achievement test designed by the International Education Association) to rural fourth grade students in Guizhou, Jiangxi and Shaanxi provinces. Jiangxi and Guizhou are among China's poorest provinces, with Guizhou ranked lowest with the exception of Tibet.

The REAP study found that these students

were testing at the very bottom of the PIRLS international roster. If their performance could be said to represent rural China, then rural China was performing behind not only all Western countries tested but also all tested developing countries including Indonesia and Morocco. More developed Shaanxi province fared slightly better, ranking above Indonesia and alongside Colombia and Qatar – but Jiangxi and Guizhou ranked behind Morocco, the country with the lowest PIRLS score, and the Guizhou rural students came in dead last.

Rozelle and his co-authors thus describe a very different China from the one depicted in PISA tests. Rozelle calls it "invisible China" in a book by that name, a China still overlooked by educational authorities in both China and the West.

KNOWLEDGE CAPITAL IN CHINA

World Bank research on knowledge and skills for China's pupils, along with analysis of the reliability of PISA's metrics, originated with the launch of the bank's Human Capital Index first published in 2018 and updated in 2020. It is a synthetic measure, intended to offer a single overview number for a country's human capital endowment, and it uses a number of statistical indicators to cover those components.

One is harmonized learning outcomes – an indicator that combines international standardized pupil achievement test results from the three major international tests using regional applications from a variety of sources. These several thousand national and subnational observations, covering well over 95 percent of the world's population, were brought into correspondence across datasets with "conversion factors" intended to harmonize scores into a single mega-set for global student achievement.

The HLO team examined PISA scores for China but found them unrepresentative and potentially misleading. They expanded their dataset for China to include the aforementioned Rozelle et al. study on student achievement in rural China. Utilizing conversion factors for merging China observations, along with PISA and PIRLS and socioeconomic data on China's provinces, the team modeled all-China mean level of academic achievement for pre-college boys and girls.

Counterintuitively, the 2018 super-high PISA results for China led the World Bank team to lower their all-China HLO number due to the steeper implied slope connecting the performance of more developed regions of China to those of less developed regions.

If accurate, what would the latest all-China score in the HLO database signify? For one thing, it would mean China's national level of student aptitude was over 130 points lower than PISA numbers suggested – the equivalent of three years less school achievement. It would also put China well below (rather than far above) all Western countries. And it would place China roughly between Mexico and Turkey.

The bank also came up with a new statistical construct it called learning poverty, intended to focus attention on the lack of basic knowledge and skills early in life for boys and girls. It estimated the proportion of 10-year-olds who cannot read a text (or in practice, often a single sentence).

Estimates of the prevalence of learning poverty combine the fraction of fourth-grade students (or 10-year-olds) who cannot manage basic reading with the proportion who are not in school at the grade-four level (and thus presumed to be unable to read a text). Data on reading proficiency for fourth graders come from either standardized achievement tests (such as PIRLS) or from national large-scale assessments.

CHINESE STUDENTS

Intriguingly, China participated in the learning poverty report, providing domestic data not available through other auspices. It is impossible for outsiders to know just how comprehensive or representative these numbers actually were. But they indicated a very different situation for Chinese pupils' knowledge and skills from the profile offered by the PISA 2018 report.

According to the World Bank, 18.2 percent of Chinese children could not read a basic text in 2016. That compares with 2.8 percent for Singapore in 2016 – the country China supposedly outperformed across the board in reading, math and science in PISA 2018. For the U.S. in 2016, the corresponding learning poverty estimate was 4.9 percent.

If accurate, China's learning poverty rate would be half as high as expected for a country of its income level, and about a third as high as India's (55 percent). On the other hand, China's learning poverty would still be far higher than for developed countries, and utterly inconsistent with PISA estimates of student achievement in China.

It is also informative to compare World Bank estimates for learning poverty with PISA 2018 mean academic achievement scores. China, not surprisingly, is a glaring outlier. One of the most interesting comparisons is between China and Turkey. According to the bank, learning poverty is significantly lower in Turkey – 15 percent versus China's 18 percent. But once again, Turkey and China look to be in the same league.

BASIC SKILLS AS A METRIC

The HLO methodology for "harmonizing" unrelated test score datasets has its critics. But Stanford's Eric Hanushek and his German colleagues Sarah Gust and Ludger Woessmann came up with an ingenious end-run around that harmonizing issue, arriving at a simpler common metric for judging "knowledge capital" for pupils all around the world.

They ignore the scores in these various datasets and focus instead on the skill levels indicated. These tests, they explain, work with a commonly agreed conception from international educators for judging skill levels – a proficiency scale ranging from basic (Level 1) through advanced (Levels 5 and 6).

They examine performance in math and

Parents see students off as they head for the Chinese college extrance exam.

STR/AFP VIA GETTY IMAGES

science only, leaving out reading competence. Then they look at the proportion of students who do not complete basic pre-college schooling (presuming this additional group by definition lacks basic skills). The sum of these two quantities gives the number that Gust et al. arrive at for the proportion of a society's youth who lack basic skills.

In attempting to assess the true basic skill level for pupils for the whole of China, they confront the same dilemmas everyone else faces in wrestling with PISA test results. They decided to take the PISA 2018 China results on their face, accepting the scores as authentic representations of the capabilities of randomly selected students in those provinces.

Given the astronomical China scores from PISA 2018 and the high levels of compulsory school enrollment in China, they calculate that just 18 percent of these tested youths lack basic skills – better than their corresponding estimates for most OECD countries. But then

Southeast University graduates celebrate in Nanjing, Jiangsu Province.

YANG BO/CHINA NEWS SERVICE/VCG VIA GETTY IMAGES

Gust et al. make an adjustment. They posit that their figure only pertains to urban China – and that rural China, which they say contains 65 percent of China's pre-college pupil population, remains untested.

To estimate an all-China number, they take a "sensitivity analysis" approach – "what if" calculations based on bounding the possible estimate on the high end for rural China's performance with the top performance for rural pupils in a largely rural low-income East Asian country, and also at the low end by the poorest performance by such a country. For the high bound they pick Vietnam, for the low bound, Cambodia. In rural Vietnam, an estimated 19 percent of pupils lacked basic skills, while the corresponding figure in Cambodia was about 95 percent.

Based on those parameters, Gust et al. calculate that all-China's true share of pupils lacking basic skills would fall somewhere between 19 percent and 69 percent. This calculated range is unsatisfyingly wide – after all, countries with roughly a 19 percent share of pupils without basic skills would include Denmark and the Netherlands, while at 69 percent, countries include Iraq and Indonesia. However, if we split the difference – assume,

say, 35 percent – we end up both worse than Europe (28 percent) but distinctly better than the 42 percent average for upper-middle-income countries, the World Bank income grouping in which China falls.

As coincidence would have it, 35 percent also happens to be the Gust et al. estimate for Turkey's share of youth without basic skills. We are drawn to this comparison, not least because our own previous statistical modeling and the World Bank's HLO dataset arrive at a rough equivalence between Turkey and China in "knowledge capital" for the precollege population.

WHAT ALL THIS MEANS

Too much speculation and not enough hard statistical evidence? This excursion through the data thickets certainly demonstrates how difficult it is to assess the actual state of knowledge capital for youth in contemporary China. China is a vast and highly variegated country, and the released results from internationally standardized achievement tests cover only a small fraction of its population. Moreover, there are important unanswered questions about even these results – and answers are elusive because PISA cannot be as open in China as it is elsewhere if it hopes to continue collaborating with Beijing.

It is possible that China as a whole is outperforming other developing economies at its income level with respect to academic achievement. It is also possible that overall aptitude for students in China is similar to that of students in Turkey, a country at roughly China's level of socioeconomic development.

