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FINANCE & DEVELOPMENT INTERNATIONAL MONETARY FUND

DECEMBER 2025

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STABLECOINS
And the global monetary system

AI ECONOMIST
Sendhil Mullainathan and the algorithm age

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FSC FPO

Editor's Letter

Data that Delivers

WE LIVE IN A GALAXY OF DATA. From satellites and smartwatches to social media and swipes at a register, we have ways to measure the economy to an extent that would have seemed like science fiction just a generation ago. New data sources and techniques are challenging not only how we see the economy, but how we make sense of it.

The data deluge raises important questions: How can we distinguish meaningful signals of economic activity from noise in the age of AI, and how should we use them to inform policy decisions? To what extent can new sources of data complement or even replace official statistics? And, at a more fundamental level, are we even measuring the metrics that matter most in today's increasingly digital economy? Or are we simply tracking what we looked at in the past? This issue of *Finance & Development* explores these questions.

Author Kenneth Cukier suggests that harnessing alternative data requires a new mindset. He likens today's economists to radiologists who once resisted having clearer MRI scans because they were trained to read fuzzier ones. Are we clinging to outdated metrics even as new data offers faster, granular, and sharper insights into economic reality and a better reflection of "ground truth"?

More data doesn't automatically mean better insights or decisions. New or alternative data is often a by-product of private business activity, with all the biases of that environment. It may lack the long continuity and robust methods that underpin official economic indicators. That's why official statistics remain essential.

Claudia Sahm shows how central banks are tapping new sources of data to fill gaps—including falling response rates to national surveys—but always in tandem with trusted official sources. To improve data quality, she calls for strong ties between statistical agencies, private providers, government officials, and academics. Relying on data sources not available to the public erodes transparency, which is critical to central bank accountability, she cautions.

For the IMF's Bert Kroese, reliance on private data must not diminish resources available for official number crunching. Without strong, independent national statistical agencies, the integrity of economic data, and the policies built on it, could falter.

"To serve the public good, data needs to help us see our world more clearly, make better decisions, and respond intelligently to complexity."

That's not to say government agencies always get it right. Rebecca Riley argues that core economic metrics like GDP and productivity are increasingly misaligned with a rewired, data-driven economy. She calls for a modernization of measurement systems to better reflect the growth of intangible assets such as digital services, and the evolving structure of global production.

Better data collection serves the public good only if the data is widely available. Viktor Mayer-Schönberger warns that the concentration of data collection among a handful of Big Tech companies threatens competition and innovation. He makes the case for policies that mandate broader data sharing.

Elsewhere, Laura Veldkamp discusses the value of data, raising questions about how we price, use, and share information, and proposes novel approaches to turn intangible data into something we can count. Jeff Kearns shows how innovative approaches like nowcasting are helping developing economies close information gaps. And the head of India's statistical agency, Saurabh Garg, explains in an interview how he is tackling challenges of scale as public demand for real-time data grows.

This issue serves as a reminder that better measurement is not just about more data—it's about using it wisely. To serve the public good, data must help us see the world more clearly, respond intelligently to complexity, and make better decisions. Data, after all, is a means not an end. F&D

Gita Bhatt, editor-in-chief

Kaleidoscope

A global view, in brief

THE BIG PICTURE: Global growth is projected to slow slightly to 3.2 percent this year and 3.1 percent next year, according to the IMF's latest *World Economic Outlook*. Asia will remain the biggest driver of global growth, contributing about 60 percent in both years. *Above, people attend the 2025 Bangkok International Motor Show. IMF Photo/Andre Malerba.*

No Time for Timidity

INTERNATIONAL COOPERATION is at its weakest in 80 years, just when the world needs it most to counter resurgent economic nationalism and zero-sum attitudes, Singapore's President Tharman Shanmugaratnam warned in a lecture at the IMF's annual meetings in October.

Shanmugaratnam said that the post–Cold War's open, rules-based order lifted a billion people out of poverty but that the mood has shifted, especially in advanced economies. "While the gains in jobs and incomes vastly exceeded the losses, the pain of job loss has been more deeply felt," he said, urging robust public policy to support people displaced by technology and trade competition.

The transition to a multipolar world does not ensure economic security between nations but risks a self-reinforcing decline into global disorder, Shanmugaratnam warned in the Per Jacobsson lecture. "We must reset the rules and norms...and develop a renewed multilateralism suited to this new era."

Shanmugaratnam called for reform of the World Trade Organization's consensus decision-making process and stronger rules to ward off a global subsidy race that could fragment markets. "We have to build a pathfinder multilateralism through plurilateral agreements and regional agreements...that can create momentum for fair and open trade."

He called for a new AI safety framework, modeled on the United Nations Intergovernmental Panel on Climate Change, to prevent the greatest risks to humanity, from autonomous weapons to dangerous disinformation.

He stressed the need for a new "equilibrium" between the US and China. "The interaction and competition between the two superpowers is not a threat to be eliminated, but an opportunity to be managed," he said, adding that collaboration in specific areas could benefit both nations and drive global innovation.

"It is our responsibility to make possible a future of dignity, sovereignty, and a livable planet for our children and generations after," Shanmugaratnam concluded. "This is no time for timidity."

Overheard

"I am not sure we'll go back to the world of fairly orderly multilateralism we came from. But it doesn't mean a world not based on international cooperation, just that we will cooperate in different configurations and a different manner."

—IMF Managing Director Kristalina Georgieva

"Monetary sovereignty will be challenged—we have to face that fact—and there will be fewer currencies."

—Jeremy Allaire, Circle chairman and CEO, on the ascent of stablecoins

"We need to have African voices at the table. And we must understand that digital inclusion in the 21st century is economic inclusion."

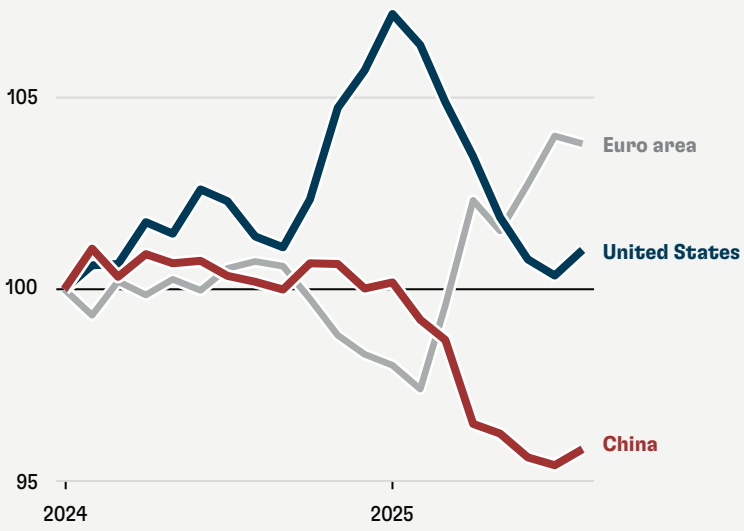
—Tony Elumelu, chairman of Heirs Holdings

IN THE NEWS: Dan Katz, previously chief of staff to US Treasury Secretary Scott Bessent, was appointed IMF first deputy managing director in October. "Significant shifts in policies, rules of engagement, and partnerships are reshaping the international economic system," Katz said in his first remarks in the role, stressing the need for particular attention on emerging market and developing economies, especially fragile states that are vulnerable to shocks. *Above, Katz meets visiting officials at the 2025 IMF annual meetings. IMF Photo/Stephen Voss.*

By the numbers

China's real depreciation pulls against rebalancing.

REAL EFFECTIVE EXCHANGE RATES: JAN. 2024 = 100



SOURCE: IMF, Global Data Source database.

Back to Basics

How Does the IMF Finance Itself?

Think of it as a credit union for countries that funds itself through the interest it charges borrowers minus the interest it pays creditors

Anna Postelnyak

THE IMF MAY BE BEST KNOWN for providing loans to crisis-hit countries. But what about its own finances? How does it fund its critical functions and cover its running costs? Let's remember that the IMF is not only a global financial firefighter. It's also a source of essential policy advice and helps its member countries bring about the right macroeconomic conditions for boosting growth, creating jobs, and lifting living standards.

This unique mandate comes with a unique financial structure. Think of it as a credit union for countries—with a lending capacity of nearly $1 trillion. How does it work?

The IMF pools the resources of its members, charges interest to those that are borrowers, and pays interest to its creditor members. The difference between these two rates covers the administrative costs associated with the IMF's general, or non-concessional, lending. The IMF also earns income from investments, which covers other administrative costs, such as for surveillance and capacity development. Unlike many other international organizations, therefore, the IMF does not require its members to make annual contributions.

When countries join the IMF, they are assigned individual *quotas* based broadly on their relative positions in the world economy. These quotas determine each member's financial deposit in the IMF, how much it can borrow, and its voting rights on the Executive Board. To ensure that the IMF has sufficient lendable resources, the institution is working with its members to implement the 50 percent quota increase under the most recent general review of quotas.

Interest-earning deposits

All members initially deposit one-quarter of their quota in what the IMF calls *freely usable currencies*. These are the currencies most commonly used in international transactions and widely traded in foreign exchange markets. Today they comprise the US dollar, the British pound, the euro, the Japanese yen, and the Chinese renminbi.

This portion of a member's quota constitutes its initial *reserve tranche position*, as recorded on the IMF's books. Members receive a market-based interest rate on this position and can withdraw up to the full amount in case of a balance-of-payments need. The remaining three-quarters of a member's quota is deposited in its own currency, often in the form of a non-interest-bearing promissory note.

When the IMF provides loans to members in need, it draws only on the currencies of members whose economies are sufficiently strong to be creditors. These members are included in what is known as the *financial transactions plan*. If they are called on to lend to a country in need, they convert their IMF deposit to one of the five freely usable currencies (if their own currency is not already freely usable). The IMF then uses this to provide the loan to the borrowing country.

The amount each country lends is added to its reserve tranche position, earning market-based interest. In 2024, some 50 creditor countries received a total of about $5 billion in interest on the resources they had provided for non-concessional IMF lending.

DALE CROSBY-CLOSE

Meanwhile, the interest rate a borrower pays equals the interest rate the IMF pays to creditors—plus a margin (currently, about half a percentage point per year). This income helps cover the administrative costs associated with the IMF's lending operations. Any remaining surplus is typically put into the IMF's reserves to build *precautionary balances* that underpin the institution's balance sheet.

Defaults and arrears

What if a borrower falls into arrears while repaying its IMF loan? This rarely happens because IMF-supported programs are designed to ensure that a borrower's economy stabilizes and its balance of payments improves so that it can repay the loan when it falls due. Programs include *conditionality*, which helps ensure that the borrowing country implements the policies agreed on with the IMF. Its central bank must also undergo a *safeguards assessment* to minimize the risk of misuse of funds. No borrowing country has ever defaulted outright on its IMF loans, although there have been cases of protracted arrears, especially during the 1980s debt crisis (there are none currently).

When a borrower falls behind in paying interest on its loan, the IMF has a *burden-sharing mechanism* to cover any shortfall in its income. Under this mechanism, all creditor and debtor members provide temporary financing in equal amounts. This is done by reducing the interest rate creditors receive on their reserve tranche positions and increasing the interest rate debtors pay on their loans. These sums are refunded once the borrowing member pays its arrears.

IMF lending is thus a safe investment for creditor countries. They earn interest on quota resources that are lent to countries in need while bearing only a fraction of the risks.

Borrowing countries also benefit, because IMF program design and conditionality support domestic reforms to strengthen their economies. This, in turn, gives them access to affordable loans. Interest rates on IMF loans are far lower than what crisis-hit countries would typically pay in private capital markets, assuming they're able to borrow at all.

More broadly, IMF lending supports the rest of the world economy by reducing the risk of spillovers. Without IMF support, crisis-hit countries would be forced to severely cut their imports, which would harm not only domestic producers and consumers that rely on imports but also their trading partners. IMF lending also reduces the risk of crisis contagion, whereby a crisis in one country triggers crises elsewhere.

Concessional loans

The bulk of IMF lending is *non-concessional,* which means the borrower pays market-based interest. In addition, the IMF provides cheaper, *concessional,* loans to its poorest members, using resources richer members have voluntarily provided for this purpose. The IMF pools these funds in the Poverty Reduction and Growth Trust (PRGT), which is separate from the IMF's own balance sheet.

When members contribute financial resources to the PRGT, they decide whether to give a grant or make a loan. Since the borrower pays little or no interest on the concessional loan it receives, the difference between what the borrower pays and what the creditor receives is covered with the help of a *subsidy account* funded by voluntary member contributions and the IMF's own resources. IMF members recently decided to create a framework that allows them to allocate part of the surplus they receive from non-concessional lending to PRGT subsidies.

At the Bretton Woods Conference, which established the IMF in 1944, US Treasury Secretary Henry Morgenthau noted that the details of the international monetary and financial agreement may seem "mysterious." And yet, at its core, the IMF is a simple credit union that funds itself through the interest it charges borrowers, minus the interest it pays to creditors, to the benefit of both and to the world economy at large. F&D

"The IMF's unique mandate comes with a unique financial structure."

ANNA POSTELNYAK *is a senior research officer in the IMF's Strategy, Policy, and Review Department.*

Point of View

Instilling Trust through Statistics

Bert Kroese

Strong and independent national statistical agencies safeguard data integrity and underpin sound policy

In the mid-2000s, Argentina's once-reliable inflation statistics became a flashpoint for controversy. Official figures started to diverge from independent estimates. At first, the discrepancies were small. Then they grew. By 2007, private analysts pegged inflation as much as triple the officially reported rate. The credibility of Argentina's national statistics office collapsed. Investors lost confidence and pulled out funds. Policymakers struggled to make decisions without accurate statistics to guide them, compounding the challenges confronting the economy.

Beneath the surface lay a deeper problem: a statistical institution weakened by chronic underfunding and political interference. Without independence and adequate resources, the integrity of economic data—and the decisions built upon it—is compromised.

In today's data-saturated world, the role of national statistical offices (NSOs) has never mattered more. As trusted providers of official statistics, NSOs are the foundation of evidence-based policymaking. Yet their ability to fulfill this function is under pressure—from greater economic and social complexity and competition from unverified data sources.

Apart from manipulation, neglect of statistical quality can have serious consequences. GDP and inflation series must be rebased frequently to remain useful. Nigeria waited 20 years to rebase its national accounts and then, in 2010, announced its economy was almost 60 percent bigger than previously estimated. Such revisions completely change the picture of the economy.

NSOs need independence, access to data, and adequate funding to be effective. They should be able to innovate, adapt, and publish high-quality statistics.

More complexity

Data is everywhere. From social media platforms to smart devices, information is generated at an unprecedented scale. Enabled by surging computing power and artificial intelligence, data can be transformed into insight, but these tools can also produce misleading or entirely fabricated results.

Large language models still hallucinate. For example, leading models consistently fail to produce accurate figures when prompted to produce a table of economic growth rates using the latest IMF *World Economic Outlook*—even when given the source. Most of the numbers are close but incorrect, which is arguably more dangerous than being wildly wrong: Plausible errors are harder to detect and more likely to mislead.

NSOs, by contrast, ground data in internationally harmonized concepts and methodologies. Their commitment to transparency builds trust. NSOs provide a benchmark against which other data sources can be measured. In a world where misinformation spreads rapidly and data manipulation is easier than ever, the integrity of official statistics is indispensable.

IMF PHOTO/KIM HAUGHTON

Illustration by Chantal Jahchan

"The role of national statistical offices has never mattered more."

Moreover, the complexity and interconnectedness of today's global economy demand integrated and well-defined data. Whether it's tracking inflation, measuring unemployment, or assessing economic growth, policymakers need statistics that are accurate and comparable across countries. NSOs and global standards ensure that data serve as a reliable foundation for policy discussions—so that debates focus on the policies themselves, not the validity of the underlying numbers.

Mounting challenges

Despite their importance, NSOs face mounting challenges. One of the most pressing is declining response rates to traditional surveys. The response rate to the UK's Labour Force Survey dropped below 15 percent in 2023, leading to a temporary suspension of the official releases that underpin employment estimates. As people become more wary of sharing personal information—or simply too busy to participate—data collection becomes more difficult and expensive. At the same time, the economy is evolving rapidly, with new sectors like the gig economy and digital services requiring fresh approaches to measurement.

To meet these challenges, NSOs must innovate. This means integrating alternative data sources—such as administrative records, satellite imagery, and private sector data—into statistical systems. NSOs can use big data and AI techniques to accomplish this. It also means that their data must be AI-ready, with well-structured metadata and access for application programming interfaces, so that the information can be easily found and used by modern tools and platforms. Cooperation with AI developers could ensure that official statistical data are more discoverable by those seeking statistics.

Fundamental principles

Support for NSOs starts with ensuring their independence—one of the fundamental principles behind their effectiveness. Statistics should reflect reality—not political agendas. Legal frameworks must protect NSOs from external interference, allowing them to choose methodologies and publish findings based on professional judgment. Leaders should be empowered to make decisions grounded in statistical expertise, and their staff should adhere to the highest ethical standards, including safeguarding confidential data and using it solely for statistical purposes.

Funding is another cornerstone of support. Unfortunately, the field of official statistics is not glamorous and is seldom a priority, particularly during trying fiscal times. By one estimate, the budget of the US Bureau of Labor Statistics—the agency responsible for producing employment and inflation data, key inputs for monetary policy—has declined by an inflation-adjusted 22 percent since 2010.

To stay relevant, NSOs must compete for talent, invest in technology, and conduct research into emerging data challenges. This includes analyzing and addressing response rates, developing new survey techniques, and exploring innovative data sources—as well as continuing the day-to-day work of producing the core statistics needed for policymaking and safeguarding their quality. Increased investment in statistical capacity is essential to maintaining data quality and relevance.

Access to public and private data is crucial. Governments should facilitate the sharing of administrative data with NSOs, and legal frameworks should enable secure and confidential data exchange between NSOs and other official statistics producers, such as central banks. Best practice includes establishing national coordination committees to oversee statistical governance and promote collaboration.

Guardians of integrity

Stronger NSOs are a strategic imperative. Reliable statistics are essential for effective governance, economic planning, and public accountability. NSOs should be equipped with strong, innovative, and independent leadership capable of navigating the complexities of the modern data landscape.

NSOs should collaborate with other official statistics producers, academic institutions, and international organizations, such as the IMF, to share knowledge, align methodologies, and build capacity. Partnerships with technology companies can help, both as data providers and as channels for disseminating statistics.

Communication is another area for improvement. Producing high-quality data is only half the battle; making it accessible and understandable is equally important. NSOs should invest in data visualization, interactive dashboards, and plain-language summaries to reach diverse audiences. They should embrace open data initiatives and use modern communication channels—such as social media and data portals—to engage with the public and counter misinformation.

Doing so will enhance visibility, build public trust, and improve survey response rates. When people understand the role of NSOs and trust data handling practices, they are more likely to participate in data collection.