These alternatives would have very different implications for China – and the world. China is a mighty presence in economics, technology and geopolitics, but the proverbial 600-pound gorilla may weigh in closer to 300 pounds. Only further research, under what for outsiders are unfavorable conditions at least for now, could cast more light on this important matter.

Beijing, of course, could clear up the mystery of just how skilled its rising cohorts of young people are if it wanted to. But that would entail sharing sensitive information to audiences both at home and abroad by an autocracy that increasingly prioritizes information control. For that matter, notwithstanding their aspirations to lead a true surveillance state, it is not clear that Chinese authorities themselves have a nuanced understanding of the knowledge and skills of their student population.

Ironically, China's breathtaking PISA scores could make it more difficult for China to open up about nationwide student performance. Consider the parable of India's engagement with PISA testing.

In a 2009 test-drive, India administered PISA tests in two states – Himachal Pradesh and Tamil Nadu – but the readings were disastrously low, almost at the very bottom of all populations tested. India withdrew from PISA after this embarrassment, and although New Delhi eventually agreed to rejoin, it has yet to participate in another round of PISA exams.

Where Indian officials were disincentivized from going nationwide with international achievement testing by embarrassingly bad regional scores, authorities in China could face a parallel dilemma in allowing greater testing coverage because their most recent results are incredibly high. After the 2018 PISA report came out, China's Ministry of Education sent out a victory-lap press release hailing its findings. Who wants to be the education minister to do the climb-down release if and when a more accurate national assessment is conducted?

CEMENTING CARBON

Constructing the Low-Carbon Future

BY GERNOT WAGNER

TO appreciate how fundamental a role cement plays in human society, one must first understand the importance of the carbon cycle in the evolution of the planet. Carbon dioxide (CO_2) in the atmosphere dissolves in seawater and gets metabolized by living corals and plankton that eventually die and decompose into ocean sediments. The sediments are compressed over millions of years until they become limestone – a natural storage vault for elemental carbon, like coal, oil and gas. ¶ Through tectonic uplift of the earth's crust over eons, that limestone rises above sea level to expose cliffs, mountains and other rock formations. But unlike most coal, oil and gas that must be extracted at considerable cost from deep underground, this limestone just sits there for the taking. ¶ Using limestone as construction material dates back at least some 10,000 years, with archeologists unearthing lime mortar floors in buildings in areas spanning from modern-day Turkey to Israel. Limestone found its early lasting glory in the Great Pyramid of Giza, which is made up of 2.3 million blocks of limestone measuring about 1 by 1 by 1 meter and weighing around 2.5 tons each.

NATTAPHOL PHROMDECHA/ALAMY

LIU JIN/AFP VIA GETTY IMAGES

CEMENTING CARBON

The ancient Romans began using a lime mortar, mixing lime with sand and water to build some of their eternal structures, including the Colosseum and Pantheon. They also discovered the utility of volcanic ash found near Pozzouli, on the outskirts of modern-day Naples in the shadow of Mount Vesuvius. Mixing lime with this ash made the cement stronger. And it turns out that making cement this way also releases less CO_2 into the atmosphere, a fact that would form the basis for current attempts to displace clinker (processed limestone) with natural or synthetic "pozzolans," named with a nod to Pozzouli's ash.

The emphasis here is on *processed*. It was not until the 1800s that builders realized that burning limestone to a crisp at temperatures of around 1,450 degrees Celsius, about 2,600 Fahrenheit, made for much stronger building materials. At those temperatures, limestone ($CaCO_3$) "clinkered," turning it into lime or calcium oxide (CaO).

For those keeping track of the chemical symbols, we are left with an equation with one unfortunate byproduct:

$CaCO_3 + Heat = CaO + CO_2$

That's the rub. Limestone burned in hot, rotating kilns makes one of the most fundamental building materials of the modern world, along with a byproduct that poses one of the most fundamental challenges to the survival of the modern world: CO_2 released back into the atmosphere, where it all started.

HARD TO ABATE?

The carbon cycle is, of course, circular. CO_2 in the air is eventually returned to its rightful place in nature. The catch is the time disconnect between the millions of years it takes for CO_2 to be turned into limestone and the constant churn of over 3,000 cement kilns around the world producing around 4 billion tons of cement annually. Each ton of cement produced releases almost its own weight in CO_2 into the atmosphere through the calcination process.

Worse, most of the heat powering the transformation in those kilns currently comes from burning coal, another major source of CO_2. All told, global cement production is responsible for an astounding 5-8 percent of CO_2 emissions globally – a lot less than fossil fuel consumption, but a significant part of what is often viewed as especially hard to abate.

In contrast to, say, internal combustion engines propelling cars forward where the carbon emissions are the product of burning fuels, most of the carbon emissions in cement-making come from the chemical process itself. Getting CaO out of $CaCO_3$ releases CO_2, and it's been proven to be rather difficult to meddle with this fundamental chemistry.

Indeed, so much depends on how cement is made that many – though importantly, not all – construction standards for cement are based on what recipe is being used. Diverge a bit from that standard, for example, by substituting lower-carbon materials for CaO, and builders may reject the concoction lest they be held liable for diverging from tried-and-true recipes that have literally held up buildings for centuries.

For over 200 years that industry gold standard has been "ordinary Portland cement," in which the CaO (aka clinker) gets ground up and mixed with gypsum and other common materials. The name, by the way, comes from its resemblance to stone found on the tiny Isle of Portland in the English Channel. It has nothing to do with the city in Oregon (or the

GERNOT WAGNER is a climate economist at Columbia Business School and faculty director of its Climate Knowledge Initiative.

Ancient cement in Pella, Greece.

ATHANASIOS GIOUMPASIS/GETTY IMAGES

one in Maine) – but you can be sure both cities have been built from it.

Almost all of the 4 billion tons of cement produced annually are of the Portland variety, making ordinary Portland cement the third most ubiquitous manufactured material on the planet. Number two? Sand and gravel. Mix cement with sand, gravel, and water, and you get the single most ubiquitous manufactured material: concrete.

Indeed, there is only one other type of manufactured material that comes anywhere close to concrete in systemic importance to the world and in its impact on CO_2 emissions: steel. The parallels are striking, right down to the fact that most CO_2 resulting from its production comes from turning iron ore found in the earth's crust into iron, which in turn is to steel what cement is to concrete.

The two industrial sectors share another fundamental characteristic: they are both low-margin commodity businesses, where competition is fierce, volume is a key to success, and innovation has been glacial – until, suddenly, it is not.

DRY KILNS

The basic recipe for ordinary Portland cement may have stayed the same for almost two centuries, but the industry has seen a dramatic shift in how the different ingredients get mixed together. The calcination of limestone into clinker – that is, getting from $CaCO_3$ to CaO – happens in kilns that are massive, fiery, rotating tubes roughly the size of your average bus.

For the longest time, the industry standard was what has since been known as "wet" kilns, wherein raw materials are mixed with water to form a slurry. The high heat in the kiln easily evaporates the water, but the step adds to the energy bill. It is more energy-efficient to bypass the slurry step and grind the raw materials into a fine powder to form a raw meal.

In an industry that is as energy-intensive (and as competitive) as cement, even the smallest process improvements, once proven to work, spread like wildfire – and the savings in the shift from wet to dry kilns wasn't small. The average dry kiln is 45 percent more energy-efficient than its wet cousin. Adding more technical refinement to the dry-kiln process adds another 10 percentage points for a total improvement of around 55 percent.

Over 80 percent of global cement production (90 percent in Europe) has made the transition to dry kilns. The lesson, then, is that rapid change is possible, as long as it yields certain results and is cost-effective.