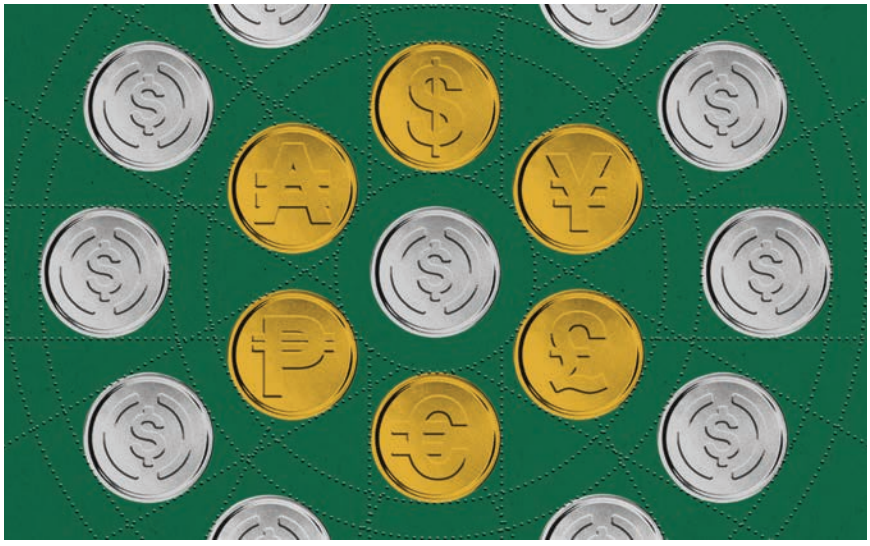
National statistical offices are the guardians of data integrity and the backbone of informed decision-making. Ensuring their independence, adequate resources, and capacity to innovate is fundamental to good governance and effective policymaking. Without strong statistical institutions, trust in economic data collapses—and with it, the foundations of sound policy. F&D

BERT KROESE *is the IMF's chief statistician and director of the Statistics Department.*

The Stablecoin Paradox

Eswar Prasad

Stablecoins may concentrate financial power and reinforce the current structure of the international monetary system



Crypto's early revolutionaries intended to end the choke hold of central banks and large commercial lenders on financial intermediation. The great ambition of the original crypto asset, Bitcoin, and the blockchain technology that underpins it, was to cut out the middlemen and connect transacting parties directly.

The technology was meant to democratize finance by giving everyone, the poor as well as the rich, easy access to a broad range of banking and financial services. New insurgent providers would use the technology to offer competitive financial services—including bespoke products for managing savings, credit, and risk—without setting up expensive brick-and-mortar operations. All this was meant to sweep out the old financial institutions, which had forfeited people's trust during the global financial crisis, and build a new financial order in their place. Competition and innovation would flourish in this brave new world of decentralized finance. Consumers and businesses alike would benefit.

But the revolution was soon subverted. Decentralized crypto assets like Bitcoin, which are essentially created and managed by computer algorithms, proved untenable as mediums of exchange. Their volatile values and inability to process a large volume of transactions cheaply made them impractical for everyday use and led them to fail in their intended purpose. Instead, Bitcoin and the rest have become what they were never intended to be—speculative financial assets.

Stablecoins stepped in to fill the void by serving as more reliable mediums of exchange. They use the same blockchain technology as Bitcoin but maintain a stable value by being backed one-to-one with reserves of central bank currencies or with government bonds.

Stablecoins are facilitating decentralized finance, but they are the antithesis of decentralization. They don't rely on decentralized trust mediated by computer code but rather on trust in the institutions that issue them. Governance isn't decentralized, with users deciding the rules through public consensus, either. Instead, the firm that issues a stablecoin decides who can use it and how. Stablecoin transactions are posted to digital ledgers maintained on a decentralized network of computer nodes, the same as Bitcoin. But the stablecoin issuer, rather than a computer algorithm, validates these transactions.

Payment pathway

Perhaps the larger objectives are more important. Stablecoins could still serve as a pathway for people of all income levels to access digital payments and decentralized finance, undercut the privileges long enjoyed by stodgy commercial banks, and level some aspects of the playing field between richer and poorer nations. Even a small country could benefit from easier access to global finance through integration with payment systems with fewer frictions.

And stablecoins have indeed lowered costs and removed frictions in payments, particularly those that cross national borders. Economic migrants can send remittances to their home countries far more easily and cheaply than before. Importers and exporters can complete transactions with foreign counterparts

COURTESY ESWAR PRASAD

Illustration by Chantal Jahchan

instantaneously rather than having to wait for days.

Yet beyond payments, decentralized finance has become an arena for financial engineering that has spawned complex products of dubious value for anything other than speculation. Decentralized finance activities have hardly improved the lot of indigent households and could even hurt less sophisticated retail investors who get duped by the prospect of outsize returns and don't appreciate the risks.

Shift in regulation

Will recent US legislation that permits a broad range of corporations to issue their own stablecoins promote competition and check less savory issuers? In 2019, Meta tried to create its own stablecoin, called Libra (later renamed Diem). But the project was halted in the face of fierce opposition from financial regulators, who feared that such a stablecoin could undermine central bank money.

A shift in the regulatory climate in Washington, with a new crypto-friendly administration, has now opened the door wide for private stablecoin issuers. Stablecoins issued by large US corporations, such as Amazon and Meta, backed by their sizable balance sheets, could sweep away other issuers. Minting stablecoins would ramp up the power of these corporations. It would lead to more concentration not more competition.

Large commercial banks are also adopting some aspects of the new technologies to make their operations more efficient but also to extend their reach. Turning bank deposits into digital tokens allows them to be transacted on blockchains, for instance. It's conceivable that large banks could one day start issuing their own stablecoins. All of this would undercut the advantages of smaller banks, such as regional and community lenders, and entrench the power of the big players.

International dominance

Stablecoins are also likely to reinforce the current structure of the international monetary system. Dollar-backed stablecoins are in the greatest demand and most widely used around the world. They could end up indirectly boosting dollar dominance of the global payment system and weakening potential rivals. For instance, Circle, a company that issues the second most popular stablecoin, USDC, has seen little demand for its other stablecoins, whose values are pegged to other major currencies such as the euro and the yen.

Even major central banks are rattled. Concerns that dollar-backed stablecoins could be used for cross-border payments is pushing the European Central Bank to issue a digital version of the euro. The euro area's payment system within its own perimeter is still fragmented. It's possible to move money from a Greek to a German bank, but making a payment in one euro area country using money from a bank account in another is still not seamless.

Stablecoins pose an existential threat to the currencies of smaller economies. People in some corners of the developing world are likely to trust stablecoins issued by well-known companies such as Amazon and Meta more than local currencies that have suffered from high inflation and have volatile exchange rates. Even people in a well-managed economy with a trusted central bank might find it difficult to resist the temptation of using stablecoins that are convenient for both domestic and international payments and whose value is pegged to the dominant global currency.

Many inefficiencies

Why have stablecoins gained so much traction so quickly? One reason is that high costs, slow processing times, complicated processes, and other inefficiencies still bedevil international and even domestic payments in many countries. Some countries are contemplating issuing their own stablecoins to prevent their domestic currencies from being sidelined by dollar-backed stablecoins. This approach is unlikely to succeed. They would be better off fixing problems in domestic payment systems and working with other countries to remove frictions in international payments.

Stablecoins appear safe but pose a variety of risks. One is the possibility that they could lubricate illicit financial activities, making it harder to police money laundering and terrorism financing. Another is that they threaten the integrity of payment systems by creating a disparate set of systems managed by private corporations.

Fixing the problems

The solution seems obvious: effective regulation that tamps down the risks, leaves space for financial innovation, and ensures fair competition by curbing excessive concentration of economic power in the hands of a few companies. The internet knows no borders, so regulating stablecoins at the national level won't work as well as a cooperative approach that involves all countries.

Alas, this is an unlikely outcome at a time when international cooperation is in short supply, with each country aggressively protecting and promoting its own interests. Even major economic powers such as the US and euro area are going their own way on crypto regulation. Even with a more coordinated approach, smaller economies are unlikely to have a seat at the table. These countries, with weaker financial systems, limited regulatory capacity, and a lot more riding on sound regulation, could be hit with rules that pay little attention to their concerns, foisted on them by the larger powers.

Stablecoins are serving a useful purpose by shining a light on the inefficiencies that pervade existing financial systems and showing how innovative technologies can fix these problems. Yet stablecoins might well lead to a world where power is more concentrated. And that might foster a new financial order—not of flourishing innovation and competition and a fairer distribution of financial power as crypto's pioneers intended, but of even greater instability. F&D

ESWAR PRASAD *is a professor of economics at Cornell University, a senior fellow at the Brookings Institution, and author of* The Future of Money. *His latest book,* The Doom Loop: Why the World Economic Order Is Spiraling into Disorder, *will be published in February 2026.*

Why Data Should Be Shared

Viktor Mayer-Schönberger

Economic innovation in the AI age could stall without regulations that mandate access to data

Google is remarkably good at guessing from users' misspelled queries what they intended to type into its search engine. This is because it doesn't guess: The internet giant trained its spellchecker some 20 years ago with typos billions of users made when searching. No competitor could come close because no one else had access to a similar fire hose of relevant data. Today Google accounts for 9 in every 10 internet searches—and faces new restraints after a recent antitrust ruling.

Using data to innovate, as Google did, is known as the "feedback effect." Big Tech companies benefit from it most because they have access to the most data: They can crunch it at their data centers, transform it into insights, and use these to improve their products and services.

AI is turbocharging the feedback effect and widening the imbalance between the data haves and have-nots. It takes massive amounts of information and processing power to train and tune AI models, which large internet platforms have in spades. And what they don't have, they can buy with the avalanche of capital seeking to invest in AI.

The consequences for dominance are clear. Six Big Tech companies—Alphabet (Google), Netflix, Meta, Apple, Amazon, and Microsoft—account for almost half the world's internet traffic. Four of these—Alphabet, Microsoft, Meta, and Amazon—dominate AI computing capacity.

As more data lead to better products and services, the largest players attract more customers, generating even more data. The feedback effect leads to self-reinforcing market concentration dynamics that competitors less flush with data can't join.

Concentration effects

Economists have long worried about the effects of concentration. Economies of scale and scope suggest that larger firms produce more cheaply than their smaller competitors, increasing sales while dictating price and pocketing profits, as Joseph Schumpeter argued in 1942. Innovation is the best antidote for concentration: Better ideas lead to improved or even completely novel products. This is crucial to economic dynamism.

Yet it is increasingly difficult for conventional companies to challenge the data economy's dominant players. They often lack the processing power and technical skills, but most important is the lack of a data mindset: the realization that using data creates value. Many conventional companies collect data but underutilize it; surveys show that at least 80 percent of what's collected worldwide is never used. Companies that collect data but don't know how to use it see the value of their digital resources seep away. Their capacity to innovate suffers, and they fall farther behind more data-savvy companies.

Innovation not only stalls within conventional companies. Dominant data platforms eventually suffer, too. Economists such as the University of Chicago's Ufuk Akcigit have shown that companies often lose interest in innovation once they become dominant and instead prioritize protecting their market share. Without robust competition they no longer need to innovate to stay ahead. Instead, they can weaken their offerings and still keep their substantial market share, as the writer Cory Doctorow argues.

The threat of data concentration and

COURTESY VIKTOR MAYER-SCHÖNBERGER

Illustration by Chantal Jahchan

loss of economic dynamism is serious enough to warrant policies that prevent or at least mitigate this misfortune. But identifying the best policy intervention is tricky.

Competition regulation

Using antitrust and competition regulation to break up large data platforms tackles the symptoms but not the cause of data concentration. If authorities were to break up Meta, for instance, another large platform would likely take its place. Because it doesn't change the underlying dynamic that rewards those that can access and use the most data.

Similarly, policies that give individuals more control over their data—think of the EU's General Data Protection Regulation—routinely fail to counter data concentration. Surveys show that many people care about their personal data, but few exercise their right to control it. This points to a problem of collective action: People must spend time curating access to their data, but they get only limited benefits in return, even though there are collective benefits. Everyone waits for others to act, and nothing happens: Powerful platforms continue to use data at will.

Policies that grant legal ownership or some similar exclusion right over data face similar practical hurdles. And given the complexity of licensing, these policies may result in less data being accessible overall, negatively impacting innovation. Moreover, transaction costs are not spread evenly: Complex negotiations over use licenses disproportionally burden individuals and small start-ups, tilting the playing field even further toward large platforms.

But regulations mandating access to data, especially nonpersonal data, offer more promise. If cleverly designed, they can reduce transaction costs—no licenses need be negotiated—helping smaller firms gain access to data. If data holders can extract value only by using the data themselves, it motivates those who have it to use it, pushing more conventional firms to become data savvy. Such regulations advance data use—what's currently lacking—rather than data collection.

"Using antitrust and competition regulation to break up large data platforms tackles the symptoms but not the cause of data concentration."

Ideation and innovation

Innovation benefits as well. Multiple players can apply their ideas to data, so that ideation, not data hoarding, is rewarded. Data access mandates also adhere more closely to economic principles of value generation: The secret is often in data's clever application, or use, rather than its collection. To employ an industrial-age metaphor, access mandates facilitate value extraction rather than possession of raw materials.

Data access mandates may sound novel, but they are not, as Thomas Ramge and I show in our 2022 book, *Access Rules*. Governments worldwide are already legally obligated to offer access to troves of data. The best example is the locational data made available by the GPS system, operated by the US military, and the EU's Galileo system. The availability of costless yet accurate positional data has not only improved safety for airplanes, ships, and cars, it has yielded more efficient and sustainable logistics. It begot a multibillion-dollar industry.

Laws in many jurisdictions require companies to make certain data public, from financial results to emissions data. In the EU, large digital platforms must now share some data with smaller competitors. In the US, meanwhile, antitrust settlements have repeatedly required companies to let competitors access their data. Google had to do so just recently as part of an antitrust trial. But the most spectacular (and often overlooked) case stems from an antitrust settlement in the 1950s that required AT&T to let US firms use its transistor patents for free. Start-ups seized this opportunity, designing and crafting integrated circuits—essentially bootstrapping Silicon Valley and the digital age.

More generally, the very mechanism at the core of the patent system in most countries is based on free information access: Patent holders get exclusive use of their invention only for a limited time, and only if they share the details of their invention so that others can learn from it.

The value data can generate by fueling innovation will only increase as the world transitions toward a comprehensive data economy. Unfortunately, this will also strengthen concentration dynamics that have spillover costs for the economy at large. Many policy interventions have been suggested. Data access mandates hold the most promise. F&D

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RESILIENCE AMID UNCERTAINTY

Amid rising global uncertainty, regional integration offers one route to resilience

GLOBAL UNCERTAINTY has surged to new highs, yet world sentiment is holding up—it's a paradoxical mix of "anxiety and resilience," as Kristalina Georgieva, the IMF's managing director, put it in a recent speech. And it's within this context that policymakers must chart a course toward sustained growth. Among the medium-term priorities the IMF identifies—repairing public finances, addressing internal and external imbalances, and lifting trend growth—regional integration stands out as a key lever for resilience.

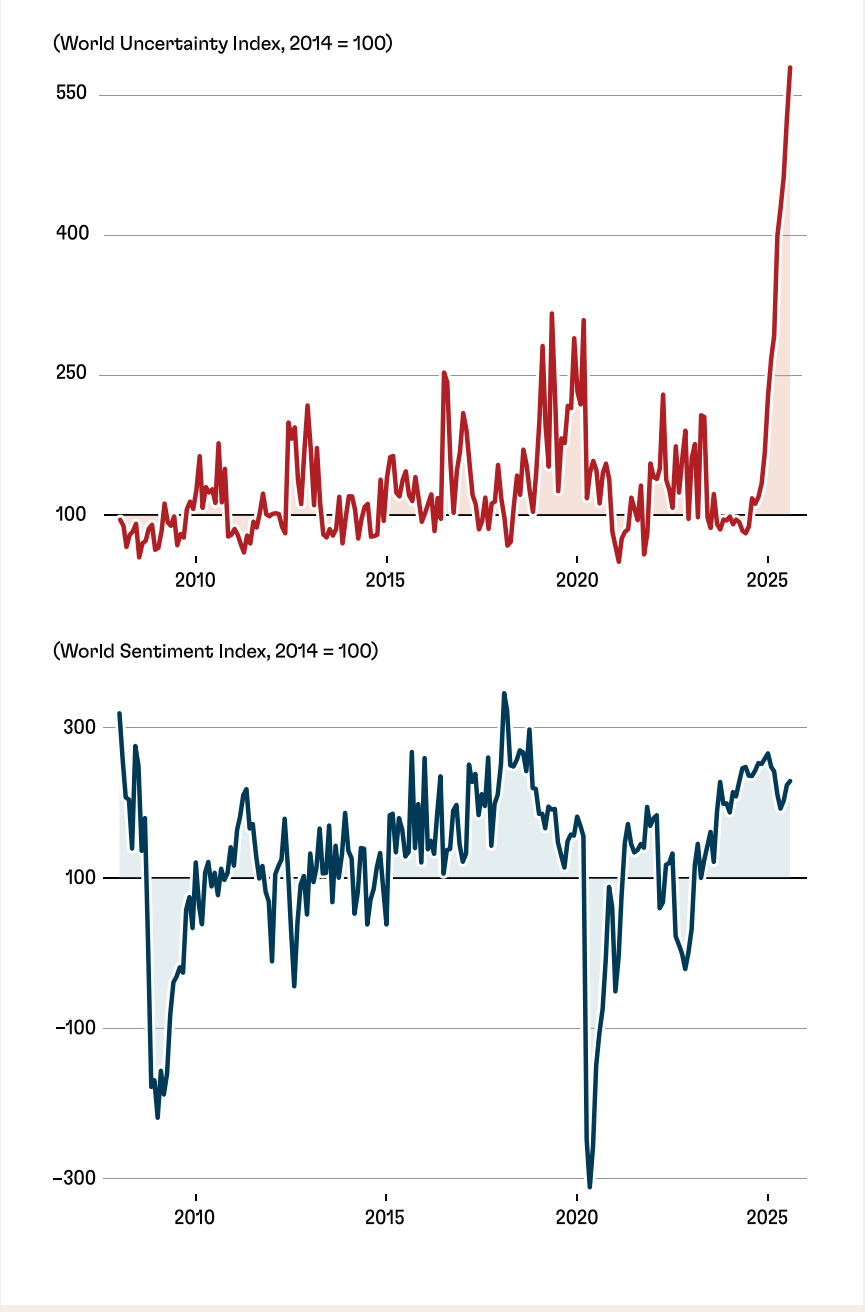
The world's trading system, once a pillar of openness, is being reshaped by shifting alliances and new barriers. Smaller, export-dependent economies often find themselves disadvantaged, while larger and relatively less open ones—or those that control critical inputs to global supply chains—wield greater negotiating power. The global trade map reflects this imbalance: Many of the biggest economies cluster as large but inwardly focused, while many smaller nations are more open to trade and rely on it more for growth, making them more vulnerable to changing conditions.

In response, many countries are seeking to build strength and find voice through cohesion. By joining forces in regional blocs, they gain scale and stability that no single economy can achieve alone. "Reduce your internal frictions and press forward with integration for resilience and growth," Georgieva advises. In an uncertain world, regional cooperation is not just a shield—it is a strategy for confidence and lasting prosperity. F&D

This article draws on an October 17, 2025, speech by IMF Managing Director KRISTALINA GEORGIEVA

Anxiety and resilience

Global uncertainty keeps rising; sentiment is holding up.

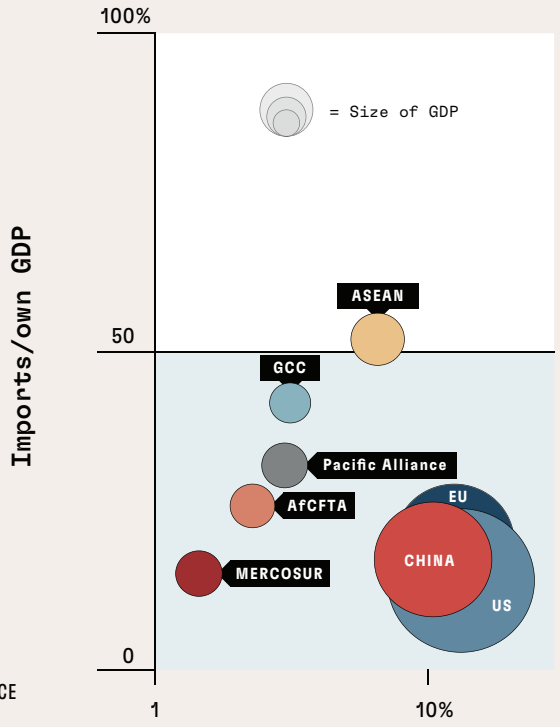


SOURCES: World Uncertainty Index. www.worlduncertaintyindex.com; and IMF staff calculations.

Strength in numbers

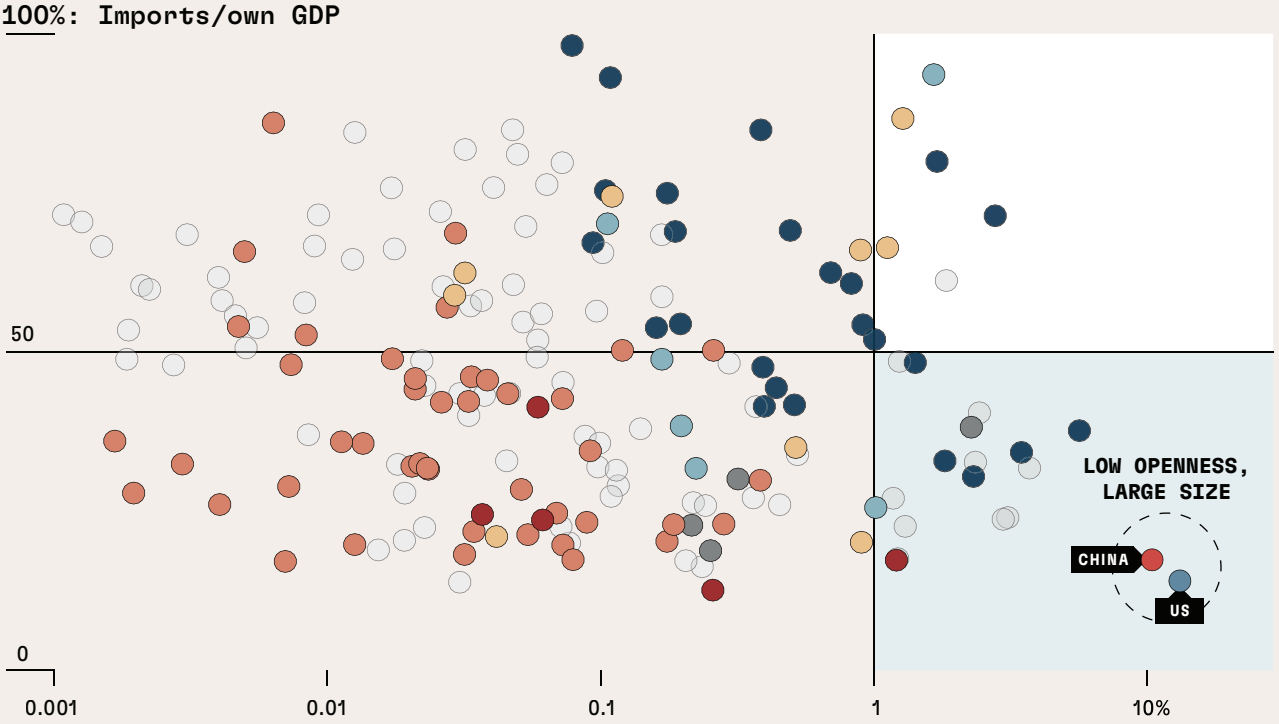
The scatterplot below shows how economies differed in trade openness and size in 2024. Each dot represents a country's share of world imports and imports as a share of its GDP. Larger economies such as the United States and China dominate world trade but are relatively less open, while many smaller economies are open yet carry less influence. The pattern shows how size matters: Larger economies shape global trade, while smaller, more open ones are more exposed to shifting conditions.

On the right, the same data are regrouped into selected regional trading blocs and scaled by their combined GDP. Viewed collectively, these blocs move closer to the world's largest economies on the trade map, illustrating how integration can magnify both economic heft and resilience.



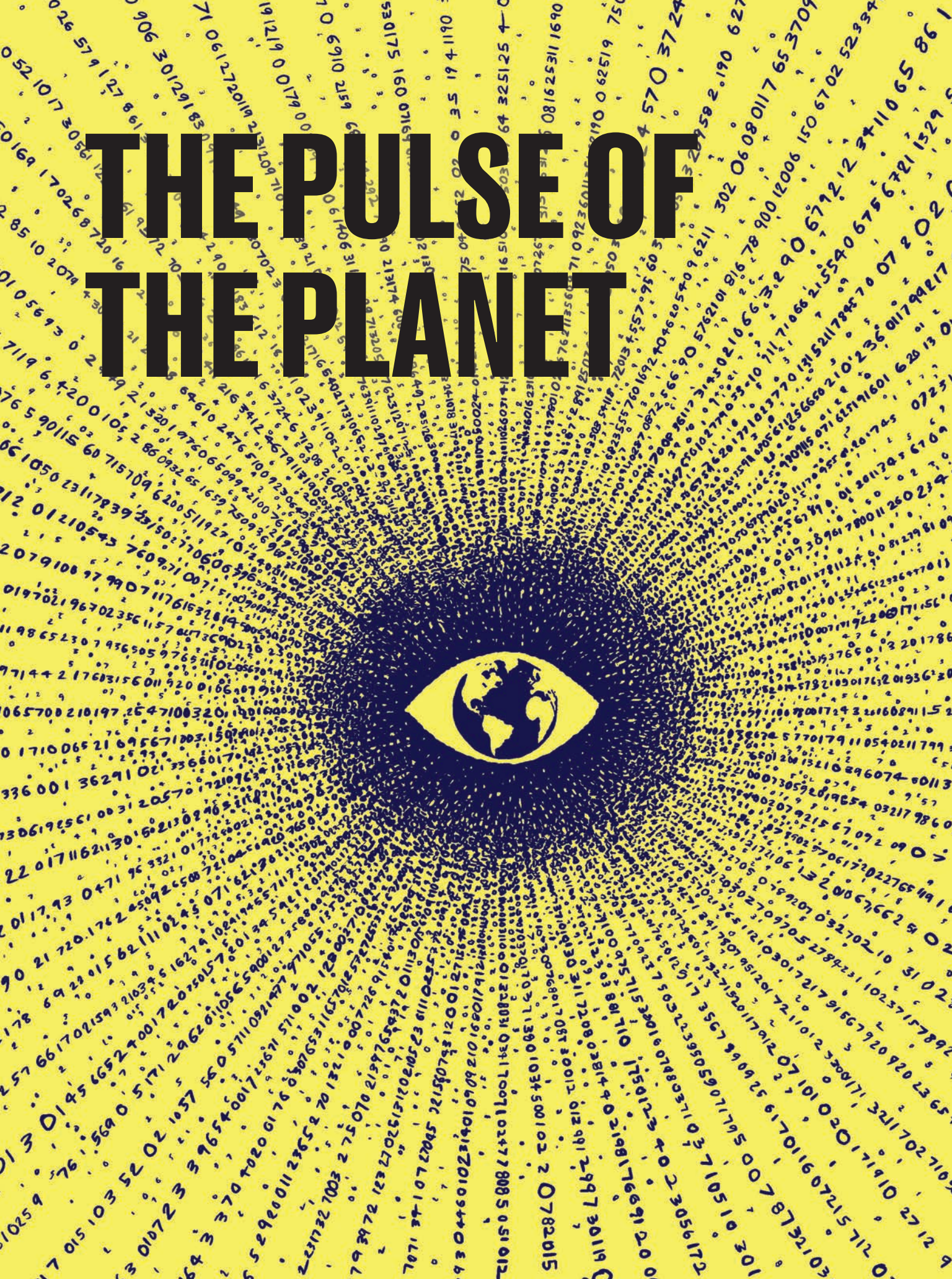
Trade openness vs. economic size

AFRICAN CONTINENTAL FREE TRADE AREA · MERCOSUR · PACIFIC ALLIANCE
GULF COOPERATION COUNCIL · ASSOCIATION OF SOUTHEAST ASIAN NATIONS
EUROPEAN UNION · CHINA · UNITED STATES · OTHER COUNTRIES



SOURCES: ASEANstats; Eurostat; IMF, *Direction of Trade Statistics* and *World Economic Outlook*; World Bank; and IMF staff calculations.
NOTE: Imports for trading blocs exclude intra-bloc imports.

THE PULSE OF THE PLANET



The explosion of data offers new ways to understand the economy—and change what gets measured, not just how

Kenneth Cukier

Illustration by Alex Robbins

We see the world not as it is, but as we are. In the domain of data, economists need to rethink what information they use to portray ground truth, and to reimagine what truth they wish to record. The field suffers from a "déformation professionelle," viewing the economy through the lens of a "small data" world they have long known. But in a "big data" universe—when the variety, frequency, and granularity of data sources (and features to measure) are vastly more numerous—a new mindset is required.

To get a flavor of what such a collision looks like between more information and traditional thinking, consider a bit of history from the field of health care.

In 1990 General Electric released an update to the software for its Signa magnetic resonance imaging (MRI) machines, used for medical scans. Engineers had uncovered a flaw in the system that compressed how it showed tissue containing lipids, or fat. But when the more accurate images became available, many radiologists rebelled. They were unaccustomed to seeing the better scans and felt more comfortable assessing the older ones. There were fears of misdiagnoses owing to new images. GE was forced to add a feature to the MRI machines that let radiologists see the old scans—labeled "classic," in a nod and a wink to the debacle over the launch of "new Coke" a few years earlier.

An MRI scan is pictorial, informational. It's not the thing itself. In this way, it's a bit like economic data, such as growth, unemployment, inflation, and the like. The radiologists in the 1990s preferred the information that was less accurate because they had become accustomed to using compressed scans; their skills were largely honed to work within those constraints. They resisted better images. Is there a risk that today's economists are vulnerable to the same mental trap?

Galaxy of data

Consider the galaxy of data and AI all around us today, and how novel it is. A quarter-century ago, most things in life did not have a computer chip or connect to a network. It was a bygone age of letters, subway tokens, travel alarm clocks, and credit card transactions that required a signature on a carbon paper form after going through an imprinter, known as a zip-zap machine. Your sleep and exercise weren't tracked by your wristwatch. Your cordless phone didn't recognize your face; your bank didn't verify your voice signature. Cars without satnav systems meant drivers relied on badly refolded maps. Don't be wistful: The point is that the digitalization of society means that activities that could never be easily rendered into data now are.

This offers the possibility to understand the economy in ways that are more accurate, a better reflection of ground truth, the actual thing being measured. Reporting can happen much faster, perhaps in quasi real time, and in ways that are more granular, down to small segments or even individuals, which older methods were incapable of—instead compressing information like a pre-1990 MRI scan. Accuracy, speed, and details improve. Moreover, what gets measured can itself change, leading to new ways to understand the world (and by doing so, hopefully improve it).

Yet the entities compiling the information will come from the private sector, since it is generating the data in its operations. For example, satellite imagery can track farm yields. Job posting sites can identify which urban areas are growing faster than others, while home sale sites can show which are in decline. In many instances, firms find themselves in the middle of data flows from others' operations. The payroll processor ADP handles one in six US workers: Its monthly jobs report is used by economists to supplement data from the US Bureau of Labor Statistics.

"The datafication of activities that have never been rendered into the form of data offers a unique opportunity to learn new things about the world. Society is at the outset of a major transformation in understanding."

Alternative indicators

Such alternative indicators (or "alt-data") may not be compiled using the academically rigorous methods of state statistical agencies. Harnessing the data will require a shift in thinking by today's practitioners—who may need to reconceive their responsibility, from generating information to working with the private sector to bolster and validate the data's integrity so that it can be used for broader purposes. It is an echo of the field's origins.

The term statistics derives from the German "Statistik," coined in the mid-1700s to mean the "science of the state." Such metrics may be based on inference: generalizing from what is easily measurable to reach conclusions about what is hard to learn. Because it was often expensive or impossible to count the things themselves, the accepted practice was to find proxies and extrapolate. This approach characterized stats' earliest days. "The city of Dublin in Ireland appears to have more chimneys than Bristol, and consequently more people," wrote William Petty at the start of an essay on "political arithmetick" in the 1680s to estimate populations.

Today, developed economies spend billions of dollars a year to produce reliable economic and social indicators. To the high priests and priestesses of official metrics, it is a holy calling, a mark of civilization. "Knowledge is power: Statistics is democracy," famously stated Olavi Niitamo, who led Statistics Finland from 1979 to 1992.

Data is only a simulacrum of what it aims to quantify, qualify, and record. It is an abstraction, never the thing itself, just as a map is not territory and a weather simulation won't get you wet. Data contains an "information quotient" of what it depicts. As the world changes, so too must the statistics with which social scientists take the measure of man. Despite worldly philosophers embracing more serious methods to establish a dismal science, informal proxies and extrapolations are still used.

Anecdata

Alan Greenspan, the Federal Reserve chairman from 1987 to 2006, is infamous for embracing "anecdata"—a cross between anecdote and data—to get a leg up on official indicators. As a young economist, among the data he scrutinized were sales of men's underwear. In his thinking, it is an economic bellwether: the sort of thing people cut back on when belts tighten.

His successors at the Fed followed his lead. At the start of the financial crisis in 2008, just days after Lehman Brothers' collapse, Janet Yellen, then president of the San Francisco Federal Reserve Bank, warned of a nasty economic downturn during a Federal Open Market Committee meeting. "East Bay plastic surgeons and dentists note that patients are deferring elective procedures," she reported, according to transcripts released five years later. "Reservations are no longer necessary at many high-end restaurants." Her colleagues laughed.

How did the statistical agency do? In the fourth quarter of 2008, the first figure released for the US was a decline in GDP of 3.8 percent. That was quickly revised a month later to a drop of 6.2 percent. In the final revision, in July 2011, it was recalculated as having fallen by 8.9 percent—the largest downward revision of GDP on record, and more than twice as bad as first reported. Perhaps alternative indicators would have helped.

The new data sources might have done a faster and better job than existing indicators, and with more detail. For example, ADP, the payroll firm, could have spotted a decline in new employees and a slowdown in pay raises. Google searches related to home purchases may have slowed precipitously. Likewise, professional job listing sites like LinkedIn and Indeed have a lens on recruitment ads—not only those that are posted, but those that are pulled. (That data is used by investors since it's an early predictor of business wobbles and analyst downgrades, and thus stock prices.)

Tool for transparency

During crises, official metrics may fail because of reporting lags. Alt-data flourished at the outset of the COVID-19 pandemic. GPS in Apple and Android phones measured a decline in visits to retailers—and revealed which places disobeyed lockdown orders. Likewise, during the US government shutdown in October 2025, statistical agencies could not release data so the private sector filled the breach. Employment trends were provided by ADP and Carlyle, a private equity fund managing 277 companies with 730,000 employees.

Alt-data holds governments accountable. Argentina's official inflation data became so ridiculous in the early 2010s that *The Economist* used figures from PriceStats instead, a company founded by two economists from Harvard Business School and the Massachusetts Institute of Technology. It tracks changes in 800,000 daily prices from among 40 million products in 25 economies. As questions are asked about the integrity of US data after the head of the Bureau of Labor Statistics was fired by President Donald Trump in August 2025, following a negative jobs report, alt-data can be an independent tool for transparency.

The explosion of new data sources and techniques is especially important in developing economies, which lack the institutional capacity, funds, skills, and political will to collect, analyze, and report statistics. With creative thinking, private sector data can be transformative. For example, many developing economies cannot afford meteorological equipment in remote areas to measure weather events like rainfall, for advance notice of flooding. But mobile operators have cell phone towers across the countryside. These towers are constantly communicating with each other for network information and to hand off traffic. Yet the strength of the signal weakens in rain—making them useful to measure rainfall. More such originality is needed to overcome data gaps in poor places.

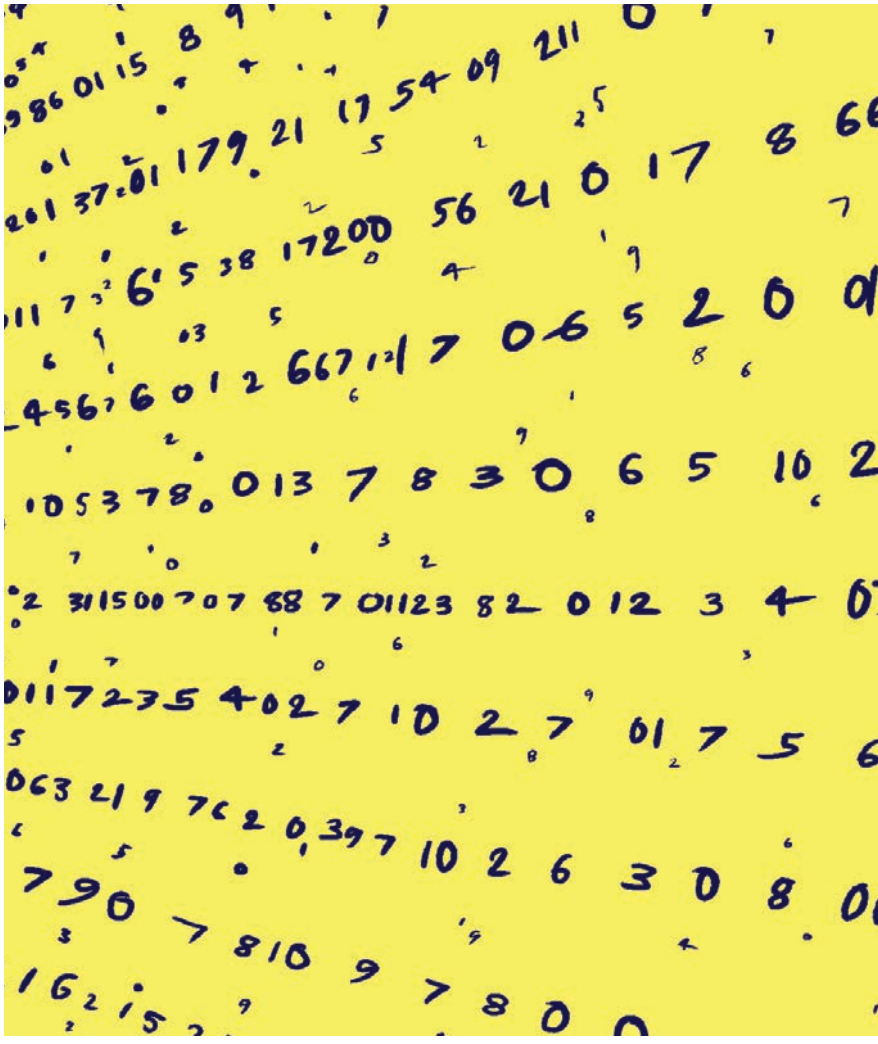
However, creating more accurate, granular, and timely indicators means little if there is no way to use them effectively. "Unless we concurrently increase the speed of implementation, 'big data' is of limited use," said Greenspan in an interview I conducted over email in 2014.

Brave new world

Moreover, the stakes are even higher than the need to improve what exists or fill in known gaps. The datafication of activities that have never been rendered into the form of data offers a unique opportunity to learn new things about the world. Society is just at the outset of a major transformation in understanding.