INPUT AND OUTPUT EFFICIENCY

All told, global cement production increased by some 160 percent in the first 15 years of this century. During that same time, carbon emissions from the cement industry grew by just 120 percent, implying modest but significant efficiency improvements.

One big reason for the improvements

brings us back to the foot of Mount Vesuvius and Pozzouli's volcanic ash. "Pozzolans," whether natural or synthetic, can substitute for clinker in cement, in some cases even producing a better final product. Lucky is the cement company situated in the shadow of a volcano and able to reduce its use of clinker at low or even no cost.

Costless mitigation options are hard to

ZOONAR/VALERIY SHANIN/ALAMY

come by for all the obvious reasons that have the makings of one of the classic economists' jokes. Two University of Chicago – i.e., conservative – economists are out walking, and one finds a $20 bill on the sidewalk. The other economist dismisses his good fortune: "If the $20 bill were real, someone would have picked it up already."

The joke works only if you suspend disbelief about the workings of the real world for a moment. Truth is, we all know that companies and markets do not always operate at 100 percent efficiency. If they did, those two Chicago economists would be the first ones to lose their jobs because Chicago's business school, home to some of the most conservative of Chicago economists, would not need to exist. Why train people in how to run a business, if all

businesses are already run perfectly?

Turns out, there are plenty of opportunities to increase efficiency in cement production, where blending with pozzolans can both increase strength and cut costs. The catch-all term for materials that can replace clinker is a mouthful: supplementary cementitious materials, or SCMs. Natural pozzolans top the list of seemingly environmentally benign SCMs that also improve the strength and durability of cement. Others are fly ash and steel slag, the byproducts, respectively, of coal-fired electricity generation and coal-fired blast furnaces producing primary iron.

Now, coal will remain a part of steel production for decades to come, but its days as a fuel for power plants are clearly numbered. That also means fly ash will soon be a dwindling commodity, making this particular SCM a temporary substitute.

REMY ROMA/ALAMY

Luckily, there is another type of blended cement that comes with even greater CO_2-sparing benefits, plus its own acronym: limestone calcined clay cement. LC3 is the product of chemical optimization that showed how a mix of limestone plus calcinated clay makes it possible to swap out more of the energy-intensive clinker. Where traditional SCMs can cut CO_2 emissions by around 15 percent, LC3 can double those emissions savings.

That puts this particular intervention on a par in terms of efficiency gains with the switch from wet to dry kilns. But, alas, LC3 has been around for years, and it has yet to take over the industry. One reason: large upfront capital costs relative to the expected savings. At (great) risk of overusing our economists' joke, there may be $20 bills lying around, but you need an expensive tool to pick them up.

Yet technology that increases process efficiency in cement-making can't do it all. At very best, it could cut carbon emissions by around 30 percent – nice but not a revolution for a global economy that's going to need a whole bunch of technological revolutions to contain atmospheric warming to manageable levels. There is, however, an entirely different aspect of efficiency, one the cement industry may not appreciate: the potential for getting the same construction jobs done with a lot less cement.

Global cement production has plateaued in the past decade, and one big reason is that it is, indeed, possible to build taller and bigger with less cement. If wasting inputs are bad for cement companies, wasting cement is bad for construction companies and the planet alike. In part, the efficiency gains are linked to builders using better techniques to achieve the same outcome. Sometimes it is engineers and architects rethinking buildings from the ground up, with everything from 3D printing to construction that swaps out cement and concrete in favor of wood and other products.

Note, however, that using less cement does not always mean less CO_2 emissions if builders end up using more steel and glass made with fossil fuel inputs. Consider, too, that thick concrete walls often provide better insulation than walls made of other materials, reducing a building's lifetime emissions.

The one certainty: less cement means less output for the cement industry. So unless cement conglomerates expand downstream and produce other construction materials, cement companies' shareholders are unlikely to appreciate this particular approach to reducing carbon emissions. But there is an entirely different type of change rattling the foundation of the cement industry.

FROM LAB TO SCALE

When you visualize smart, ambitious researchers out to change the world, you may picture Silicon Valley coders creating the next killer app or molecular biologists developing the next mRNA vaccines. But hardhats and kilns should have a place somewhere in this technology Valhalla.

Meet Cody Finke and Leah Ellis, 30-something PhDs, who have zeroed in on cement process technology, founding Brimstone Energy in Oakland, California, and Sublime Systems in Somerville, Massachusetts, respectively.

Every startup faces daunting cost barriers until they reach reasonable scale. Prototypes necessarily cost more to produce than the hundredth unit and far more than the millionth unit. The big question is whether there is a financially viable pathway to get to competitive scale, and to do so in the usual funding cycles and timescales that define the life of a startup.

The giants of the cement industry – the CEMEXs, Heidelbergs and Holcims – have

the financial resources and industrial know-how to scale new technologies fast. They even have internal venture capital shops seeking out new ideas – and, indeed, one of them (the Swiss-based Holcim) is now partnering with Sublime. But incumbents face a dilemma unique to them.

Amazon signing an agreement with Brimstone for one of its first sizeable batches of cement, or Microsoft doing something similar with Sublime, is one thing. Either cement startup turning into a runaway success would hardly affect Amazon or Microsoft's core business. Cement incumbents face quite different incentives. If Brimstone, Sublime and other low-carbon technologies scale too slowly or fail as businesses before reaching scale, investing in them is wasted money and effort. If they scale too fast, they might render manufacturing capacities in legacy technologies prematurely obsolete, forcing incumbents to explain to their shareholders why they helped cannibalize their own businesses.

Finke and Ellis, for their part, are still far from having to worry about that eventuality. Their day-to-day worries mirror those of most other founders of fast-growing startups. Finke is currently choosing a site for Brimstone's pilot plant. Ellis's Sublime is farther ahead, with a pilot plant in operation since 2023. The first commercial plant is under construction in Holyoke, a former industrial town in western Massachusetts. The 40,000 residents of Holyoke – ground-zero to the first industrial revolution in the United States in the early 19th century – are more used to seeing manufacturing plants leaving town than knocking on their doors.

PROCESS VERSUS PRODUCT

Brimstone and Sublime tackle the same underlying problem, but have devised fundamentally different paths in search of low-carbon cement. Brimstone's Finke likes to emphasize how his company aims to produce the same old Portland cement that the industry has long been used to. Brimstone's secret sauce: instead of calcinating limestone ($CaCO_3$), a process that necessarily releases CO_2 on the way toward producing clinker (CaO), Brimstone substitutes carbon-free silicate rocks. These silicate rocks are beyond abundant – silicates in general make up 90 percent of the Earth's crust. And the "impurities" in them that need to be removed to get

PHOTOS FOR YOU/GETTY IMAGES

to CaO may also be valuable on their own.

Indeed, that co-production aspect is just what Brimstone focuses on in outlining the company's value proposition, emphasizing how it produces three distinct products: CaO (of course), but also alumina found in its silicate rocks and copious amounts of SCMs.

All that creates some real advantages. The biggest is that Brimstone's technology yields a very familiar product. Clinker is clinker, and the resulting Portland cement is just that: as ordinary as anyone else's.

But what might count as an advantage for Brimstone to scale quickly into a crowded industrial space, may also be its biggest limitation. If everything else stays the same, avoiding the process emissions caused by the $CaCO_3$-to-CaO transformation caps Brimstone's maximum emissions reduction at 60 percent. Using ordinary kilns heated to 1,450 degrees Celsius means that the emissions associated with getting kilns to that temperature won't change.

To be clear, the heat for those kilns does not need to come from coal. Electric resistance heating powered by 100 percent renew-

ables, or any other kind of zero-emission electricity, is perfectly capable of getting to these temperatures. But no matter how you slice and dice it, it is expensive to generate this much heat.