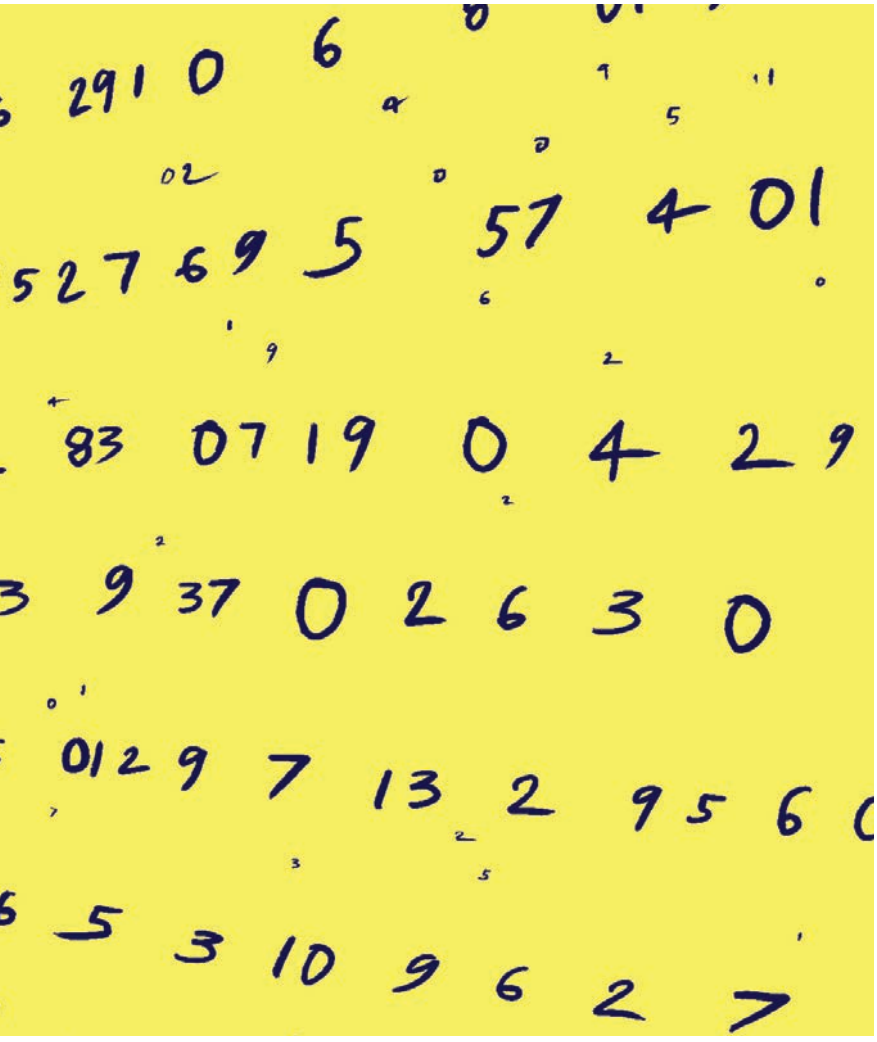
An early dimension of this transformation is LinkedIn's "economic graph." It measures the work activities of 1.2 billion people, 67 million companies, 15 million jobs, 41,000 skills, and 133,000 schools. Many countries use it to answer questions like "What skills are growing quickest, what places are gaining and losing jobs, how hard are mid-career transitions by occupation, and in which industries and countries are women in more senior leadership roles?" This information could never be tracked, analyzed, and compared until now.

Though such deep analysis of people's personal information may seem to threaten privacy, it need not. Advanced data processing techniques—with space-age names like federated learning, homomorphic encryption, secure multiparty computation, and differential privacy—allow for analysis of encrypted data, so the actual record is not visible to the data processor. The system is still in its infancy since it's hard to pull off. But companies and statistical offices are already experimenting with it.



Of course, there are limits to using corporate "data in the wild." It's often in the form of data exhaust—that is, generated as a by-product of a company's regular business activities. Hence it will contain the biases of that environment. Carlyle's firms accepted a private equity owner (so perhaps were not the strongest); LinkedIn probably has more professionals than working-class members (so perhaps skews wealthier); ADP is silent on the gray economy of nannies, house cleaners, car washers, and the like (whose numbers may be even stronger signals of economic health).

Furthermore, alt-data can't be relied on entirely if it may not always be around. For example, the US software company Intuit produced a small-business index based on aggregated data from its QuickBooks accounting software. But in 2015 it discontinued the reports—before relaunching them with a different, more robust methodology in 2023. So the future won't be based solely on alternative data, but on complementary official and unofficial sources. Still, this is a brave new world.



Modern metrics

And that brings us back to the MRI. Magnetic resonance imaging dates to 1974, when it was patented by Raymond Damadian of the State University of New York as a noninvasive way to detect cancer. That same year marked a brutal recession in the US, which inspired a Yale University economist and former White House advisor, Arthur Okun, to create a new indicator to account for its toll on individuals, not the abstract unit of the economy as a whole.

His Economic Discomfort Index—later dubbed the "misery index"—became a staple of US politics. Ronald Reagan used it to defeat President Jimmy Carter for the presidency in 1980. But it is simply the sum of the unemployment and inflation rates. A modern metric for the AI era is easy to imagine.

It would gather all the ways people might express their misery, from shifting spending patterns—not buying fewer things (a blunt number) but actually switching from eating steak to ramen. Likewise, missed utility bills and overdue car payments. Then, incidents of road rage, erratic driving, and fender benders—not in aggregate but tracked down to the person. Apple watches can track the quality of sleep and stress during the day. Closed-circuit TV cameras in streets, shops, and offices that have facial-recognition capability can record individuals' emotions. Toilets with biosensors can track users' levels of hormones such as cortisol and epinephrine that spike in moments of anxiety.

This comes as close to ground truth as it gets. Such sci-fi stats probably strike many people as true misery: The privacy implications are frightening, even if the data, in theory, could be anonymized. Armed with such information, doesn't the state have a duty to intervene to help individuals and protect society? "After such knowledge, what forgiveness?" lamented T. S. Eliot.

Such alt-data won't happen soon, if ever. Paradigms shift one funeral at a time. And a "techlash" is gathering force as the public grows wary of unbridled data use and the optimism of the early internet ebbs. Ideally, today's social scientists have the care, ethics, and flexibility of mind to harness the best of AI and big data and prevent their shortcomings. After all, radiologists no longer need the "classic" view for MRI scans. F&D

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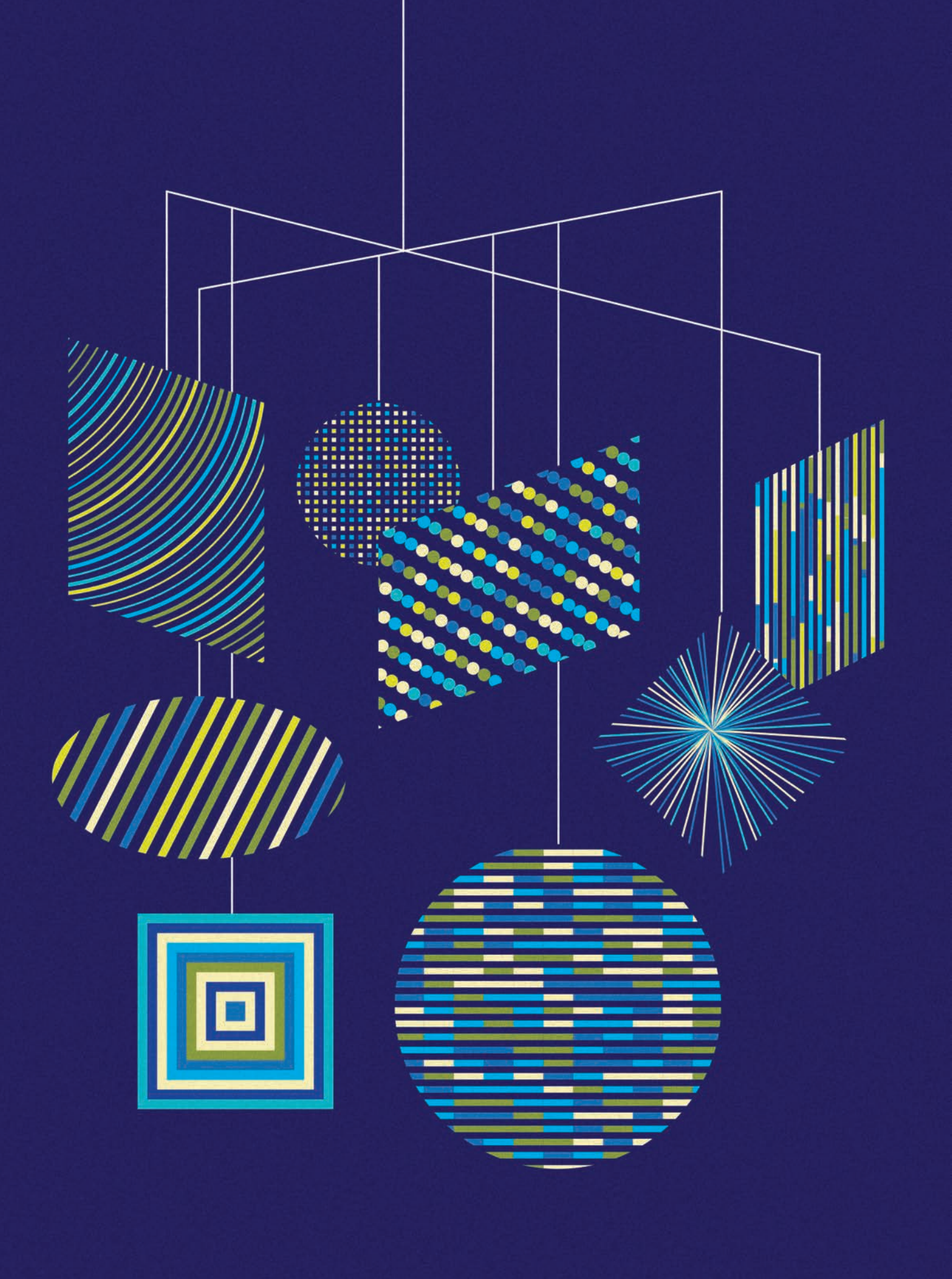

ALTERNATIVE DATA AND MONETARY POLICY

Claudia Sahm

Central bankers are tapping nontraditional data sources for a more complete picture of the economy

In the spring of 2020, the Federal Reserve faced a challenge: The COVID-19 pandemic was upending daily life with shutdowns, social distancing, and heightened uncertainty, but the traditional economic statistics the Fed used to calibrate monetary policy struggled to keep up with the pace of change and did not cover some of the novel features of the pandemic economy. Yet the Fed was not flying blind; it was able to pivot to nontraditional data sources it had previously developed, such as payroll processing and credit and debit card transactions, to track the rapid deterioration in the economy.

Even in the best of times, high-quality, timely data is critical to making sound monetary policy. If policymakers see signs of higher inflation, for example, they may consider raising interest rates to cool the economy. But, if the job market appears to be weakening, they may consider lowering rates to spur economic activity. It takes time for changes in interest rates to affect economic outcomes, so speed in accurately assessing the direction of the economy is also important for effective policy.

To keep a finger on the pulse of the economy in real time, the Fed relies on a wide array of statistics generated by government agencies such as the Bureau of Labor Statistics (BLS) and the Department of Commerce. These statistics, typically based on representative surveys, are considered the gold standard by policymakers, investors, business leaders, and the public. Increasingly, though, the Fed has supplemented them with nontraditional sources of data, often supplied by private companies. The defining feature of these nontraditional sources is the data was not created for the purpose of making economic statistics; rather it originated in the process of running a business or a government program and then was repurposed for economic statistics.

Filling gaps

This nontraditional data is often timelier or more granular and, as a result, can fill in some gaps in government statistics. It can also provide an added perspective on critical economic outcomes, such as employment. Finally, it can be used to improve the quality of traditional data sources. Nevertheless, nontraditional sources should be viewed as a

Illustration by Greg Mably

complement to traditional data in informing policy, not as a substitute.

The central focus of monetary policy is stabilization of the business cycle, so there is a premium on accurately and quickly assessing turning points. Nontraditional data can be particularly helpful in these circumstances. That's because government statistics on key variables like unemployment, inflation, and economic growth are published weeks or even months after the fact. The delay in releasing private company data is often substantially shorter, a few weeks or even days.

The timeliness of alternative data sources was particularly useful at the start of the pandemic, which triggered a short, deep recession. A review by Fed staff noted that its internal weekly estimates of employment, based on data from ADP, a large payroll processor, showed large declines in late March 2020. This was more than a month before the BLS published its own monthly employment report, which also showed large declines.

The pandemic downturn was unusually fast-moving, but higher-frequency and timelier estimates of employment have broader applications. For example, anytime the monthly BLS estimates of jobs shift down sharply, as occurred in 2025, the weekly ADP estimates offer early insight into whether the trend will persist or reverse. In addition, ADP estimates are highly relevant during government shutdowns resulting from a congressional impasse over the budget, when official data isn't available.

Inflation episodes

The granularity of alternative data is another advantage for Fed policymakers seeking to assess the impact of changes in trade policy on consumer price inflation. Theory and experience suggest that an increase in import tariffs will cause a one-time rise in the level of prices, which only temporarily increases inflation. In that case, the Fed should "look through" tariff-related inflation and not raise rates. But testing the hypothesis is challenging, because key statistics the Fed consults don't identify prices of goods by country of origin. Instead, the analysis must compare the prices of broad categories of goods by their average share of imports in the past.

This is where the granularity of alternative data offers a more direct path to monitoring tariff price effects. Alberto Cavallo, a professor at Harvard University, and two collaborators are one such data source. They have constructed daily price indices using online data from five major US retailers, which include country of origin, tariff rates, and selling price for 350,000 goods. They find that the prices of imported consumer goods have risen more quickly than those of goods produced domestically, relative to pre-tariff trends. Moreover, the price effect of tariffs is more pronounced for domestic goods that compete directly with tariffed imports than for domestic goods that do not. Overall, the effects have been relatively modest, a finding consistent with studies using traditional data sources. Such high-frequency, granular data can also help assess whether the upward adjustment to the price level is complete.

More granular alternative data sources also proved useful to the Fed and other decision-makers during the pandemic, which dramatically shifted consumer and business behavior. Private company data on physical mobility was deployed to monitor those shifts during social distancing, along with administrative data on the number of COVID cases. Measures of supply-chain stress were also instrumental in gauging inflationary pressures. In addition to surveys of purchasing managers and shipping price indices, the stress on supply chains was gauged with real-time data on shipping container movements. To be sure, traditional data sources also helped fill gaps in policymakers' understanding of the economy. The Census Bureau, a major source of traditional data, quickly stepped into the breach, launching short online surveys to gauge the pandemic's impact on households and small businesses.

Loss of precision

Alternative data can help maintain, and even improve, the quality and cost-effectiveness of traditional statistics. Government agencies rely heavily on surveys of people and businesses, which are designed to be representative of the overall economy. But these have drawbacks. For one, costs have increased over time as people and businesses become less willing to participate. For another, falling participation rates reduce the precision of the resulting estimates.

This loss of precision can create uncertainty about inflation or employment dynamics and hinder a timely, appropriate monetary policy response. Nontraditional data offers a potential solution. For example, the BLS now uses private company data instead of surveys for several components of the consumer price index, including prices of used cars, airline tickets, and wireless telephone contracts.

There is scope for further use of private sector data, though the acquisition cost and reliability of such data present challenges. A private company could decide to stop sharing its data or sharply raise its price, which could threaten the continuity of the government statistics. Careful testing at statistical agencies is also necessary to ensure that nontraditional sources improve the precision of estimates rather than substitute new sources of noise for old ones.

Business formation

Improving the accuracy of the initial estimates of traditional data is another area where alternative data could be useful, especially at economic turning points. Monetary policy decisions are made in real time, so the real-time data must be as accurate as possible. The government's monthly estimate of payroll employment is one example. It relies on a survey of business establishments, with results adjusted for the fact that businesses come and go. (The adjustment is based on something called the "birth-death model.") Shifts in net business formation during and after the pandemic, combined with long lags in data availability, have led to significant errors in the model and substantial annual revisions in previous employment estimates. Researchers have shown that weekly tax filings for employer identification numbers provide a reliable forecast of business formation in subsequent quarters. Aligning the birth-death model with more timely indicators of business formation could improve the accuracy of the initial estimates of employment when economic conditions are changing.

Even official data is subject to error, such as sampling error resulting from using partial surveys instead of a full census. So using multiple independent estimates can improve our understanding of official estimates. A new initiative from the Federal Reserve Bank of Chicago, for example, blends official with alternative data on the labor market to construct an estimate of the current month's unemployment rate. The analysis includes data from Indeed, a site used by job seekers and recruiters; Lightcast, a provider of labor market analytics; and Google searches on unemployment. However, the project is in its early stages, and it will take time to establish its reliability.

Impact of policy

Once Fed officials have adjusted monetary policy, they must assess its effects. Nontraditional data can be helpful here as well. Research on the distributional consequences of monetary policy, for example, has expanded with the availability of sources such as household-level credit records, bank accounts, and administrative records. During COVID-19, when interest rates fell, a study using data on property tax forms and deed records from CoreLogic showed that Black, Hispanic, and lower-income borrowers were less likely to refinance than Asian, White, and higher-income borrowers. Systematic differences in refinancing costs played a role. Another study, using Internal Revenue Service individual income tax records, found that unexpected tightening in monetary policy led to greater income inequality, primarily by worsening outcomes for low earners. Unexpected easing, however, decreased inequality.

For all the advantages of nontraditional data sources, they are not a replacement for the traditional kind. Indeed, their usefulness often depends on traditional data. As an economist at the Fed, I worked on a project to transform credit and debit card transactions from First Data (now Fiserv) into daily state-level estimates of retail sales, which were later used to track the economic effects of Hurricanes Irma and Harvey in almost real time for the Federal Open Market Committee.

But this source presented challenges. The growth in sales in raw transactions mixed factors specific to First Data, such as the acquisition of clients for its payment-processing business, with changes in US consumer spending. Only the latter is relevant for economic statistics. As one step to solve this problem, we used the five-year Economic Census from the Department of Commerce to reweight the card transactions from the company's clients to be representative of US businesses. Such benchmarking is common when building economic statistics from nontraditional sources. Our project faced other problems common to alternative data sources, such as short time series for seasonal adjustment and troubleshooting anomalies. Comparisons with national monthly retail sales estimates from the Census Bureau gave us confidence in using the more granular private data for policy work.

Any user of nontraditional data faces challenges. For the Fed, the limited availability of such data to the public poses special difficulties. The Fed's strategic framework for monetary policy emphasizes that transparency is critical to accountability and improves the outcomes of monetary policy. Relying on data sources that are not widely accessible reduces transparency; outsiders cannot verify the Fed's analysis, and only market participants who pay for access to private data can see what the Fed sees.

We have seen how policymakers can use alternative data sources to gain a fuller picture of economic conditions, potentially leading to better policy outcomes. Improving the quality of data will require strong ties between government statistical agencies, private sector data providers, government officials, and academics. Nontraditional data presents opportunities and challenges, but understanding macroeconomic dynamics is the goal of both nontraditional and official government statistics. F&D

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IT'S TIME TO MODERNIZE MEASURES OF GROWTH

Rebecca Riley

Economic assessments may miss important changes in a rewired, data-driven economy

Assessments of the world's economies may be off by trillions of dollars. The existing metrics for GDP, consumer prices, productivity, and the like are struggling to match the rapid pace of change in technology, business models, and consumer behavior in today's data-driven economy. Continued innovation in measurement systems is needed to avoid a growing gap between what is measured and the new increasingly diverse economic reality we are living.