Ellis and Sublime thus have the seemingly more creative solution: change the process to consume less energy. Why not use electrochemistry to revolutionize a centuries-old sector from the ground up, doing away with 1,450-degree kilns altogether, substituting a process where temperatures no hotter than a hot cup of coffee will suffice? Such is the promise of Sublime's electrochemistry.

Ellis, then, is altering the product as well as the process. She takes the resulting challenges in stride, arguing that her cement already passes other construction standards that are based on functionality rather than the exact ratio of CaO to gypsum.

Even if the final product performs better than what came before, it is hard breaking into a construction supply chain dominated by old boys' networks and deeply ingrained institutions. That goes as far as to include insurance companies writing policies for contractors and builders. Using tried-and-true methods in cement production makes it easier to get plug-and-play contracts for the resulting building. Change the process, and insurers might balk.

TECHNOLOGY, INTERRUPTED

For all their concerns about the economics of scaling their emissions-saving technologies to the break-even point and, in Sublime's case, selling what is effectively a new product to the conservative-minded construction industry – the startups thought they had an ace in the hole. Both had won hefty grants from the Department of Energy as part of the Biden Administration's green industrial policy push: Brimstone $189 million, Sublime $87 million.

But what the Biden administration gaveth, the Trump administration taketh away. Both companies lost their grants in June. And while both are pressing forward without the federal money, the challenge of proving their technologies and reaching profitable scale relying entirely on funds from private investors is now even more daunting.

The Trump effort to reverse many of President Biden's signature efforts also hit a $500 million grant given to cement giant Heidelberg for a proposed new plant in Indiana that would have gone all-in on carbon capture, utilization and storage (CCUS). The size of that grant alone speaks volumes, showing how much emphasis both cement incumbents and the Biden DOE put on the technology.

The reversal on that $500 million grant might have also come as a bigger surprise than the cuts to Brimstone and Sublime because the main forces driving CCUS are typically seen to be more closely allied with the current occupant of the White House. Indeed, heavy lobbying by fossil fuel interests have helped preserve and even expand generous Biden-era tax credits for CCUS. To see why, listen, for example, to Occidental Petroleum CEO Vicki Hollub, who has argued that direct air capture could give the fossil fuel industry "a license to continue to operate for the 60, 70, 80 years that is … going to be very much needed."

To its credit, the Global Cement and Concrete Association has an ambitious net-zero goal by 2050. The group's Net Zero Roadmap looked at a number of different efficiency and technological levers proposed to meet this goal, but the "net" still does significant work in form of the single biggest lever: CCUS accounts for around 36 percent of the total re-

Skidmore, Owings & Merrill's Urban Sequoia, a green tower concept to be built with "better" cement.

ductions. The American Cement Association has its own net-zero plan. There, the role for CCUS? Just over 50 percent.

* * *

All that leads us back to Brimstone and Sublime, and technologies that promise to revolutionize cement production.

Neither company's success is guaranteed – far from it. Such is the life of startups that must spend huge amounts of money to find out whether their technologies are commercially viable, and now must manage the job without assurance of financial help (or even goodwill) from Washington.

Possibly the highest praise and hope for change comes from the industry's oldest lobby. The American Cement Association had been known as the Portland Cement Association for the first 109 years of its existence. It changed its name this past May, justifying the move by arguing that "the new name better represents the diversified range of materials produced by our members."

Brimstone and Sublime still have a long way to go before filling out the membership form and joining the big cement players. But the door at least has been opened a crack.

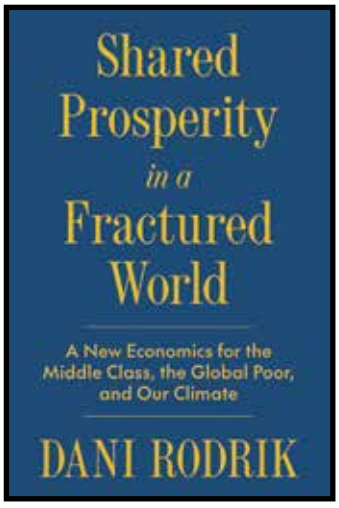
SOM/COVER IMAGES VIA REUTERS CONNECT

Shared Prosperity in a Fractured World:
A New Economics for the Middle Class, the Global Poor and Our Climate

BY DANI RODRIK
ILLUSTRATIONS BY
ADAM NIKLEWICZ

Check the zeitgeist and you'll discover that Dani Rodrik is a serious candidate for the social scientist of the decade – a pragmatist intent on finding paths out of the multiple crises of democratic capitalism. Or if you're not into zeitgeist-gazing, just check out the influence of Rodrik in virtually every centrist forum wrestling with these issues. ¶ Since the late 1990s this Turkish-born, Princeton-educated professor of economics at Harvard's Kennedy School has been exposing the dark side of globalization, arguing that the cost of further integration in terms of socioeconomic dislocation exceeds the likely gains in productivity. And in his new book, *Shared Prosperity in a Fractured World: A New Economics for the Middle Class, the Global Poor, and Our Climate*,* Rodrik takes on the challenge of describing in detail how disciplined government intervention is desperately needed to create good jobs without undermining growth. ¶ In the chapter excerpted here, Rodrik makes a convincing case that a leaner and smarter industrial policy can complement market forces and the welfare state in the struggle to save democratic capitalism from itself. Skeptical? I'm guessing you won't stay that way for long.

— Peter Passell



Whether it is fostering the green transition, rebuilding the middle class through good jobs, or reducing poverty in the developing world, engineering structural change is key. Meeting each of

these objectives requires moving the economy's resources – innovation, organizational capacity, entrepreneurship, capital and workers – to activities that are more productive and achieve social, environmental and developmental goals in the process. The strategy that connects all three domains is *productivism*, a paradigm that I describe here in detail.

Market fundamentalists would say structural transformation is a task better left to the operation of markets. Of course, they would readily acknowledge that some tweaking of market forces may be required. But the task of government policy, in their view, should be limited primarily to letting the markets do their job of allocating resources to their best – meaning most profitable – uses.

We have seen time and again that success requires something different: more government intervention than what market fundamentalists would want, but also better government intervention. The task in this essay is to make the case for governments' role in structural change. It is also to distill what we learn from experience about how governments can be more effective in this role. Don't let the label productivism turn you off. Call it sensible, pragmatic policymaking and you'll have it exactly right.

THE VISIBLE HAND

In his 1980 TV series *Free to Choose*, Milton Friedman held up a pencil to illustrate the power of markets. It took thousands of people all over the world to make this pencil, Friedman said – to mine the graphite, cut the wood, assemble the components and distribute the final product all around the globe. No single central authority coordinated their actions; that feat was accomplished by the magic of free markets and the price system. It was Adam Smith's famous invisible hand at work.

Forty-five years later, the pencil story serves a very different narrative – one that gives government policy a much more prominent place. Today China is the world's leading producer of pencils. Yet China was hardly a natural destination for the industry. There are better sources of graphite in Mexico and South Korea. Forest reserves are more plentiful in Indonesia and Brazil. Germany and the United States had better technology when China's industry got off the ground. China had lots of low-cost labor, but so did Bangladesh, Ethiopia and many other developing countries. Much of the credit belongs to the initiative and hard work of Chinese entrepreneurs and workers. But leaving out the Chinese government's contribution would be like staging *Hamlet* without the prince of Denmark.

The initial investments in technology and labor training were made by China's state-owned firms. The government then stimulated the industry by keeping wood artificially cheap, providing generous export subsidies and intervening in currency markets to enhance Chinese producers' competitiveness on world markets. As in so many other branches of manufacturing, China's government subsidized, protected and goaded its firms to ensure rapid industrialization.

Or consider orchids in Taiwan. The industry took off four decades ago thanks to concerted efforts by the Taiwanese government

to diversify away from sugar. Sugar had traditionally held an important position in Taiwan's countryside, both as an export commodity and as an employer for farmers. But it had fallen on hard times due to declining prices on world markets.

In many countries, the outcome might have been deteriorating incomes, rising indebtedness for farmers and a depressed rural sector. The Taiwanese government chose instead to mount a comprehensive investment drive to develop a world-class orchid industry. It paid for a genetics laboratory, quarantine site, shipping and packing areas, new roads, water and electrical hookups for privately owned greenhouses, and an exposition hall. It provided low-interest loans to help farmers build the greenhouses.

Supported by government extension services, large numbers of orchid growers, from micro enterprises to medium-sized ones, became part of the orchid cluster and supply chain. Today, Taiwan is the world's third biggest exporter of orchids behind the Netherlands and Thailand.

Maybe it is just East Asian nations that are able to pull off these feats? Not really. Consider a case from Latin America. Fundación Chile is a nonprofit set up in 1975 that acts as a public venture capital fund. It served as an

incubator for new technologies, adapting them to the Chilean context and then selling off the successful ones to the private sector.

In 1981, Fundación Chile acquired a small, local aquaculture company. Using Norwegian and Japanese salmon farming technology and through a process of learning by doing, it developed an entire supply chain from specialized feed to export logistics. The knowledge it acquired was disseminated freely to private firms, producing an explosion of salmon farming. Exports went from 300 tons to 24,000 tons per year by the 1990s, making Chile the second largest exporter of salmon after Norway.

The reality is that virtually all instances of productive transformation since the Industrial Revolution have been the result of combined public-private initiatives. This is as true for countries that are normally associated with free market ideology as for others. Chile has long been lauded as one of Latin America's most successful economies, and as one of its most market-oriented. But the state has played a role in all its major exports.

The country's largest copper company is state-owned; the forestry sector benefited from generous subsidies, including under the free-market-radical President Pinochet. The wine industry was promoted through supplier development and export credit programs funded by government agencies. Scratch any modern export success story, and more likely than not, you will find the hand of government hiding beneath.

The U.S. government has always played a significant role in R&D. During the second half of the 19th century, land grant colleges and agricultural extension services disseminated know-how and helped create the most productive agriculture in the world. U.S. manufacturing grew, caught up and eventually surpassed Britain behind high tariff walls. In the postwar period, government funding by the Small Business Investment Company played a significant role in launching Silicon Valley and laid the groundwork for the subsequent development of the private venture capital industry.

The U.S. Department of Defense, through its procurement and R&D programs, enabled all the critical innovations that would eventually constitute the digital revolution.

The U.S. Department of Defense, through its procurement and R&D programs, enabled all the critical innovations that would eventually constitute the digital revolution. Its Defense Advanced Research Projects Agency is responsible for the internet, GPS, flat-panel displays and the computer mouse, among other innovations.

"Stop," I hear you say. "We get the message. Government intervention works!" If that's what you are thinking, we are halfway – but only halfway – there. My point is more nuanced. Government policy does work, but not always. It sometimes fails massively. And if we want to apply similar policies to the new domains of services and green industries, we'd better think hard about both the successes and failures, and learn how to improve their practice.

WHAT SOLYNDRA TEACHES US

Here is a cautionary tale. Solyndra was a solar cell company founded in 2005 and one of the first to get funding under an expanded gov-

ernment loan-guarantee program. Then-president Obama was keen to develop green technologies. The government provided Solyndra with $535 million in loan guarantees to supplement $450 million raised from private investors.

For Obama, Solyndra was much more than a startup experimenting with a new technology. It was a company that exemplified the economic transformation he wanted to achieve. Obama personally extolled the company at a visit to its facility in Fremont, California, in May 2010. "Companies like Solyndra are leading the way toward a brighter and more prosperous future," he declared.

But government also had a big role to play. It had to "create the conditions in which students can gain an education so they can work at Solyndra, and entrepreneurs can get financing so they can start a company, and new industries can take hold."

Not unlike the Chinese government, the Obama administration hoped to accomplish multiple goals with the program. Stimulating demand and employment, spearheading new technologies, competing with China and benefiting the environment were all cited in selling the program to congressional interests and the broader public. "If we want to compete with other countries that are heavily subsidizing the industries of the future," said President Obama, "we've got to make sure that our guys here in the United States of America at least have a shot."

By August 2011, Solyndra had gone bankrupt. The company had made a gamble that did not pay off: the viability of its business plan depended on silicon prices remaining high. Its technology for producing photovoltaic cells relied on CIGS (copper indium gallium selenide) as the semiconducting material instead of silicon, which was vastly more common in the industry.

CIGS was cheaper than silicon but less efficient at converting solar energy. At the time this seemed a reasonable gamble, as silicon prices had been rising. However, after 2008, silicon prices tumbled precipitously, thanks to new capacity coming online in China. The company failed even though it had met its own technological and cost-reduction goals.

Its bankruptcy became a major source of embarrassment for the Obama administration. Solyndra's offices were searched by FBI agents, and the company's top executives were hauled before Congress (where they invoked the Fifth Amendment). This is what you get when you pick winners, critics scolded. The most damaging consequence may have been that it made it virtually impossible for the U.S. to expand the initiative and truly match China's ambition in renewables – at least until the IRA [the Inflation Reduction Act of 2022 that committed heavy subsidies to the energy transition] more than a decade later.

The simplistic version of what went wrong in this case is that the government backed the wrong company (and the wrong technology). But this is the wrong lesson. It is the very nature of innovation that R&D and market outcomes are inherently uncertain. When venture capitalists invest in a variety of firms and technologies, they do not expect all their investments to succeed. All they hope is that enough of them succeed to pay for the ones that fail. In fact, the calculus of profits under uncertainty ensures that, under an optimal investment strategy, some of the projects will necessarily be failures. As Thomas Watson, the founder of IBM, is said to have advised his managers, "If you want to succeed, raise your error rate."

It is no different when new technologies are supported by the government. The failure rate at DARPA, probably the world's most successful innovation agency, is as high as 85-90 percent. At Fundación Chile, the four

most successful investments have more than paid for all the flops.

Similarly, the Department of Energy, which issued Solyndra's loan guarantee, had backed a variety of green technology projects. The true test of the government's success is whether the social return to the overall portfolio is high enough – higher than the government's cost of borrowing.

I am not sure whether the DOE ever undertook such a calculation, but we do know that some of the private investments it backed were very successful. In fact, around the same time that Solyndra received its loan guarantee, the DOE also issued a $465 million loan to Tesla to build an all-electric plug-in vehicle. The financial crisis of 2008-9 had left Tesla in dire financial straits, and the loan was critical to the company's survival. It certainly was a risky investment. But the rest is history, as they say.

Tesla would have another brush with bankruptcy in later years, but the company grew to be not only the world's premier EV manufacturer but also its most valuable auto company. We can thank the same government agency that financed Solyndra for enabling this outcome.

If there are lessons from Solyndra, they are about government failures of a different kind. First and foremost, the government was never upfront about the experimental and risky nature of the technologies it supported. There was no public messaging about the need to prepare for disappointments or to evaluate the outcomes. Worse, the Obama administration publicly showcased and invested political capital in a single firm, Solyndra, before success was assured.

The government cannot consistently pick winners, but it can stop backing losers. The worst aspects of the Solyndra debacle could have been avoided if there had been closer scrutiny of the company's progress, or lack thereof. One of the hallmarks of successful innovation programs is that the relevant government agency sets intermediate targets and clear milestones to determine whether projects should continue to receive support or be written off.