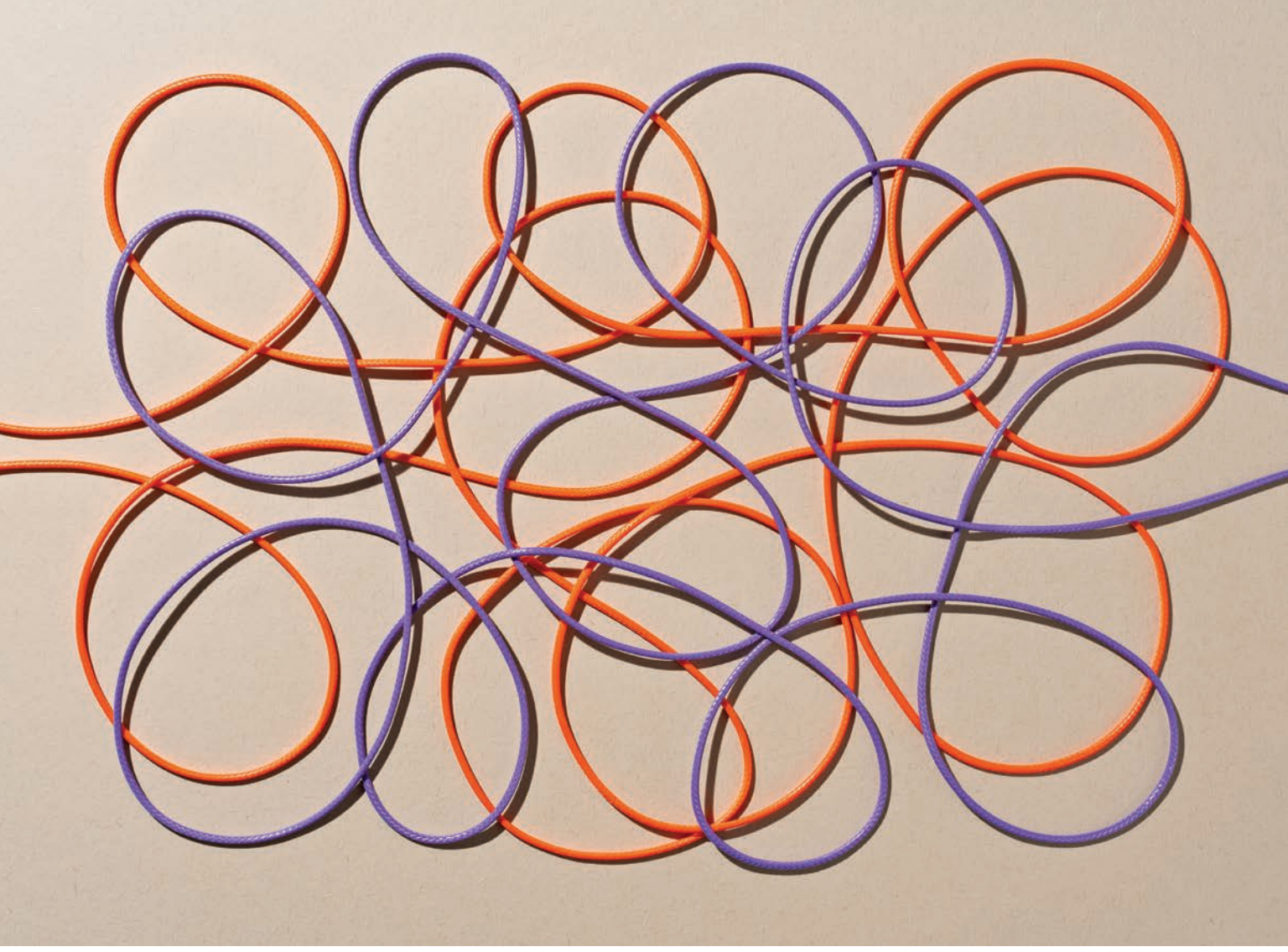
Without accurate information on the true state of the economy, economic policymakers will be left in the dark, uncertain when to step on the gas to counter a recession or pump the brakes to slow inflation. Without detailed information on the structure of the economy, they can't know how best to promote economic growth for all. This is more than a little bizarre in a digital world characterized by abundant new data that could help in monitoring the economy and in guiding action by central bankers, fiscal watchdogs, and economic policymakers at large.

It's time to rethink the critical infrastructure of key economic statistics. This means that our economic concepts need to keep up with the changing times, developing data and methods to measure these concepts, and embedding them in the production of core economic data. It also means tapping into new sources of information.

As promising as this may sound, it's important to acknowledge the significant hurdles to harnessing new data sources and developing meaningful and trustworthy economic statistics. And yet, as many advances already achieved show, overcoming the obstacles promises real benefits in the form of better economic policymaking.

The rewired economy

Decision-makers rely on economic statistics to provide a map of the economy. National statistical agencies produce the core economic accounts of nations based on concepts articulated in the United Nations System of National Accounts (SNA), the global benchmark. Similarly, inflation measurement is guided by the IMF's consumer price manual.



MIRAGEC/GETTY IMAGES

The resulting economic statistics are written into official policies and underpin policy assessments and budget forecasts. These statistics also guide interest rate policy and adjustments to welfare payments and business contracts.

The data-driven digital economy has transformed the way we produce goods and services and how we consume them. In essence, technological advances have rewired our economy, but we've been slow to rewire our economic statistics, which leaves huge blind spots for decision-makers.

It doesn't take much to get a sense of the disconnect. Producers and consumers use data-driven digital technologies every day to create new and enhanced products and services such as ride-sharing apps, social media platforms, AI-enhanced software, and online marketplaces. The world's biggest companies by market capitalization are almost exclusively data-reliant global tech companies. Much of this new economic activity goes uncounted or is invisible in economic metrics.

For example, one hallmark of the data-driven digital economy is its reliance on intangibles such as software, marketing databases, and companies' "organization capital" (the structure, processes, and culture that allow them to operate efficiently). In many advanced economies, businesses invest at least as much in intangibles as they do in buildings and factories, which no doubt runs into hundreds of billions of dollars and more likely trillions.

But official measures of productivity and GDP don't fully reflect these intangibles. Conference Board economist Carol Corrado and her research colleagues estimate that fully half of intangible investments in advanced economies are essentially data investments that economic accounts are only starting to include as part of an update to the SNA this year. These would add substantially to our understanding of the drivers of productivity growth.

The rising importance of intangible investment, in combination with the globalization of production, poses a separate set of difficulties in measuring national output. For example, the use of intangibles by multinational enterprises has led to profit shifting to minimize tax obligations, with ownership of intellectual property and revenue from it transferred

to low-tax countries. This can result in production inputs being counted in one country while the associated revenues are counted somewhere else.

Macroeconomic aggregates

Researchers have demonstrated the importance of these issues for macroeconomic aggregates such as GDP, trade balances, and productivity by reapportioning the output of multinationals across countries in line with employment or sales. In some small and open economies, such as Ireland and Denmark, statistical agencies increasingly look to a broader set of data to draw a picture of economic health, complementing GDP with other national accounts aggregates and indicators that are less sensitive to the effects of globalization.

Calculations of real GDP and real household consumption are a basis for estimating changes in average material living standards. Increases in real GDP are intended to capture gains in the quantity and quality of goods and services rather than increases in monetary value alone. But measuring the quality of products is notoriously elusive, particularly when rapid innovation leads to new or improved products that replace old ones.

Consider the information and communications services industries, for example. They rely heavily on data and digital technologies, and we would expect them to record strong, innovation-led growth. And yet, measured productivity in those sectors stagnated substantially in several advanced economies during the decade after the 2008 financial crisis, contributing to a slowdown in global growth.

Research by UK Office for National Statistics economist Richard Heys, in collaboration with engineers and academics, led in 2021 to a new approach. The research suggests that actual growth in the telecommunications industry was more in line with what would be expected because of a sharp fall in quality-adjusted prices. This finding, implemented alongside other methodological advances, shaved a quarter of a percentage point off the estimated slowdown in UK productivity growth during that decade. National statistical agencies have taken a range of approaches to adjusting for quality gains in digital products, which has affected the balance of measured inflation and economic growth within countries and the comparability of these statistics across countries.

The challenge of accurately measuring the quality of production takes on a particular twist in a data-driven digital world. Many digital services are essentially consumed for free and hence are simply not counted in household consumption. For example, consumers use search engines, social media, and open-source software at zero monetary cost. But the value of these digital services is far from zero, based on experiments that ask consumers how much they would be willing to pay for them.

The Organisation for Economic Co-operation and Development's Paul Schreyer developed a way to conceptualize these services. He includes the use of social media as an input for digitally enabled leisure services and incorporates that value into an extended measure of economic activity. Experimental estimates suggest that the nominal value of digital leisure services produced by households is large. Preliminary research on the UK put it at 8 percent of nominal GDP.

Households also use free digital services to carry out activity that previously might have taken place in the market economy, where they would be counted in GDP, such as making travel arrangements. Another activity is voluntary household production of software and advice material. An accurate assessment of the scale of this kind of activity requires good information on households' use of time.

DATA

50%

Half of intangible investments in advanced economies are data investments that economic accounts are only starting to include.

Harnessing new data

The data-rich economy needs rewired economic statistics to reflect new realities. An update to the SNA this year—the first since 2008—is a welcome effort that seeks to better capture macroeconomic developments, like digitalization and globalization, while taking into account environmental sustainability and well-being.

But there is another set of challenges. Today's economy provides a raft of opportunities in the form of new data collected through people's interactions with digital systems. These could help make economic statistics more timely, accurate, and granular. To do that, though, will take significantly expanded capabilities and potentially heavy up-front costs in an environment of constrained resources and competing incentives.

Directing new data sources toward the public good may call for data-sharing agreements or changes in legislation, investment in technologies for data processing, and trusted institutions. New forms of data that yield meaningful and trustworthy economic statistics demand investment in the development of new economic and statistical methods, proofs of concept, and data exploration methods.

This is already happening with consumer price indices, among the most closely watched indicators for inflation. Traditionally, government agencies build these indices using data obtained from monitoring retailers' prices and through surveys of consumers about spending. This is costly. It is

also getting harder as people become less willing to respond to surveys.

Increased use of barcodes and scanners by retailers and the prevalence of online data are changing the game, though. During the past decade, statistical agencies in The Netherlands, Australia, and Canada have gradually incorporated point-of-sale data into consumer price indices. The statistical agency in the UK is also making progress in this area. The collection of such data allows for timelier and more accurate measurement of inflation; moreover, these developments may also enable statistical agencies to better capture the experiences of consumers in different parts of the country and at different income levels. Underpinning these advances lies a barrage of technical gains in handling large-scale and inherently messy data, as illustrated by Kevin Fox and colleagues at the University of New South Wales and the UK Economic Statistics Centre of Excellence.

One of the main benefits of private sector data for mapping and tracking the economy is the potential to improve the timeliness and granularity of economic indicators. This was particularly evident during the pandemic. There was demand for high-frequency evidence on economic developments at both national and local levels. Statistical agencies and researchers embraced private sector data to fulfill that demand. Partially offsetting the benefits are statistical noise, the potential for double counting, and inadequate samples that could mask economic signals.

Researchers have explored these issues by benchmarking private sector data against representative national statistics, highlighting necessary adjustments and the value added by complementary data sources. Others have highlighted the benefits of linked administrative and survey data, as well as the potential of AI-assisted surveys. The production of key economic statistics is likely to draw increasingly on a range of data sources from the private sector, public administrative systems, and surveys in a blended approach shepherded by national agencies.

The way forward

It is time to strengthen investment in our economic statistics infrastructure. We may be losing our ability to monitor the economy and make informed decisions because trillions of dollars of economic activity may be unmeasured or measured in insufficient detail. The importance of addressing this issue should not be understated, and neither should the challenges.

The obstacles include overcoming bureaucratic inertia, paying for the overhaul of economic accounting systems, and carrying out coordinated actions. If we don't make headway on trusted statistics produced by national agencies with statistical rigor in an accountable, transparent manner—with impartiality and equal access—there will be plenty of noise to fill the gap in today's data-rich world.

What might lie ahead? The 2025 revision to the SNA and updates to the IMF's balance of payments manual are a starting point and will be most effective if implemented widely by statistical agencies around the world. But the issues involved suggest that statistical agencies cannot be expected to resolve the problems on their own. The COVID-19 pandemic showed us what can be achieved through coordination and leadership. Advancing economic statistics in a data-rich and digital economy calls for collaboration between public and private sector data owners, and across government agencies, supported by legal and technical frameworks. Collaboration between statistical agencies internationally and with university academics is necessary as well.

Some of this is happening at the margins. Examples include the Economic Statistics Centre of Excellence at Kings College London, established by the UK Office for National Statistics; the Economic Measurement Research Institute at the National Bureau of Economic Research in the US; the work of the Centre for Applied Economic Research at the University of New South Wales in Australia; and the Measurement in Economics Chair at the Paris School of Economics, supported by the national statistics agency, in France. Economists and statisticians would be wise to adopt such collaboration. F&D

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THE HIDDEN PRICE OF DATA

Laura Veldkamp

Revealing data's true price can turn passive users into active suppliers who demand fair value

Data is the fuel for the artificial intelligence algorithms that have lifted stock markets to historic highs on the promise of transforming economies. But how do we determine data's value? Data is not mined from the ground, not forged in factories. It accumulates unseen as a by-product of modern life: Every search, click, or morning walk with a phone in your pocket leaves a residue of information that someone, somewhere, can use.

When a good has no observable price—like a government service, for example—we typically value it at cost. But data has no explicit cost. When a retailer logs sales or a map app notes your location, that is data production. Of course, firms spend lavishly to process, analyze, and transform data. They hire armies of data scientists and invest in computing infrastructure to extract patterns from the noise. But the underlying raw data is like exhaust fumes from our economic engine. How do we value something that just appears?

The truth is that data is not free. We are all paid data producers. Once we comprehend that data is produced through transactions, a deeper economic logic emerges. If a profit-maximizing firm values the data it receives from customers, it has an incentive to encourage more transactions, because more transactions mean more data. Customers buy more when they pay less. Firms that fail to offer discounts will see customers turn to competitors that do. Thus profit-maximizing firms must *discount* their goods and services, not out of fairness, but to generate more sales and more data.

Most of the economy today operates under this hidden bargain. Every digital purchase, every app download, every click is a dual transaction: Consumers buy a good or service, and at the same time, they *sell* their data. The observable price—the amount of money that changes hands—is really the *net price* of these two exchanges. Firms get revenue and data; consumers get products and convenience.

Price bundling

Here's the problem: As customers, we do not know what price, what discount, we received for data. This makes it impossible to know whether we received enough. Consumers typically do not have the option to purchase a good without selling their data. Requiring two transactions at the same time—in this case, a data sale and a product purchase—is

what economists call bundling. By hiding the price of data, bundling ensures that customers get less.

Imagine arriving in a foreign country with a different currency. On arrival, you pay the equivalent of $18 for a lunch that should cost $3. After a few days, you learn when to haggle, when to walk away, and what price is fair. In the digital economy, we are perpetually that first-day tourist. We sell our data every time we browse or buy. But because the transaction is bundled, we never see the price. We can't learn from experience.

Regulations that require firms to *unbundle* transactions—to post both the price with the right to use the transaction data and the price for a private transaction—would throw light on the data market. Consumers could observe the data discount. Some might decide it's worth it; others might withhold their data unless the discount is substantial. Over time, consumers would evolve from naive tourists into savvy suppliers of data, demanding their share of the data economy gains.

The challenge for economists and policymakers is to turn data—an ambient, invisible asset—into something we can count, contain, and price. Economists have begun to build a data measurement tool kit. Each approach offers a different take on "value" and will be feasible in different situations.

Five approaches

First, the market prices approach. Some data is traded in open markets, on platforms such as Snowflake or Datarade, where data sets are bought and sold. But this data is not a representative sample of economically important data. Most firms will not sell you their most valuable data, because it's central to their competitive advantage. But for the subset of data represented in these marketplaces, the price is a tried-and-true signal of value.

Second, the revenue approach. This treats data like any other productive asset: worth whatever extra revenue it can generate. This method asks a counterfactual question: What would profits look like if a firm didn't have some data? This approach requires a model that can predict what profits would have been without data. In finance, this is feasible because we know investors use data to buy more assets that will generate high returns. In other settings, data may have multiple uses that are harder to measure and quantify.

Third, complementary inputs approach. One way to infer the value of a firm's data stock is to look at the resources it devotes to managing and exploiting that data. Data doesn't produce value on its own; it becomes productive only when paired with people and tools. If you know how much labor and computing power a firm engages to work with data, and how much it costs, you can infer the implicit value of the data stock that makes the spending worthwhile. It's indirect, but the surest sign that something is valuable is that firms pay real money to use it.

Fourth, the correlated behavior approach. If data improves decisions, we should see that in the alignment between what people do and the reward for those choices. Economists can measure those correlations between actions and payoffs to estimate how much information decision-makers must have had. In consumer markets, that might mean tracking how accurately recommendations match purchases, or how accurately a firm stockpiles goods that will sell well. High covariance implies valuable data at work. This approach measures data by its behavioral footprint.

Finally, the cost-accounting approach. By instinct accountants just add up the bills to get data. To some extent the new United Nations System of National Accounts does this by counting purchased data sets as assets. The hitch is that most data isn't bought; it's bartered. Consumers "pay" with information when they buy goods or use digital services. Those implicit discounts rarely appear on the books. A true accounting of data's cost would have to impute the value of the dollars or cents knocked off each purchase to encourage more transactions and more data revelation.

"We must move data from the realm of intuition to the realm of quantification."

It's the simplest approach in theory and the hardest in practice, because it asks us to see data transactions that have never been itemized. Unbundling data and goods transactions by requiring separate pricing for transactions with and without the rights to use the transactions' data would make cost accounting feasible.

Toward quantification

Together, these five approaches describe an invisible asset class. Each captures an aspect of data value: labor devoted, revenue earned, the precision of actions, a market price, or implicit cost. None is infallible, feasible in all cases, or holistic in its measurement. Measurement is always imperfect. However, to make informed choices and craft sound policy, we must move data from the realm of intuition to the realm of quantification. Until then, the economy runs on a resource whose price we can only guess at, and whose value Silicon Valley can freely exploit. F&D

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INSIDE THE AI-LED RESOURCE RACE

Thijs Van de Graaf

Material demands—for energy, chips, and minerals—will determine who dominates data

Artificial intelligence is often cast as intangible, a technology that lives in the cloud and thinks in code. The reality is more grounded. Behind every chatbot or image generator lie servers that draw electricity, cooling systems that consume water, chips that rely on fragile supply chains, and minerals dug from the earth.

That physical backbone is rapidly expanding. Data centers are multiplying in number and in size. The largest ones, "hyperscale" centers, have power needs in the tens of megawatts, at the scale of a small city. Amazon, Microsoft, Google, and Meta already run hundreds worldwide, but the next wave is far larger, with projects at gigawatt scale. In Abu Dhabi, OpenAI and its partners are planning a 5-gigawatt campus, matching the output of five nuclear reactors and sprawling across 10 square miles.

Economists debate when, if ever, these vast investments will pay off in productivity gains. Even so, governments are treating AI as the new frontier of industrial policy, with initiatives on a scale once reserved for aerospace or nuclear power. The United Arab Emirates appointed the world's first minister for artificial intelligence in 2017. France has pledged more than €100 billion in AI spending. And in the two countries at the forefront of AI, the race is increasingly geopolitical: The United States has wielded export controls on advanced chips, while China has responded with curbs on sales of key minerals.

The contest in algorithms is just as much a competition for energy, land, water, semiconductors, and minerals. Supplies of electricity and chips will determine how fast the AI revolution moves and which countries and companies will control it.

NATHAN HOWARD/BLOOMBERG VIA GETTY IMAGES

A data center faces multifamily housing in Ashburn, Virginia.

A hungry industry

Artificial intelligence is devouring electricity. Data centers already use about 1.5 percent of global electricity supply, roughly the same as the United Kingdom. Only a portion of that demand comes from AI, but it is growing fast. Training an advanced model can consume as much power as thousands of households use in a year, and running it at scale multiplies the burden. The International Energy Agency (IEA) expects data center demand to more than double by 2030, with AI responsible for much of the increase.

Globally this surge is manageable: AI accounts for less than a tenth of added power demand this decade, far below that of electric vehicles or air-conditioning. But national balances tell a different story. In the US and Japan, data centers could account for nearly half of new demand by 2030. In Ireland, they already use more than a fifth of the country's electricity, the highest share among advanced economies.