At ARPA-E (modeled after DARPA, but for advanced energy technologies), award recipients are required to participate in periodic reviews to assess the work performed and determine whether technical milestones are being achieved. ARPA-E staff members rate progress using a traffic light system: red for projects that miss a critical milestone and are at risk of failing; yellow for projects that miss a milestone but are expected to recover; and green for projects that are on track. Red ratings lead to intensified oversight and possible termination.

The DOE loan guarantee to Solyndra was not structured in a manner that would have provided similar monitoring. The drop in silicon prices, which should have raised some red flags, was overlooked. And as Solyndra's financial difficulties mounted, it seems that DOE officials justified the losses by arguing that this was common in all startups. The DOE never responded to repeated requests from the Office of Management and Budget to answer specific questions relating to Solyndra's finances.

The final mistake the administration made was to let itself be wooed politically. Solyndra spent nearly $2 million on lobbying from 2008 to its bankruptcy in 2011. The principal private investor in the firm was a fundraiser for Obama, who had at least one discussion on Solyndra with White House staff in then-Vice-President Biden's office. Regardless of whether political connections played a role in the quick approval of the loan and its aftermath, this was a bad look.

Solyndra holds important lessons on how

to conduct industrial policy, especially in a democracy. First, an ability to pick winners is neither a prerequisite nor even a determinant of the success of productive transformation programs. The failure of an individual investment is not on its own a black mark against such programs. The appropriate metric is the performance of the entire portfolio of projects.

Second, it is important to cut losses when individual initiatives appear not to be working. This in turn requires clear and measurable yardsticks for progress and continuous monitoring. Having multiple goals – innovation, employment, national security – may make it politically easier to sell industrial policy, but it also makes it more difficult to discern whether the program is on track.

Finally, the practice of industrial policy must be insulated from lobbying and rent-seeking. Politics does have a role: it is inevitable, and necessary, that the overarching goals of productivist policies will be shaped by politics. But the process by which projects are selected and supported should not be subverted by politically connected firms pulling strings.

GETTING PRODUCTIVE TRANSFORMATION POLICIES RIGHT

In short, some of the critics' concerns about government involvement in structural change do carry weight. Even when they are well intentioned, governments are not omniscient, and they make mistakes. Sometimes short-term political calculations override concerns over the public interest. These considerations do not undermine the case for productivist policies, but do highlight the need to be careful when designing and implementing them. The real question is not *whether* these policies should be carried out but how. Basic econom-

ics and the broad experience around the world provide some helpful answers.

Let's begin with the economics. Markets are generally very effective at directing resources to areas where their contribution to economic well-being is high. When consumers value certain things highly, their willingness to pay is reflected in markets in the form of high prices and prospective profits. This incentivizes entrepreneurs to supply the goods and services in high demand. When goods and services are no longer in high demand, their prices fall, telling investors and producers to look elsewhere. This beautiful system can work to maximize a society's productive potential as if there were an invisible hand guiding the allocation of their labor, capital, natural resources – and ingenuity.

One important criticism of markets is that they do not ensure distributional equity, even when they allocate resources to their most productive uses. For one thing, wealthier consumers get a disproportionate say in how resources are allocated because their preferences shape market demand. One dollar, one vote! More importantly, those who have more to contribute to the economy, whether through hard work or sheer luck, skill or inheritance, get bigger paychecks. These distributional outcomes may violate our sense of social justice.

Market enthusiasts generally do not disagree that free markets can produce too much inequality. They would argue, however, that intervening in markets for goods, services, labor, or capital is never the best response. If inequality has to be tackled – a big if for libertarians – it would be better to do so by redistributing a limited amount of purchasing power so those who start with limited resources get a leg up. This could take the form of vouchers for education, for example, or a universal basic income.

The welfare state paradigm, while less enamored of markets, essentially takes this idea one big step further. It prescribes broad access to education, health care and social insurance, either through public provisioning or through an extensive system of social transfers.

Coordination failures occur when getting a new economic activity or technology off the ground requires complementary investments side by side and along the supply chain.

What concerns us here is a more fundamental shortcoming of markets: the failure to allocate resources efficiently. When markets fail in this fashion, the structure of economic activity is distorted and does not maximize overall productive potential. This problem goes to the heart of a market system because it calls the invisible hand theorem into question.

These are the kinds of problems where productivist policies come into their own. The immediate objective is to target and correct such inefficiencies. Typically, they also serve broader goals, such as the climate, the middle class and poverty reduction. But they do so by fixing markets directly rather than redistributing resources or ensuring broad access to public services.

There are three circumstances in which markets fail to do their primary job of allocating resources well. First, many economic activities produce "externalities" – positive or negative – that markets do not price in the decisions of firms or consumers. Environ-

mental externalities, whether local or global (as in the case of climate change), are the best known negative externalities.

On the other hand, technological innovations typically produce positive externalities. When firms learn how to produce solar cells more efficiently, for example, other firms can also reduce their costs by copying the techniques or poaching the workers and managers who are adept at using them. A third type of externality, which is less well recognized but is central to this book, is good-job externalities.

When a large employer in a small town shuts down, the economic and social costs can go significantly beyond the wage losses incurred by the workers. Similarly, creating middle-class jobs where good jobs have become very scarce creates benefits that extend beyond newly hired workers if it helps revitalize the community. In the absence of government intervention, economic activities that generate negative externalities are overproduced, and those that generate positive externalities are underproduced.

Coordination failures are the second category of market malfunction. These typically occur in the presence of significant scale economies, when getting a new economic activity or technology off the ground requires complementary investments side by side and along the supply chain. Each investment may be unprofitable on its own.

For example, there may not be high enough demand for electric vehicles in the absence of a network of fast charging stations. And producing EVs may be too costly if cheap electric batteries, a key input, are not available. At the same time, it makes little sense to invest in fast-charging stations or batteries if there isn't a large enough fleet of EVs already being produced. Creating training facilities for specialized technical skills will not be profitable unless there are firms that will employ the graduates. Those firms, in turn, will not exist unless they already have access to trained personnel in the first place.

In such circumstances, profitable clusters of new activities may never exist in the absence of some visible hand coordinating the activities of diverse actors. It is often the government that supplies that visible hand.

Third, many industrial and service activities require particular types of public inputs specialized to the needs of certain sectors, but not so distinct that it would make sense for each firm to procure them on their own. Workforce development, infrastructure, technical knowledge, regulations and standards that are specific to a sector are examples. Government has a role in providing these kinds of inputs as well.

One benefit of articulating these rationales explicitly is that they clarify the type of government policy that is called for. In the case of externalities, taxes or subsidies that are directly targeted at the source of the externality are generally the best response. For technological or good-job externalities, this means subsidizing the types of investments that produce those externalities. Subsidies for R&D, for solar cell or advanced semiconductor facilities, and for investments by firms that will create jobs that would otherwise be unavailable are some examples. Subsidies may take different forms, such as grants, tax incentives, and cheap loans or loan guarantees.

The other two circumstances require different kinds of government policy. Coordination failures can be addressed at little fiscal cost, in principle, by bringing upstream and downstream investors, potential cluster members or the different stakeholders together around the table.

Government guarantees that do not entail budgetary outlays can serve a similar function in certain settings. For example, until the

Asian financial crisis (1997-98), South Korean governments provided informal bailout guarantees to their conglomerates if they invested in priority areas. Since those investments generally proved successful, the guarantees were not called and the government did not incur any fiscal cost. The risk with such guarantees is that they may spur investments that are too risky along with those that are jointly profitable.