The local strains are sharper still. Unlike steel plants or mines, data centers cluster near big cities, can be built in months rather than years, and keep getting bigger. This combination makes them uniquely disruptive to local grids.

In northern Virginia, the world's largest data hub, data centers already consume about one-quarter of the state's power, forcing utilities to delay or cancel other connections. Rising electricity bills became a flash point in the state's governor's race. In Ireland, Dublin's grid operator froze new projects in 2022, approving only those that could generate their own power. Singapore halted approvals altogether in 2019 and now allows facilities only under strict efficiency rules.

Big Tech turns to power

Technology companies are becoming power players themselves. The largest firms are now among the world's biggest corporate buyers of renewable energy. Microsoft, Amazon, and Google have each signed multibillion-dollar power purchase agreements that rival those of traditional utilities. Their decisions about where to site data centers increasingly shape which solar and wind projects get built.

Some are adding on-site generation at data centers to cut reliance on the grid, or are betting directly on new technologies. Microsoft has explored nuclear, from small modular reactors to possible acquisitions of mothballed plants such as Three Mile Island in Pennsylvania. Google is backing advanced geothermal. Amazon is testing hydrogen for backup power. With President Donald Trump rolling back many of President Joe Biden's climate policies, the AI power race has unexpectedly cast Big Tech as a lifeline for clean-energy investment.

Over time, Big Tech's capital could help accelerate innovation in clean power, but it could also cement dependence on fossil fuels. While AI has boosted renewables in Europe, demand in the US—home to more than 40 percent of the world's data centers—still leans heavily on natural gas, adding to emissions.

Smarter machines

Artificial intelligence is not only a voracious consumer of electricity, it can also help manage it, balancing power grids, forecasting renewable output, and optimizing energy use in buildings and industry. Some cities are even piping waste heat from server farms into district heating networks. These applications will not erase the sector's footprint, but they can soften the strain.

Efficiency is improving too. New generations of chips, such as Nvidia's Blackwell processors and Google's tensor processing units (TPUs), are designed to deliver more operations per watt. On the software side, China's DeepSeek, released in January 2025, was trained at a fraction of the cost and energy of what OpenAI and Google spent on comparably sized models.

Yet efficiency brings its own paradox. History suggests that cheaper computing power sparks more use, an effect known as the Jevons paradox. AI may indeed deliver smarter, leaner models, but the appetite for applications is likely to grow even faster.

If electricity is AI's first constraint, semiconductors are the second. Training state-of-the-art models requires thousands of specialized chips, most designed by Nvidia and manufactured almost exclusively in Taiwan Province of China by the Taiwan Semiconductor Manufacturing Company (TSMC). That concentration has made chips the single most strategic choke point in the AI supply chain.

The geopolitical stakes are already clear. The US has restricted advanced chip exports to China while subsidizing domestic fabrication plants. Far from stifling progress in China, those curbs may have pushed its companies to innovate around them, as DeepSeek has shown. Beijing is racing to build its own domestic champions. Europe, Japan, and India are pouring billions into their own industries. Access to chips is now a litmus test of technological sovereignty.

Mineral footprint

Chip fabrication itself is resource-hungry. A single cutting-edge fabrication plant can consume as much electricity as a small city and require vast amounts of ultrapure water. But the deeper story lies farther upstream, in the minerals that make advanced chips and data centers possible.

They need gallium and germanium for advanced circuitry, silicon for chips, rare earths for cooling fans, copper for the cabling that binds servers together. A single hyperscale campus can contain nearly as much copper as a midsize mine produces in a year.

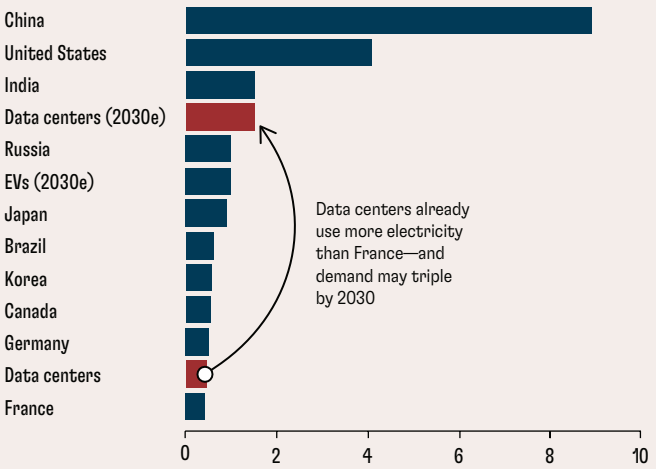
By 2030, data centers could be consuming more than half a million metric tons of copper and 75,000 tons of silicon each year—enough to lift their share of global demand to 2 percent, according to the

CHART 1

More data, more power

All data centers combined use as much power as some of the world's largest economies, and demand continues to climb.

(electricity demand 2023, thousands of terawatt-hours)



SOURCES: International Energy Agency; Organization of the Petroleum Exporting Countries; and IMF staff calculations. NOTE: Electricity demand of data centers compares with that of the biggest national users as of 2023. e = estimate; EVs = electric vehicles.

IEA. For gallium, the leap is sharper still: Data centers could account for more than a tenth of total demand. Those percentages may sound modest, but they come on top of surging requirements from electric vehicles, wind turbines, and defense industries, all chasing the same finite supply.

That supply is highly concentrated. China controls 80–90 percent of global refining of silicon, gallium, and rare earths. In 2023 it restricted exports of gallium and germanium; since late 2024 new curbs have followed on tungsten, tellurium, bismuth, indium, and molybdenum. All are critical inputs for microprocessors, diodes, and server hardware. Prices for many of these metals have spiked. Washington, Brussels, Tokyo, and Seoul have responded with critical-mineral strategies, from recycling programs to alliances with resource-rich countries in Africa and Latin America.

The scramble for minerals, as for chips, leads to concentrated supply chains and high barriers to entry, with clear geopolitical stakes. Securing stable, sustainable access will shape who can truly harness the AI revolution.

Land and water

Hyperscale data centers thrive where cheap power, abundant water, and fast fiber-optic links converge. Land is seldom the limiting factor. These sites are vast by urban standards but modest compared with farming or mining acreage. Even so, their arrival can still reshape local economies as farmland in northern Virginia or Oregon is concreted over by endless rows of server halls.

Water is more contentious. Cooling demands millions of gallons a day, and two-thirds of new US centers since 2022 have been built in water-stressed regions, Bloomberg News reports. In Arizona, projects have sparked fights over whether scarce water supplies should go to households or to Big Tech. Similar disputes are emerging in Spain and Singapore. Yet most of AI's water footprint is indirect. Power plants that supply data centers consume far more water than the centers themselves.

Climate and minimizing network delays also shape siting decisions. Ireland's dense cluster reflects its role as a transatlantic cable hub. Abu Dhabi's planned 5-gigawatt campus was chosen partly to minimize delays with Asia and Europe. And colder countries, from Norway to Iceland, tout their climate advantage: less energy needed for cooling.

The result is a patchwork geography: Some governments impose curbs to protect grids and water; others vie to host projects with cheap renewables, district heating, or simply space to build. This is another reminder of how material constraints will shape the future of AI.

"There is little public reporting from the industry on data center use of electricity, water, or minerals."

Policy challenges

The resource demands of AI force governments to treat power plants, grids, water, and minerals as an integral part of their digital policies.

One challenge is knowing what to plan for. Forecasts of data center demand diverge widely: For 2030, the highest published estimate is nearly seven times the lowest. Yet the pace of building leaves little time for certainty. Governments must expand electricity systems fast enough to keep up, but without overbuilding or locking in fossil fuels.

Another gap is transparency. Even in an information age, there is little public reporting from the industry on data center use of electricity, water, or minerals. Greater disclosure would give regulators, utilities, and communities a clearer picture of what is coming.

Finally, sustainability and equity. Expanding grids and supply chains without environmental and social safeguards risks repeating the boom-and-bust cycles of past commodity races. And the benefits of the AI boom will be tilted toward the rich world if developing economies remain just suppliers of raw materials and face higher implied costs for energy and capital.

If managed well, the AI boom could accelerate clean energy and foster more resilient supply chains. If not, it risks locking in new emissions and deepening resource dependence.

This is not just a digital contest. It's a material one—over electrons, gallons, wafers, and ores. How governments and companies handle those foundations will decide not only who leads in AI, but how sustainable and widely shared its gains will be. F&D

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COUNTING SMARTER

The head of India's statistics ministry, **Saurabh Garg**, explains how he is tackling challenges of scale as demand for real-time data grows

India's national statistical system is one of the world's largest, responsible for serving a diverse population of over 1.4 billion. It employs some 5,000 full-time staff members at the central level and over 6,000 field investigators and supervisors during major survey operations across the nation's 28 states and 8 territories.

Saurabh Garg, who expanded use of the innovative Aadhaar digital ID system in a previous role as chief executive of the Unique Identification Authority India, is now spearheading reform of the country's statistical system as secretary of the Ministry of Statistics and Programme Implementation. He spoke with F&D contributor Srikanth Srinivas about how technology and the nation's multiple tiers of digital public infrastructure are transforming the work of statisticians and the challenges ahead.

F&D: This is the age of AI, big data, and machine learning. How is India taking advantage of this in collecting and analyzing national statistics?

SG: Let's start with data collection. We still go door-to-door, to households and businesses, but data collection is tablet based. On the tablet itself, we are working on adding AI chatbots; if the person conducting the survey has a question, the chatbot responds immediately. All the tablet data is uploaded directly to a background portal, called e-SIGMA. This makes data processing easier. We're also using technology to make our website more intuitive and have launched a mobile app. There are more infographics, and data can be downloaded directly. We have developed training videos for researchers, students, policymakers, and other stakeholders on how to access unit-level data.

F&D: More statistics are produced outside the national statistical system, which in some ways compete with official statistics. How do you deal with this?

SG: The main objective of the statistics produced by the national statistical system is to inform policymaking for the public good. Decision-makers rely on official statistics like GDP, inflation, or surveys. Alternative data and high-frequency indicators are increasingly available and provide supplementary insights into the socioeconomic situation from a different perspective. We are exploring how e-commerce, scanner, mobile, satellite, and other alternative data can be incorporated into official statistics. However, official statistics remain as relevant as ever: They are underpinned by rigorous scientific methods and standards that make them internationally comparable. They go through comprehensive quality control to ensure accuracy, reliability, and comparability over time. This enhances credibility.

TRIBHUWAN SHARMA

F&D: Many agencies are involved in data collection, classification, storage, and processing. How do you harmonize different methodologies?

SG: We're looking at ways to make data from other ministries and departments machine readable so that users can collate, combine, and compare different data sets. That's one of our focus areas. We've introduced a number of guidelines. First, we made a registry of all the government data sets available, accounting for different levels of importance. Second, we developed a national metadata structure and shared it with all ministries. Third, we looked at international systems of classification and those we have nationally. We ensure data is based on definitions that are internationally recognized and thus comparable. Fourth, we looked at unique identifiers, for organizations and geographic locations. Each agency must use its own identifier; this ensures that two data sets can be read by each other. And last, we've introduced a method of reconciling discrepancies between administrative data sets.

F&D: The United Nations revised the System of National Accounts (SNA) this year. Is India ready? Will its expenditure data improve?

SG: The new SNA comes at an opportune time. We're in the process of rebasing our national accounts. We're incorporating the changes required by SNA 2025 into our rebased methodology and new guidelines, which we expect to release over the next couple of years. We've published different sectoral accounts every year for the past few years. This year, for instance, we are bringing out forest and water accounts. We're incorporating the changes that have been suggested.

On the production side, our data is extremely robust. I cannot reiterate that enough. When we last undertook a rebasing exercise, about a decade ago, we didn't have GST [goods and services tax] data, which is expenditure-side data. We have GST data now, and it will provide more granular estimates in the rebased GDP. A robust production-side data set will be accompanied by an equally robust consumption-side data set. This will ensure the overall accounts are more accurate.

F&D: What about resources? Does India face a resource constraint?

SG: Resources are both financial and human. We don't have a budget constraint. We don't need much money because our work is human- rather than finance-intensive. Once the IT infrastructure is in place, maintenance and operational costs are manageable.

On the human side, we have three levels. On top, we have the Indian Statistical Service, whose officers are extremely well qualified and drawn from some of India's finest institutions. Skill building is a constant work in progress. A second set of people are supervisors at the ground level. We are fortunate to have good people who are trained in statistics or mathematics; they comprise a large proportion of our staff.

The third set of people are enumerators who do the door-to-door surveys. We train them very intensively. We encourage all our officers to use the government-wide *Karmayogi* platform, which builds skills for people in other areas, like communication.

F&D: Everybody is interested in jobs. Is the ministry working on increasing the frequency of the labor survey?

SG: Until last year, we produced an annual labor force survey with quarterly updates, but that covered only urban India. Since January 2025, we have also produced a monthly report for both the urban and rural sectors. We also have a quarterly report, which gives more detail on sectors and types of employment. We have nearly doubled the sample size. This has increased data granularity. We have introduced new questions on employment status, education, training and skill levels, and where respondents graduated or received certification.

F&D: What challenges must India's statisticians overcome as the economy becomes more complex?

SG: Data at the national or the state level is not enough. We also need it at the district and even subdistrict level and village level. This means increasing sample sizes and—because of that level of granularity—increasing margin of error. Then there is the manpower, financing, and so forth. That's one set of challenges.

The second is frequency. People aren't willing to wait a year for data. Even a month is too long. How do we reduce the time lag between data collection and dissemination? That brings its own complexities.

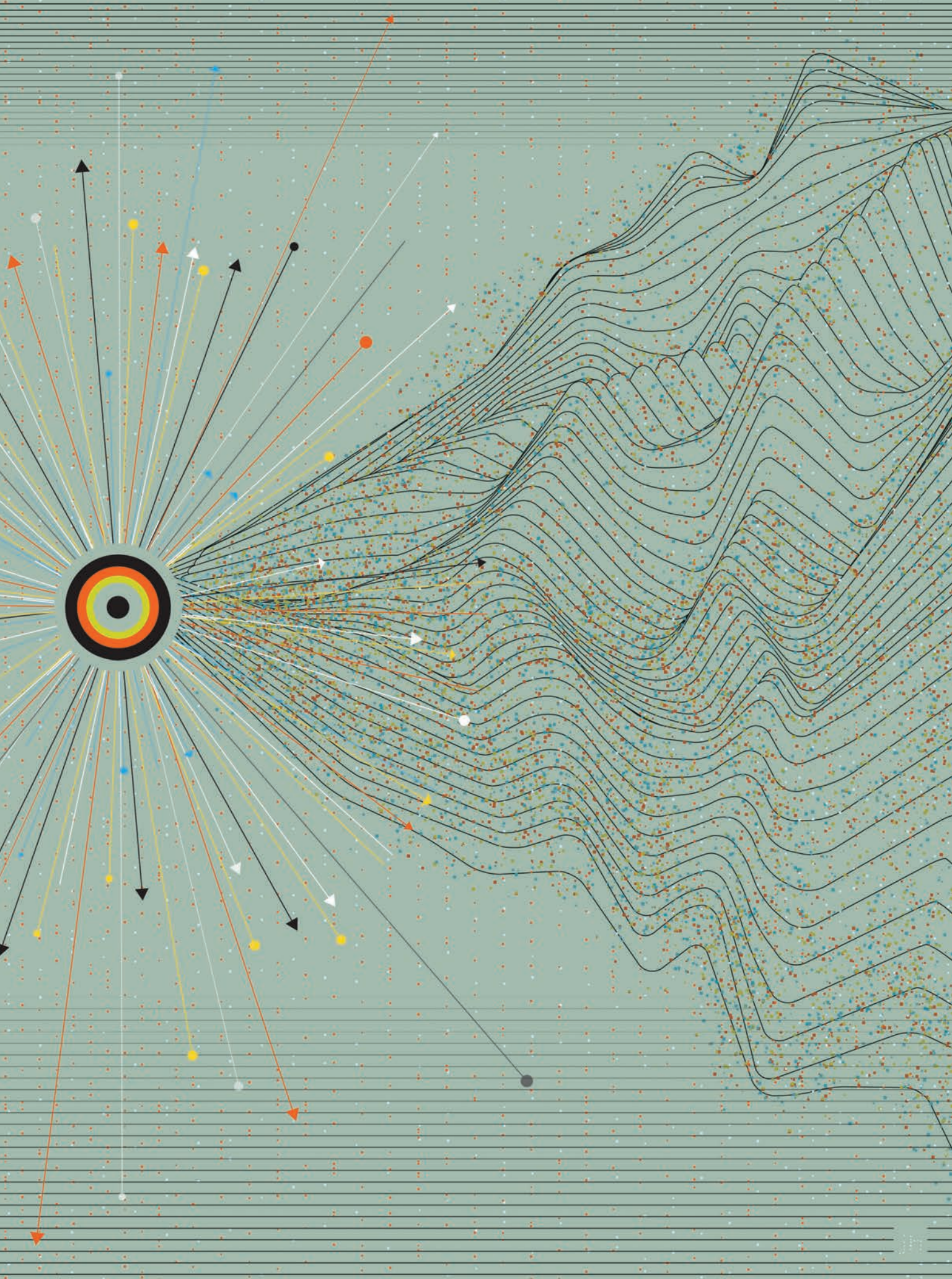
The third challenge is to ensure that people and organizations continue to cooperate to provide data. How do we ensure that people in this social media age continue to provide data without fearing that their privacy is being invaded and at the same time ensure that data is credible and verifiable?

F&D: How do you protect official statistics from political influence and maintain their integrity?

SG: Trust in official statistical systems depends to a large extent on respect for the fundamental values and principles that govern the statistical system. In 2016, India adopted the United Nations Fundamental Principles of Official Statistics, which underscore statistical agencies' professional independence and accountability. The ministry adheres to these principles, which ensure professional and impartial practices grounded in scientific methods and established standards.

We also hold regular stakeholder consultations to gather wider insights on technical matters. We organize conferences to improve users' understanding of our data and our own understanding of their needs and expectations. The National Statistics Office publishes detailed documentation for its large-scale sample surveys to allow for independent scrutiny. By keeping stakeholders and data users involved and informed, we ensure that the statistics we produce are transparent and respond to the needs of those who rely on them for decision-making. F&D

This interview has been edited for length and clarity.



FORECASTING THE PRESENT IN DEVELOPING ECONOMIES

Jeff Kearns

Nowcasting and new data sources can provide timelier and more frequent indicators

Thierry Kalisa started working with new data for real-time economic projections, or "nowcasting," a decade ago, but the pandemic brought its potential into sharper focus.

As a Rwandan finance ministry official when COVID hit Kigali, the capital, he teamed up with a joint task force with the central bank to monitor a shuttering economy under sub-Saharan Africa's first lockdown. Official economic indicators would soon be outdated, even before publication.

The group launched a weekly economic activity index based on a central bank measure incorporating factors like exports, imports, and real-time consumer spending captured from the tax authority's electronic billing machines in stores. The outlook deteriorated. The economy would soon contract.

"This helped the government revise growth projections, adjust the macro framework, and take timely policy actions," said Kalisa, who joined the central bank as chief economist in 2021.

The National Bank of Rwanda today includes nowcasting in staff briefings before quarterly Monetary Policy Committee meetings, and Kalisa's staff of economists, statisticians, and data scientists is expanding to help deliver. "This is very demanding in terms of analytical capacity, but is also producing high-frequency indicators," he said.

Data gaps

Rwanda is among developing economies taking a new approach to economic measurement. Many aim to narrow gaps with advanced economies and most emerging markets in official indicators many developing economies publish infrequently or with a delay. Those advanced and emerging market

Illustration by John Hersey

economies have the staff, funding, and other necessary resources. Large populations in developing economies, however, are left out.

Initiatives include real-time trackers of economic growth, inflation, trade, and consumption. Several low-income countries are building out data operations with support from IMF capacity development and technical assistance (see sidebar).

Data gaps affect low-income countries disproportionately. Advanced economies and most emerging markets publish GDP quarterly. But about a third of countries in the world have only annual GDP, leaving policymakers in the dark for long periods.

And GDP, even for the countries that publish it quickly, still comes out a month or more after the end of the quarter. During crises, the wait bedevils policymakers, who must steer the economy without knowing which way it's heading.

The unprecedented disruption of the pandemic drove this reality home and pointed to the need for more timely and frequent measures to complement official data. Some activities ceased, others exploded, and indicator data collection suffered, causing distortions. Bruno Tissot, head of statistics at the Bank for International Settlements and secretary of its Irving Fisher Committee on Central Bank Statistics, calls it "statistical darkness."

"Central banks around the world have recognized the primacy of providing timely indicators, for instance by mobilizing alternative high-frequency data sources, constructing weekly or even daily indicators, and enhancing their nowcasting exercises," the committee observed in a 2023 report on postpandemic central bank statistics.

Forecasting tool

Nowcasting originated in the 1980s as a meteorological term for predicting conditions just a few hours ahead. It means something else in the world of economics.

"With the weather, you look outside of your window, you see whether it's raining or not," said Domenico Giannone, a nowcasting pioneer. "In economics, you need to wait."

Giannone's 2008 paper on nowcasting, coauthored with Lucrezia Reichlin and David Small, is credited with introducing the term to economics.

Giannone and Reichlin, then at the Université Libre de Bruxelles, began developing a model for short-term forecasting in 2002, in response to a request from Ben Bernanke, one of the Federal Reserve governors at the time. He asked them to explore the feasibility of a comprehensive big data model for forecasting and policy analysis, covering interactions among key sectors of the economy. Giannone and Reichlin discovered that prediction was possible only for the present, very recent past, and very near future—what they labeled "nowcasting"—and built a model to use real-time data to do so. It put what was previously informal, and based largely on judgment, into a formal statistical framework.

"The Fed was interested in seeing whether that kind of framework could be adapted to the problem of reading all the different releases in real time," recalled Reichlin, a professor at the London Business School and former research director at the European Central Bank (ECB). "At the time, macroeconomic models were relatively small—it was before 'big data'—and we started thinking, What models could handle a lot of time series and at the same time retain some simplicity so as not to generate volatile and unreliable estimates?"

Giannone later built on that work at the New York Fed, where he led development of a nowcast of weekly estimates of quarterly US economic growth.

After roles at the ECB, Amazon, and the IMF, Giannone joined Johns Hopkins University this year to focus on improving economic activity measurement in low-income countries. He was motivated partly, he said, by the realization that nowcasting tools of larger, wealthier economies covered nearly the entire global economy, but low-income countries had almost nothing.

Flying blind

Low-income countries face challenges with nowcasting and with the official data it complements, especially when government budgets are strained and skilled staff scarce. But practitioners still see promise in sharpening real-time measures.

First estimates of GDP in many advanced economies come out about a month after the end of the quarter—two months in some major emerging market economies—then are revised. In developing economies it can take more than three months.

Kenya's National Bureau of Statistics, for example, releases GDP about three months after a quarter ends, but the central bank uses nowcasting tools fine-tuned by IMF staff and Giannone to start gauging the quarter after only a week, using private consumer spending data, then remittance data available after two weeks. Trade, money supply, tourism, and electricity data available in about 40 days help refine the picture and give a good indication of the health of the quarter in half the usual time.

Signals and movement

In countries where data is sparse, as in low-income countries, transaction data like that incorporated

"Recent advances in large language models and artificial intelligence open remarkable new possibilities for exploiting text as data."

into the Kenya model "will be extremely useful," Giannone said, and much more informative than in advanced economies, where indicators are out almost daily.

His latest research focuses on global linkages and nowcasting of one country's activity based on readings from neighbors, trade partners, and the global economy, using a model incorporating GDP for all countries.

"Every country has a global component and a regional component, and then from this we interpolate for countries that have less information, using countries that have more information," he said, citing how neighbors and major trading partners can help show the direction of activity. "If you get GDP for the United States, this provides some signal also for Cambodia. There's a lot of comovement."

Recent advances in large language models and artificial intelligence open remarkable new possibilities for exploiting text as data and for integrating data with metadata, he said.

Gauging expansions and contractions in real time holds even more promise, research he considers a priority. "To understand whether you are in a recession in a country where GDP is not available quarterly, you have to wait a year," he said. "A policymaker doesn't have a clear idea of where they are. So it's extremely important to move in that direction."

High-frequency sources

In South Africa, an emerging market economy and the continent's largest, central bank researchers want greater understanding of economic signals from real-time data, including new sources that can help gauge the effects of disruptions. For example, the economy there faced an outbreak of foot-and-mouth disease this year. Supply disruptions sent beef prices soaring, which contributed to the fastest overall year-over-year consumer price increase in 10 months.

South African Reserve Bank economists got an early read from commercial agricultural data for meat and other crops to gauge food inflation.

This underscores how nowcasting works in practice and why it's valuable. Statistics South Africa released the consumer price index (CPI) for September three weeks after the end of the month, but corresponding commercial data for the month were available two weeks earlier.

The underlying data come from high-frequency sources like wholesale and retail sales, livestock auctions, and produce markets, which offer highly disaggregated reads on food components like meat, fruit, and vegetables, according to Mpho Rapapali, an economist in the Research Department who works on the measures. Statistical analysis shows that the commercial indicators lead CPI by one to three months across components, she said.

"That's been very instrumental in helping us with our forecasts," Rapapali said in an interview. "We can also have a weekly checkpoint to see what's happening in these food categories."

'Start with the data'

Nowcasting models have become more sophisticated in recent years, and large language models allow access to more data than in the past. The novelty of promising new measurement tools may be irresistible, but there are caveats. Practitioners caution that there's no shortcut to the toil of expanding official indicators or raising the frequency and granularity of existing gauges. New methods can help the effort, working in tandem to better inform policy, but can't replace rigorous data collection.

Reichlin says sophisticated techniques usually

Data and innovation in sub-Saharan Africa

Case studies of IMF capacity development show how better economic measurement and technological innovation can aid sound policymaking

DEMOCRATIC REPUBLIC OF THE CONGO
Sharpening policy decisions

The Central Bank of the Congo is among those developing a forecasting and policy analysis system with assistance from the IMF that enhances economic analysis, supports more systematic decision-making, and improves communication with the public.

A central innovation within this system is nowcasting, which is crucial in a country where compiling reliable statistics remains difficult and official GDP figures are published only annually and with long delays. Timely information helps policymakers detect turning points in growth and calibrate policy responses more effectively. Policymakers also face challenges from high dollarization; the boom-bust cycle in the key mining sector, which contributes about a third of GDP; and the impact of exchange rates and commodity prices on inflation.

The central bank's nowcast identifies real-time economic signals by combining traditional high-frequency indicators—such as copper and cobalt production and prices and money supply—with nontraditional inputs like satellite night-light intensity and Google search trends. The results feed into a quarterly projection model that links short-term assessments with medium-term forecasts and policy scenarios. Together, these tools are helping the central bank pursue forward-looking, transparent, and data-driven monetary policy.

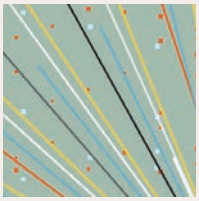
GUINEA-BISSAU
Blockchain transparency

In 2020, Guinea-Bissau faced a daunting fiscal challenge: The public wage bill consumed about four-fifths of its tax revenues, one of the highest ratios in sub-Saharan Africa. Managing salaries and pensions for civil servants was opaque, error-prone, and vulnerable to abuse.

In May 2024, and in collaboration with the IMF, the consultancy EY, and donors, Guinea-Bissau became one of the first countries in the region to deploy blockchain technology to manage its public wage bill at the ministries of finance and public administration.

The secure platform creates a tamper-evident digital ledger of salaries and pensions across government agencies, flagging transaction discrepancies and enabling near real-time tracking of who is paid, how much, and whether payments are authorized. It reduces the burden of audits and provides policymakers with accurate, timely fiscal data—all while building a foundation for future AI-enabled tools.

The blockchain project is a useful tool that supports several reforms aimed at controlling wage spending introduced as part of an IMF-supported program. The results are promising: The wage bill fell to half of tax revenue in 2024, a substantial improvement but still above the regional benchmarks. The platform will be expanded to cover all 26,600 public officials and 8,100 pensioners nationwide.



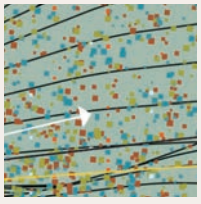
KENYA
Real-time insights

Among its peers, Kenya has relatively high-quality macroeconomic data. However, its official quarterly GDP estimates usually come with a lag of at least three months, and some other higher-frequency indicators of economic activity are also published with delays. In this context, building nowcasting models around available data could give policymakers a quick read of economic activity ahead of the official GDP releases.

Ongoing work at the IMF on nowcasting finds that it is possible to approximate Kenya's economic growth to a large extent ahead of the official GDP releases by exploiting comovement in a range of indicators (economic, financial, and others) through business cycles. The Central Bank of Kenya, supported by

IMF technical assistance, has also been exploring ways to inform its view on economic growth by using nowcasting techniques and extracting information content of its bimonthly surveys.

Nowcasts, fine-tuned with advancement in data availability and computing technology, help economists, investors, and policymakers with a real-time gauge of economic performance. Finally, the IMF's research also shows that nowcasting can be applied to countries where quarterly GDP estimates are unavailable.



MADAGASCAR
AI customs

Like many countries worldwide, Madagascar faces significant challenges in managing the complexity and volume of its international trade operations, particularly fraud detection in customs declarations.

Taxes on international trade are critical for government revenue. But while much of the customs process was already digitalized, automating some components, particularly fraud risk analysis, remained elusive, in part because of limited data and limited methods to analyze unstructured and textual information.

Customs officials in October introduced agentic AI, an autonomous decision-making form of artificial intelligence, to detect inconsistencies that signal fraud by cross-analyzing customs declarations, invoices, manifests, and external and internal databases. This automated many manual frontline inspectors' tasks, allowing experts to focus on complex cases.

The initiative, supported by IMF technical assistance and capacity development and building on earlier support from the Korea Customs Service, advanced technological capabilities while allowing the customs administration to own and further develop AI tools. The work underscores how new technologies can strengthen customs integrity and efficiency—and modernize trade controls.

SOURCE: IMF staff.

aren't the best place to start when countries have few resources. "The first thing is to try to see what high-quality data are produced in the country, or what proxy you can use if the hard data are not there," she said. "First start with the data, then you get to the technique. That's very important." Simple models often perform best, and nowcasting is more about exploiting different data releases for a timely signal and combining series at different frequencies, she said.

New data also can be noisy or nonrepresentative, and models that work well can fail when the world changes, according to Joshua Blumenstock, who has advised countries in Africa and South Asia as codirector of the University of California, Berkeley, Global Opportunity Lab, which uses novel data and an interdisciplinary approach to guide policy. He said new data tools also come with broader concerns: privacy, transparency, legitimacy, and governance.

Developing economies also face capacity challenges. Central banks and governments may lack the budgets and ability to build out rosters of economists, statisticians, and data scientists and equip them with advanced computing tools.

New appreciation

Challenges aside, the direction for developing economies is toward more nowcasting to augment data where needed, as well as expanded official economic indicators.

Just as Kalisa, in Rwanda, is expanding his department, so is a counterpart on the other side of the globe. Samoa, one of the world's least-populated countries, with just 220,000 people, is two years into a formal nowcasting system, supported by technical assistance from IMF staff. At the central bank, which has fewer than 90 staff members, Karras Lui, economics department manager, expects to expand his group from 8 people to 10.

"We'll gradually get more resources as we continue to build our capacity for doing forecasting," Lui said. "There's now an appreciation from the board not only of these new tools, but the analysis we're providing." F&D

JEFF KEARNS *is on the staff of* Finance & Development.

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A New Industrial Revolution?

Niall Kishtainy

ARTIFICIAL INTELLIGENCE MAY RIVAL STEAM, ELECTRICITY, AND COMPUTING—BUT HISTORY SUGGESTS ITS FULL ECONOMIC IMPACT WILL TAKE TIME

With the Industrial Revolution, which began in Britain in the late 18th century, came the first wave of technology to transform the economic system. In the centuries that followed were further revolutions, each associated with new forms of technology. What lessons can we draw from this history about the rapid advance of technology in our own time?

Popular debates about today's new technologies fixate either on visions of a dazzling future of AI-powered scientific breakthroughs or on a dystopian future of obsolete workers struggling to survive alongside a wealthy technological elite. But the advent of railroads and steam-powered machinery in the 19th century and information and communications technology (ICT) in the late 20th century gave rise to hopes and fears just as far-reaching. Economics and history should, however, make us wary of extreme predictions about the technological future.

Basic economic principles imply a rosy view about the impact of technology on growth and living standards. By enhancing the productivity of workers, technology can raise the demand for labor, driving economic expansion and pushing up wages. This happy story is most accurate in light of material progress over the centuries. Waves of technology over the past 200 years have not led to ever-rising unemployment. If they had, there would now be a dwindling remnant of workers performing ever-fewer activities.

But within this broad pattern are significant complicating factors. A classic debate about past industrial revolutions centers on how quickly new technology has an effect.

General purpose technology

The First Industrial Revolution was economically significant because of the emergence of a new general purpose technology: steam power. Unlike better bread ovens, which simply make bakers more

Illustration by Mark Harris

effective, general purpose technology has many uses and increases productivity throughout the economy. Beginning in the late 19th century, the Second Industrial Revolution introduced another general purpose technology, electricity, and the third, beginning in the late 20th century, brought yet another, ICT. Industrial revolutions also bring about what's been termed the "invention of a method of invention." In the First Industrial Revolution it was about finding ways to bridge the gap between scientific knowledge and the creation of useful products.

Because it offers fundamentally new possibilities for the production of goods and services and has broad application across many fields, it's likely that AI constitutes a distinct general purpose technology. It also involves novel ways of coming up with ideas and so is itself a new method of invention. We may well be living through a fourth industrial revolution as groundbreaking as those that came before.

If new general purpose technology is fundamental to industrial revolutions, then how long does it take to have an effect? The economic historian Nicholas Crafts found that the impact of steam in the 19th century was slower and smaller than previously believed: The gains came only after 1830. This is because at first steam-powered sectors made up only a small fraction of the economy and so couldn't drive dramatic productivity growth. And reaping the full benefits of general purpose technology requires broad economic reorganization, which takes time. Steam power means moving workers into factories, electrification means revamping production lines, and ICT implies reshaping firms' administrative functions.

Solow paradox

This finding should allay an often-expressed disappointment with recent productivity performance. A pioneer of growth economics, Robert Solow, once commented that "you can see the computer age everywhere but in the productivity statistics." This "Solow paradox" points to the reality that despite the advent of computers and new communications technologies, productivity growth in the late 20th century seemed unspectacular at best. But if the experience of the First Industrial Revolution is any indicator, it's overly optimistic to expect an immediate payoff from new technology. Compared with the early impact of steam, the productivity gains from ICT are in fact historically unprecedented in their speed and magnitude. Clearly society has become better at harnessing the economic potential of new technologies.

Although over centuries economic expansion and higher living standards come from new technology—from advancements in the supply side of the economy—in the short term a host of factors influence growth. Some economists have blamed sluggish growth in recent decades on weak demand, particularly following the global financial crisis of the early 2000s. But it's been suggested that even the supply-side improvements underpinning the sustained economic growth of the past 200 years are now harder to come by. The economist Robert Gordon argues that innovations like electric lighting and running water, which had a significant impact on daily life and the economy during the 20th century, were technological low-hanging fruit—and that there are fewer of these left for the taking.

Does history suggest that AI could end this impasse? Despite dazzling recent advances, the technology is still at an early stage. This is almost certainly the case in terms of its practical application in the economy. AI's contribution to productivity has so far been modest, and some have already declared it a "productivity paradox." But as with steam, electricity, and ICT, harnessing the full potential of AI will take new kinds of organization and ways of working. If the ICT experience is anything to go by, then the AI productivity impact will be felt faster than the effect of earlier general purpose technology, even if it doesn't yield the spectacular growth some enthusiasts project.

Perennial fears

The second complicating factor when it comes to the impact of new technology involves how the productivity gains are distributed. Looking at the unfolding of the Industrial Revolution decade by decade rather than over entire centuries reveals a more complex and bleaker picture, one that has stoked those perennial fears of new technology and led to critiques of industrial capitalism. In the mid-19th century, Friedrich Engels noted the differing impacts of machines on workers in the early stages of the Industrial Revolution. The invention of the spinning jenny in the 1760s lowered the cost of yarn, making cloth cheaper and increasing the demand for it. There was a greater need for weavers, and their wages rose.

But later, the mechanization of weaving itself wrecked workers' standard of living. Engels observed in the hovels of Manchester, England, a distressed class of hand-loom weavers squeezed out by new machinery. With little alternative employment available, they barely survived on collapsing wages and 18-hour workdays as more and more of the woven goods they made were "annexed by the power-loom." In the factories themselves, men, women, and children toiled alongside machines

for long hours in dangerous, unhealthy conditions. Machines and the factory system had blighted the lives of the working class, argued Engels.

The economic historian Robert Allen uses historical data to establish the basic pattern described by Engels. In the early decades of the Industrial Revolution, even as output per worker rose, real wages stagnated. Wages began to rise in line with productivity—as basic economic principles would predict—only after the middle of the 19th century. A shorter-term perspective than centuries, then, shows that new technology has complex and contradictory effects on living standards and wages.

In a series of recent studies, Daron Acemoglu and Pascual Restrepo model these various impacts. New technologies like steam-powered looms, industrial robots, and AI automate tasks that workers used to do, leading to a shedding of labor—the "displacement effect." This reduces the share of labor in national income and decouples wages from productivity.

Reinstatement effect

Other forces offset displacement. Weavers benefiting from the mechanization of spinning are an example of automation in one sector boosting demand for a related nonautomated task. But there's a more potent pro-worker effect that really got going in the second half of the 19th century: the "reinstatement effect." This happens when technologies generate new tasks that give human beings a comparative advantage over machines. During the 19th and 20th centuries, as steam engines, electricity, and computers transformed production, previously unimaginable jobs emerged: for engineers, telephone operators, machine technicians, software designers, and so on.

These various effects complicate the basic economic link between technology-caused productivity improvement and higher wages. If technology simply displaced labor, what would account for the famous stylized fact established by the economist Nicholas Kaldor in the 1960s—that the share of labor in national income had been relatively stable? On the other hand, if a new job emerged immediately for every worker who lost one to a machine, then technological unemployment and Luddite-type discontent would be impossible.

During the early phase of the Industrial Revolution, the displacement effect dominated, hurting workers; in the 20th century, the reinstatement effect became stronger, driving up wages and living standards. But since the late 20th century, real wages in many leading economies have been flat—another paradoxical aspect of the Information Age.

Acemoglu and Restrepo point out that many ICT and AI innovations have been aimed at automation rather than the creation of new kinds of tasks. This has exacerbated the problem of stagnant labor demand, slow wage growth, and rising inequality, raising fears about what an AI-dependent future might look like. They argue that there is even a danger of excessive automation directly hurting productivity. Instead they advocate the pursuit of labor-reinstating AI—for example, in education and health, where AI tools could help with individually tailored learning and treatment programs that would require more, not fewer, teachers and doctors.

Machine singularity

There's a bigger question. Given its potential to replace human creativity, is AI fundamentally different from earlier general purpose technology? Technologists talk of AI reaching "singularity," a point at which machines could improve and invent themselves, making humans redundant and eliminating labor reinstatement through the creation of new tasks.