Customized public inputs typically do require government resources, but these must entail the provision of specific public services rather than financial incentives. If a firm is deterred from investing in a community or a developing nation because of a lack of specialized skills in the workforce or poor transport, providing those inputs is the best way to overcome the obstacle. Subsidies could serve as an inducement as well, but they may not be as effective or may miss the mark entirely.

These considerations are important because economists and policy practitioners both tend to put excessive weight on subsidies when they consider productivist policies. Their goals are often better served with other kinds of remedies. This point has been made forcefully by Tim Bartik, an economist with the W. E. Upjohn Institute for Employment Research.

Bartik has found that business services, ranging from customized training to entrepreneurship courses, generally are much more effective than subsidies at creating jobs

in distressed communities. Yet the resources devoted to these programs are tiny, around $3 billion a year. By contrast, even before the industrial policy programs of the Biden administration, state and local governments spent around $50 billion annually on cash incentives and tax breaks for businesses. The magnitude of these subsidies has grown tremendously with the CHIPS Act [subsidies for manufacturing advanced digital processors] and IRA programs. It is a reasonable bet that a reallocation of resources from subsidies to customized public inputs would enhance prospects for local job creation.

The point is relevant to developing countries as well. Their governments often complain they do not have the fiscal resources to compete with China or advanced economies when it comes to wooing companies with subsidies. But often what's required may be something different – better coordination of government services, say, or specific regulatory changes.

A useful illustration comes from Peru. Piero Ghezzi, the country's minister of production during 2014-16, decided that he would run industrial policy differently. He set up a series of discussions (*mesas ejecutivas*) with groups of producers, with the objective of developing a common understanding on the most important bottlenecks that prevented productivity gains and the best ways to remove them.

When business leaders sit together with government ministers, the conversation typically focuses on generic complaints about taxes, red tape and lack of competitiveness. Ghezzi wanted a different conversation, focused on problems specific to each sector. He warned from the outset that subsidies were off the table.

The remedies discussed were divided into "your problems" and "my problems" – things firms could do on their own and things government should help them do better. From these conversations came a series of policy initiatives targeted at constraints identified in the process. In forestry, for example, the government amended legislation to facilitate the marketing of timber, simplified procedures for land concessions, established a new technology center to transfer innovations and facilitated the provision of long-term loans from the national development bank.

OVERCOMING INFORMATIONAL LIMITATIONS

Piero Ghezzi recognized from the outset that he was nowhere near the omniscient policymaker that conventional accounts of industrial

policy posit. He knew there were problems that prevented productive upgrading. But he didn't know exactly what those problems were. He couldn't simply design an industrial policy scheme and implement it. He needed to engage the firms in problem discovery. He had to keep the conversation going, monitor outcomes and change course as required.

Governments make and implement policy in a wide range of settings where there exists high uncertainty about the effectiveness of policies and future technological trajectories.

This might sound obvious, but in fact it is not what most analysts think of when they discuss successful industrial policies. Ask an economist or a technocrat what kind of policy setup maximizes efficacy, and you are likely to hear about the need to commit to a fixed set (or schedule) of policies, to keep the private sector at arm's length, and to apply strict penalties when firms fail to deliver. Ask them why East Asia's industrial policies appear to have worked better than those elsewhere, and they will explain that governments there followed these strictures.

This vision of industrial policy runs into trouble when there is rampant uncertainty about the nature of the underlying problem and the efficacy of alternative remedies. It is perhaps not surprising that it does not correspond well with actual East Asian practice either, conventional wisdom notwithstanding.

In a study of Brazil, India and South Korea, the sociologist Peter Evans found that the distinguishing feature of South Korean industrial policy was what Evans called "embedded autonomy." Yes, government bureaucrats enjoyed relative autonomy from the private sector in that they could formulate broad policy objectives they thought were in the national interest and follow through with implementation unimpeded by businesses. But they also exhibited embeddedness, meaning they were engaged in ongoing communication and collaboration with the private sector.

We might worry that close relationships with private firms could render the government prone to capture. (I tell my students to make sure they do not confuse "embedded in" with "in bed with"!) But Evans argued these links were essential to ensure that governments could get access to the information needed to design workable policies, adjust to changing circumstances and prod firms along new technological trajectories. The difference with India and Brazil, Evans explained, was less the actual policies employed and more the manner in which the relationship with the private sector was managed.

Chinese industrial policy exhibits many of these elements of embeddedness. The architects of Chinese green industrial policies, write Professor Elizabeth Thurbon (University of New South Wales) and her co-authors, "behaved less like 'top-down commanders' (as authoritarian environmentalism would have it) and more like the collaborative 'catalysts' characteristic of traditional developmental states." They argue this mode of government-business collaboration was critical to the success of their policies. Given the size of the Chinese economy, national policymakers invest significant effort to coordinate with local governments, to combine national resources with local knowledge.

In EVs, for example, the national govern-

ment selected demonstration cities, which received priority in accessing financial incentives. In return, demonstration cities were expected to put in place complementary policies and raise their own resources. Cities then engaged in close collaboration with local companies and other stakeholders. Early results would be scrutinized by central government officials and experts, policies would be revised and disseminated accordingly, and the programs would be expanded to other regions. Municipal governments also often acted as venture capitalists, undertaking analyses of market and technological conditions before making investment decisions.

Liuzhou City, which achieved very rapid EV take-up, offers a particularly interesting example. Here, the municipal government worked closely with the local EV manufacturer, starting from the development phase. The local firm developed EV models that were specifically designed for the city's transport and parking systems. At the same time, the city government introduced a variety of incentives, such as purchase subsidies, reserved parking and rapid deployment of charging infrastructure.

At the national level, the central government sought to institutionalize its collaboration with the private sector by establishing China EV100 in 2014. The group's members included domestic and foreign manufacturers all along the supply chain, as well as high-level government officials and academics. The association was used as a forum for setting broad goals, coordinating the introduction of technologies, generating ideas about new policies and obtaining feedback from the private sector.

There is evidence from the U.S. that subsidy programs combining quantitative criteria and conditionality with flexibility and collaboration can work quite well. An example is the California Competes Tax Credit program. An initial list of awardees is selected through a strict formula that quantifies projected benefits. Administrators then negotiate with firms to finalize the list of recipients. These discussions produce a schedule of incremental employment, wages and investment targets, which the government monitors annually. Firms that do not stick to their commitments can risk losing their tax credits. But prospective applicants are told that administrators will do their best to work with them to prevent them falling into breach. A careful study has found that the program is effective in generating employment, especially in services.

EXPERIMENTALIST GOVERNANCE

An economist, the old joke goes, is someone who sees something work in practice and asks whether it can work in theory, too. The supreme theorist of the collaborative approach discussed in this chapter is Chuck Sabel, a political scientist and legal scholar at Columbia University. He has studied how governments make and implement policy in a wide range of settings where there exists high uncertainty about the effectiveness of policies and future technological trajectories, including public schools, environmental regulation, industrial diversification and social services. Along with Jonathan Zeitlin and other co-authors, he has distilled the lessons into a model of policymaking he calls experimentalist governance.

The traditional framework of government intervention that economists work with makes several key assumptions. First, that the policymaker has clear, well-defined objectives, such as physical investment or exports in a sector. Second, uncertainty is low dimensional. The government may lack precise information about, say, firms' production costs but is otherwise well informed about the consequences

of its actions. Relatedly, the economic and technological environment is stable.

Finally, economists assume there is little value in direct communication between private actors and the policymaker: because firms have the incentive to be strategic, the only way in which useful information can be elicited from them is by observing their actions.

Experimentalist governance applies in settings where uncertainty is pervasive and background conditions are inherently unpredictable. In such settings, policies cannot be designed and implemented without interacting with private agents. The problem of strategic behavior by firms is real, but it is only one feature of this public-private interaction. Firms also benefit from close interaction, and they have an incentive to build a reputation in what is an ongoing, iterative relationship with government agencies.

Experimentalist governance has four elements, linked in an "iterative cycle." First, the policymaker and the principal stakeholders establish broad, provisional goals and determine the metrics for gauging progress. An example might be increasing the number of good jobs in a region or upgrading the productivity of informal firms in a particular service sector. Second, the executing agents – firms, municipal governments, innovators, civil society groups, public service providers, frontline workers – are given broad discretion along with financial/institutional support to achieve these goals. Third, these agents provide periodic reports and participate in informal peer reviews where results are compared across experiments.

Where progress is unsatisfactory, either the agents take credibly corrective steps or the experiment is abandoned. The conditionality that government imposes on agents is soft rather than hard, in the sense that agents are merely expected to show a good-faith effort to meet their commitments rather than to adhere to strict performance criteria. Finally, the objectives of the program are revised and disseminated to a broader circle of agents. And the cycle repeats.

From the perspective of experimentalist governance, what matters most to the effectiveness of productive development policies is not the policy instruments or sectors selected, but the government's ability to navigate these four steps effectively. A government evaluates its policy framework not by asking, which tax breaks or subsidies are we using, which sectors have we identified, what is the budget for productive upgrading? The more important questions are: do we have the process in place whereby policymakers engage with the private sector on obstacles and opportunities? Do we have the organizational capacity to monitor progress on the ground and respond to the needs that these conversations are helping identify? Can we coordinate the requisite policies across institutional silos within the government?

A nagging question in all discussions of productive development policies is whether government agencies have the capacity to develop and implement the required policies. Experimentalist governance does not require a great deal of state capacity, at least to begin with. Rather than presuming they can discipline firms through explicit penalties or other forms of hard conditionality, it relies on firms' own self-interest to engage in collective problem-solving. Nor does it depend on mutual trust between state and private actors. The assumption is that trust, along with general state capacity, will grow in the collaboration.

The experimentalist governance schema above captures the broad outlines of how DARPA/ARPA innovation programs operate in the U.S. The similarity with China's EV promotion policies is also obvious.

FINAL THOUGHTS

Productivism prioritizes both the green transition and the broad dissemination of economic opportunity across the economy. It differs from neoliberalism in giving the government an important role in directing structural change and technological innovation to achieve these goals. It places significantly less faith in the ability of markets and large corporations to serve these objectives on their own. It emphasizes the real economy over finance, production over consumption, and revitalizing local communities over globalization.

Productivism also departs from the welfare state. It emphasizes that redistribution, social insurance and macroeconomic management are not enough. A truly inclusive economy, one that gives people dignity and social recognition as productive members of society, also requires intervention on the supply side to create good jobs for everyone. And productivism diverges from both its predecessors by favoring collaborative, experimental solutions over technocratic ones.

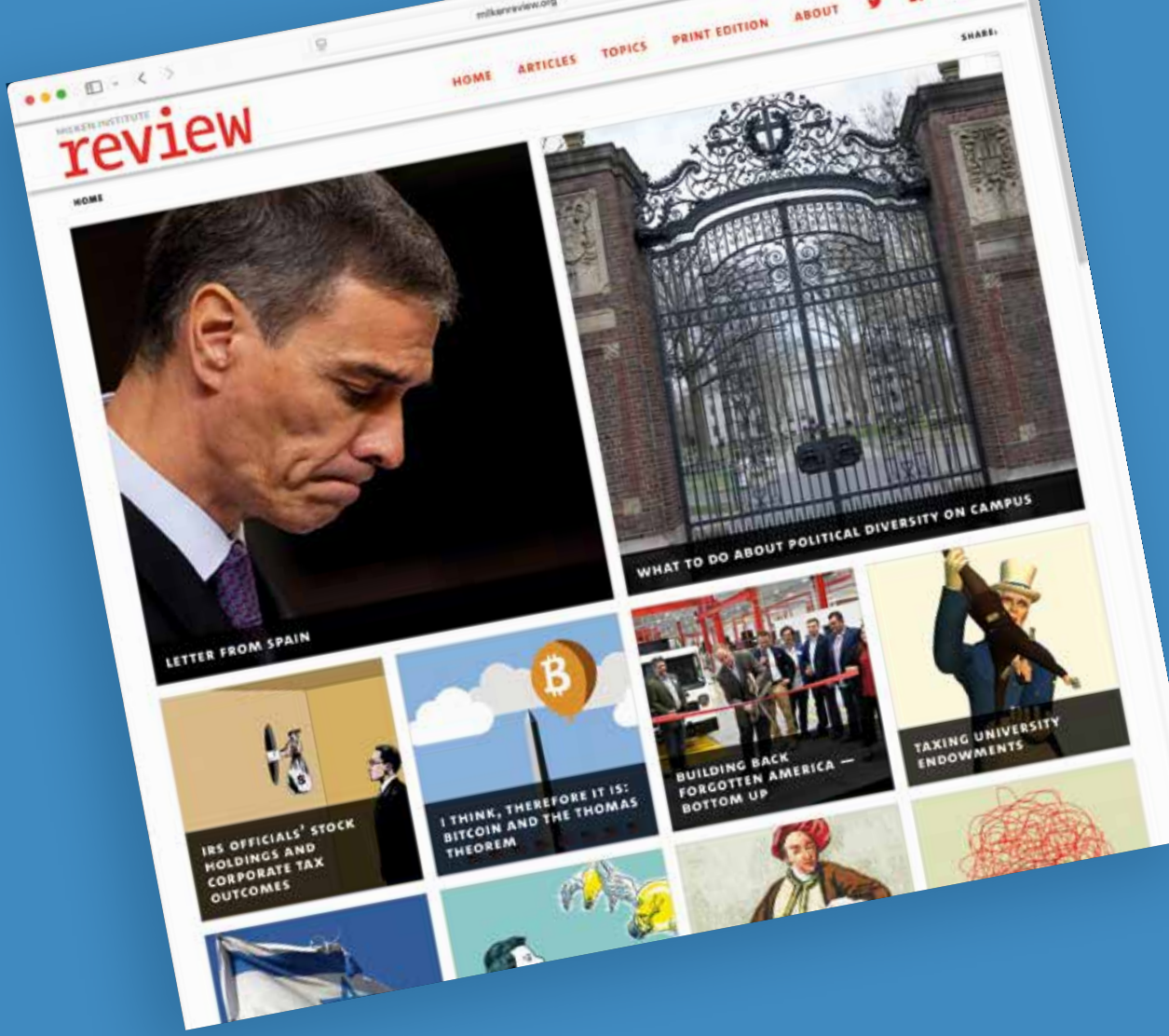
Productivism tackles inequalities where they are created. It intervenes at the source – in employment, production and innovation – instead of after the fact through income redistribution.

If you want to lift someone from poverty, the old adage goes, teach them how to fish instead of giving them a fish. The redistributive approach is akin to handing out fish, while pre-distribution policies, such as education, amount to teaching people how to fish. The productivist approach, on the other hand, makes sure there are enough fish in the pond in the first place.

Too good to be true?

VCG/VCG VIA GETTY IMAGES

Hefei, Anhui Province, China.



LOOKING FOR that memorable *Review* article from 2019?

Want to include that reference in your next presentation?

WHATEVER YOUR REASON, THE SOLUTION IS THE SAME:

***The Milken Institute Review* website.** You'll find past issues, all searchable for speedy recovery and lasting enjoyment.

MILKEN INSTITUTE

In this issue