Would such a scenario make economic comparisons with earlier eras useless? Maybe not. Even if AI did cross such a boundary, it would not necessarily translate into economic singularity—unbounded productivity improvement but human obsolescence. The economist William Nordhaus has devised empirical tests for the likelihood of such singularity and found that most of the conditions are far from being met. That's because much of the economy is physical, not informational, and is likely to remain so: For AI to completely take over, it would have to learn how to poach eggs, cut hair, and soothe crying toddlers at the day care center.

A big difference between the early 19th century and our own time is that we now have policy tools to influence the economy. It's well known that innovation has significant market failures. But choices about the path of AI are being left to corporations with little concern for the broader economic impacts policymakers and voters care about. Technology is a social choice that we can influence. Armed with the experience of earlier industrial revolutions, governments and regulators have both motive and means to guide technological development to ensure that its economic benefits are broadly shared—if they can find the political will to do so. F&D

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The Human Edge

Pablo A. Peña

CURIOSITY, CRITICAL THINKING, AND SELF-REGULATION MATTER MORE THAN EVER IN THE AI AGE

Economists have long recognized the importance of human capital—the skills and knowledge embedded in people. More than a century ago, Alfred Marshall wrote that "the most valuable of all capital is that invested in human beings." Thinkers outside economics have made the same point. The philosopher Michel Foucault, reflecting on the economic rise of the West in the 16th and 17th centuries, asked, "Was it not due precisely to the existence of an accelerated accumulation of human capital?" It's no exaggeration to say that human capital explains the rise in living standards generation after generation in modern societies.

Recent advances in artificial intelligence have raised concerns about the displacement of human capital. Will AI and human capital operate as complements, making each other more productive? Or will they be substitutes? Three critical but sometimes overlooked components of human capital—curiosity, critical thinking, and self-regulation—can help answer these difficult questions.

Curiosity

Imagine taking all the data ever recorded by humans up to the year 1939 and feeding it into a large language model (LLM). The year 1939 is significant because it was shortly before Paul McCartney and John Lennon were born. In fact, before they were conceived. Suppose we then ask that LLM to create songs described with adjectives used by music critics who listened to The Beatles. Would the LLM produce "Yesterday"?

Here are two reasons it wouldn't. First, there wouldn't be enough information to predict the creative output of the two yet unborn Liverpool lads. The Lennon-McCartney songs were inspired by their life experiences. Yet prior to the musicians' existence, there wouldn't be many clues about what those experiences were. Moreover, we couldn't confidently predict that John and Paul would even exist—we wouldn't know which of their fathers' millions of sperm cells would fertilize the mothers' eggs.

Illustration by Irene Servillo

Second, without giving specific details of the songs, our prompt would be far too vague. "Yesterday" has been described as melancholic, timeless, elegant, lyrical, and intimate. Those words may sound right, but they don't narrow down the possibilities by much. So, before The Beatles, AI couldn't have created their music by prediction: We would miss out on what some consider one of the best rock and roll songs. The same could be said about the work of your favorite painter, writer, sculptor, and so on—anyone born after 1939.

Now, think of today rather than 1939. For the same reasons, an LLM fed with all the information available until this moment wouldn't be a substitute for the talent, creativity, and curiosity of future creators. Although AI may do a decent job recombining old data (past books, records, and images), it cannot mimic human creations yet unseen.

This notion extends beyond art. As an example, consider the policy question "What can be done to reduce gun violence in Chicago?" An LLM would answer with a summary of previous studies and perhaps highlight those more applicable to that city, but it wouldn't empirically test new ideas to give a previously unknown answer. On its own, AI is not going to design a policy intervention, get funding for it, prepare survey enumerators, visit households, persuade participants to respond, and so on. Humans do that—and they are driven to do it by their intellectual curiosity. It is our curiosity that increases the stock of knowledge AI depends on.

We are bound to reach a point when all the information available has been fed into LLMs—a situation called "peak data." After that, without new information (for example, studies on new strategies to prevent gun violence), the output of LLMs won't improve much. If everyone decided to rely on what LLMs say rather than financing and conducting new research, we would soon be stuck with outdated studies—clearly an undesirable situation. Peak data implies that for AI to get better and better at answering questions, we humans must keep pushing the knowledge frontier, continuing to ask and answer new questions. We must remain creative and curious.

A financial market analogy underscores this point. Consider the efficient market hypothesis, famously postulated by Eugene Fama. The idea is that prices incorporate all the information available; therefore (privileged information aside) you cannot beat the market. This notion was later refined by Sanford Grossman and Joseph Stiglitz, who posed an information paradox: If prices already reflect all available information, investors have no incentive to gather and analyze information. But if nobody gathers such information, how can it be reflected in prices? Market participants produce and process information because there are benefits from doing so, and prices reflect such information—though not perfectly or instantaneously.

Similarly, AI may incorporate all available information at a given time, but to remain relevant and improve, it needs people to keep producing new knowledge. From this perspective, curiosity and AI are complements, not substitutes. In the long run, AI will improve only if humans develop more and better ideas.

Critical thinking

In his 1845 *Economic Sophisms*, Frédéric Bastiat describes an interesting dichotomy between hard sciences and social sciences. Hard sciences, he argues, can be known only by scholars, and "despite his ignorance, the common man benefits from them." The practical application of the social sciences, however, concerns everyone and "no one admits ignorance of them." While people tend to accept the words of experts in the hard sciences without hesitation, they seldom do so when it comes to the social sciences. Regular folks don't claim to know a better way to build computer chips or airplane engines, but they often claim they could improve the tax system or fight poverty more effectively. Bastiat's dichotomy extends to our interaction with AI.

If you ask an LLM to solve a mathematical problem, you get a simple and direct answer. Your judgment isn't required. Your preconceptions don't affect your interpretation of the information you get. In the social sciences and humanities, that is often not the case. Consider asking an LLM the following questions: How do I know someone is in love with me? Is there a God? Should I have children? Who should I vote for in the presidential election? LLMs will provide answers, but they will remix what others have said throughout history—nowhere near a definitive answer. It's up to us to weigh the arguments and make a judgment. In this sense, critical thinking becomes essential.

There is another reason critical thinking matters. Psychologist Donald Campbell warned that "the more any quantitative social indicator is used for decision-making, the more subject it will be to corruption pressures." Campbell's law also applies to AI. Because so many people rely on LLMs, bad actors are motivated to contaminate their training data with disinformation—a process called "data poisoning." So, even at the most basic level, the information provided by LLMs may be misleading. Knowing this, we must remain vigilant. Critical thinking is key in this process.

Self-regulation

AI can summarize vast amounts of information to guide our decisions, but it doesn't control what we actually do. We are fallible and often give in to our emotions. An LLM can generate the perfect personalized workout plan for you, but its success depends on your discipline: Can you stick to the plan even when you don't feel like exercising? AI can tell your colleague how much money she should save every month for retirement or tell your neighbor how much alcohol to drink at parties, but they may fail to follow its advice, even if they know it's right.

Economists since Adam Smith have acknowledged human fallibility. In his 1790 book, *The Theory of Moral Sentiments*, Smith explains: "The qualities most useful to ourselves are, first of all, superior reason and understanding...and secondly, self-command, by which we are enabled to abstain from present pleasure or to endure present pain, in order to obtain a greater pleasure or to avoid a greater pain in some future time." So it's not only about knowing what's good for us. It's also about having sufficient self-regulation to do what it takes to achieve it.

Smith's point is crucial when we think about the wide variety of human activities economists call "household production." This term means that we usually don't consume what we buy "as is." We transform it with time, effort, and skill. We may buy a stationary bicycle, but we need to ride it. The same goes for a book, meal ingredients, and even relationships. We must devote time, effort, and skill to get from them what we actually want. This process is subject to the weakest-link problem modeled by Michael Kremer in his O-ring theory (named after a space shuttle part that failed 40 years ago). In this context, other inputs cannot substitute for the effort, time, and skill people contribute. It doesn't matter how fancy your gym is if you never show up. We can apply this principle to AI: As it gets better, the weakest link will be our ability to follow through on what we know is best for us. Thus, the benefits of self-regulation will increase as AI becomes better at giving us information.

Human capital

Curiosity, critical thinking, and self-regulation are forms of human capital that grow when we are encouraged—repeatedly and deliberately—to be curious, think critically, and self-regulate. If you doubt they can be developed, consider the opposite: School systems or workplaces that discourage questioning, reflection, and autonomy clearly erode those skills.

To readers worried about the singularity—the moment when AI surpasses human intelligence and becomes capable of improving itself—talking about LLMs may seem naive. After that moment, AI could become like a new species on Earth. We can speculate about two future scenarios of human-AI interaction. In one, humans and machines are adversaries, as in the Wachowskis' film *The Matrix*. Each generation's human capital would be the only way to fight back, making its accumulation a priority. In the other scenario, AI and humans peacefully coexist. What would our interactions with superintelligent beings look like?

In some sense, humans have experienced these interactions already when working for large organizations. These "superior beings" are self-interested and agglomerate a brainpower far greater than any single human's. Still, they compensate us for using our knowledge and skills to serve their goals. If our relationship with post-singularity AI resembled our relationship with such organizations, then investing in human capital would still yield benefits. In this coexistence scenario, some people might choose to establish AI-free communities. Those low-tech places would rely on their members' human capital. Thus, whether one thinks apocalyptically or not, the case for investing in human capital is strong.

Back to the present, the newsworthy efforts of Meta to recruit human talent to develop more powerful AI technologies—offering exorbitant compensation packages—show how crucial human capital is today. The age of human capital hasn't ended; it continues to evolve. Think of the mechanization of agriculture, the automation of manufacturing, and now the "algorithmization" of services. Each stage has freed human capital in some areas and demanded more in others.

But these stages shouldn't be seen as independent processes. The human capital displaced by tractors, irrigation, and fertilizers made the manufacturing boom possible. Production lines with automated processes made the services boom possible. AI will make the next boom possible. Just because we cannot imagine it from where we stand today doesn't mean it won't happen. Picture our great-great-great-grandparents trying to imagine what Google or Nvidia does today. As before, human capital will remain relevant—just in new and perhaps hard-to-foresee ways. There will be new sectors in the future and plenty of value created in them by the skills and knowledge embedded in people. F&D

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Why Civilizations Flourish—and Fail

Johan Norberg

FROM ATHENS TO THE ABBASIDS TO TODAY'S ANGLOSPHERE, CREATIVITY AND COMMERCE DRIVE GREATNESS

Ninth century Baghdad, seat of the Abbasid Caliphate, was designed as a perfect circle to honor the Greek geometer Euclid. The empire, enriched by trade in goods and ideas, sponsored an ambitious translation movement to collect the accumulated knowledge of the many cultures it interacted with.

This open mindset is one of the keys to the success of seven great civilizations spanning two and a half millennia. The practical lessons of these cultures could not be more important today as countries choose once again to wall themselves off—physically, economically, digitally, and from new ideas.

Leaders promise safety, greatness, and a return to an imagined golden age through protection and control. It is a familiar and tempting story when the future feels uncertain. Yet history tells a different tale.

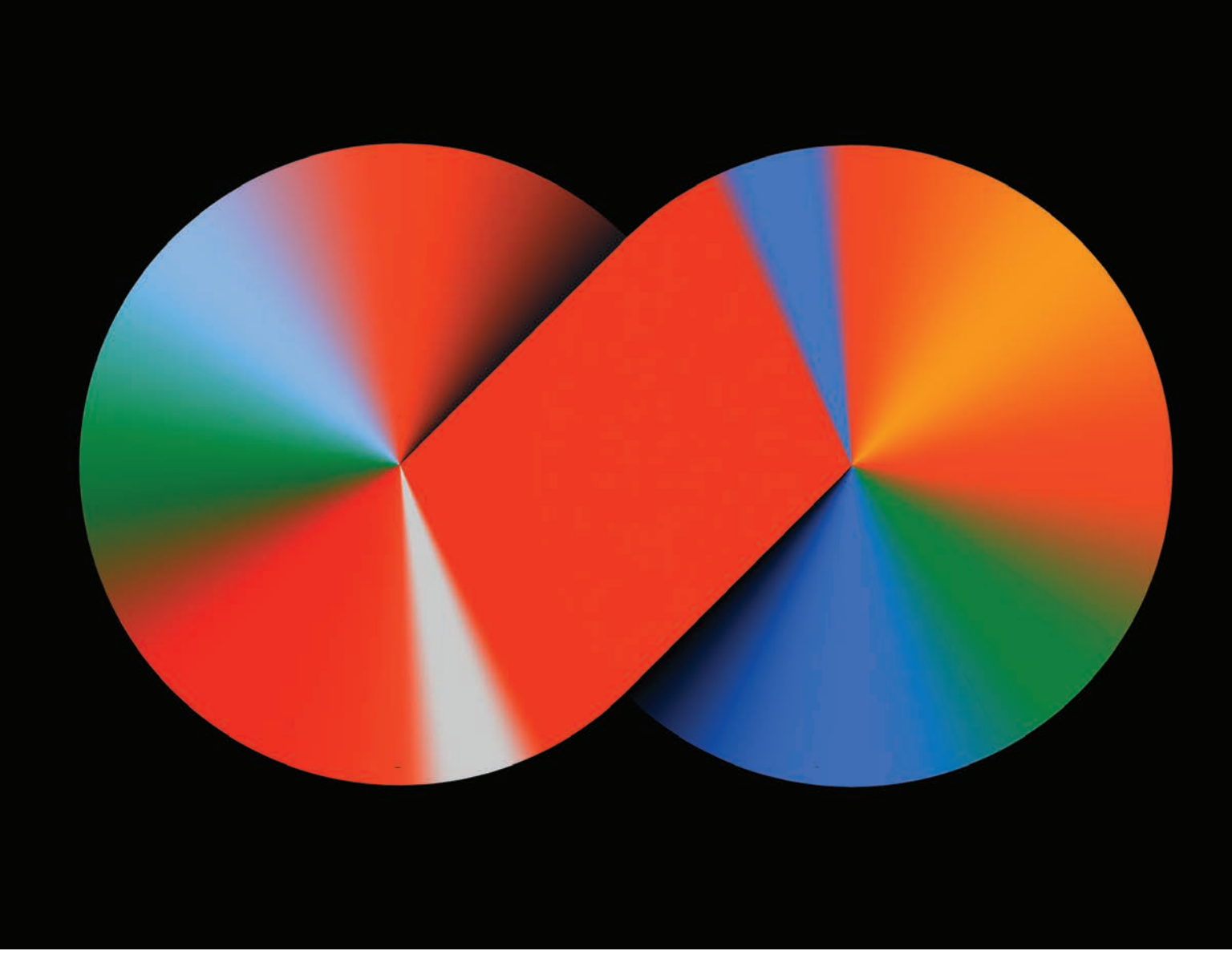
The most secure and prosperous societies did not hide from the world. They were confident enough to remain open to trade and ideas, allowing the new to challenge the known. Progress emerges when people experiment, borrow, and combine ideas in ways no planner could ever foresee; decline happens when fear overcomes curiosity.

These are among the central lessons of history's real golden ages that I explore in my new book, *Peak Human: What We Can Learn from the Rise and Fall of Golden Ages*.

Secrets of the seven

While very different, the cultures studied—from ancient Athens to the modern Anglosphere—had some striking commonalities. They all fostered periods of intense innovation, excelling in cultural creativity, scientific discovery, technological progress, and economic growth.

Admittedly, they were not golden for everyone. All practiced slavery and denied women most rights until very recently. The classicist Mary Beard has observed that when her readers express



envy for life in ancient Rome, they always seem to think they would have been senators there—a tiny elite of a few hundred men—rather than one of the millions of slaves.

But poverty and oppression have been the rule in human history. What made these seven cultures unique was that they nonetheless offered more freedom and progress, and better living standards for a larger share of their populations, than other civilizations of their time.

What were their secrets? Not geography, ethnicity, or religion. Creative and open cultures have popped up in the most unlikely places, sometimes with rough terrain and poor soil and lacking natural resources. A region that seemed peripheral in one era could become a leader in the next.

Open mindset

Great civilizations came in different flavors of pagan, Muslim, Confucian, Christian, or secular. What mattered was not the content of their creeds but that they didn't harden into orthodoxy.

Greatness emerges when imitation leads to innovation. These civilizations didn't invent all the breakthroughs that made them successful; instead, they borrowed or stole them from others. Athens learned from Mesopotamian, Egyptian, and Phoenician cultures nearby, and from a thousand other Greek city-states. The Abbasids consciously built their capital, Baghdad, at what has been described as "the crossroads of the universe" to gain access to the goods, skills, and discoveries of others.

Openness to international trade exposed cultures to new habits and undermined the notion that there is only one right way, in religion, politics, art, or production. Maritime powers, in particular, ventured farther and saw more.

Renaissance Italian merchants picked up Arabic numerals and texts on their business journeys. British merchants venturing east found porcelain

Illustration by Max Drekker

and textiles that would inspire domestic production.

The Romans absorbed methods and peoples through a kind of strategic tolerance of cultural differences that accompanied their brutal conquests, constantly acquiring better technologies and finding new talent for their legions and even the Senate. Like the United States today, the Dutch Republic drew a constant influx of new energy and talent by opening its doors to immigrants from other cultures, from the artisans who developed the textile industry to the dissidents who kick-started the Enlightenment.

Rebellious innovation

But imitation can take you only so far. To make progress self-sustaining, imported influences had to combine with local ideas and practices in ways that produced transformative innovations—from better crops and iron tools to groundbreaking art and financial instruments.

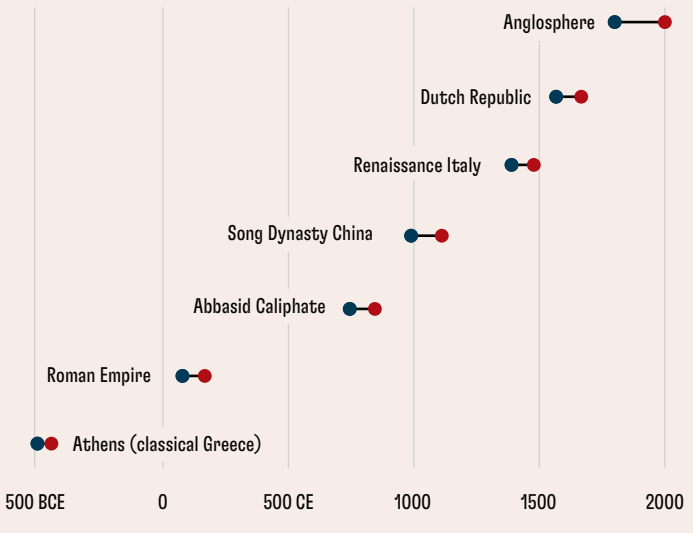
To bring something new into the world, people must be allowed to experiment with, and exchange, theories, methods, and technologies, even when it makes elites or majorities uncomfortable. Every major innovation, argues Nobel Prize–winning economic historian Joel Mokyr, is "an act of rebellion against conventional wisdom and vested interests."

CHART 1

Rise and fall

Openness to trade and ideas is one of the keys to the success of seven great civilizations spanning two and a half millennia.

(peak years of select civilizations)



SOURCE: Johan Norberg. **NOTE:** BCE = before the Common Era.

At a certain point, progress became self-reinforcing, as it reshaped how these cultures saw themselves. When new influences and combinations improved living standards and spread more widely, they sometimes generated a culture of constant, self-renewing creativity—a culture of optimism. That proved decisive.

But as long as conventional wisdom and vested interests hold veto power, not much happens.

In these creative cultures, they rarely did. Athens had its direct democracy, where every free man had a voice and a vote in the assembly. The Italian city-states and Dutch Republic were governed by the wealthy, but power was dispersed, and there were mechanisms to check arbitrary rule. Some form of division of power has always been essential to protect liberty and innovation, as the US founders learned by studying the ancients.

The rulers of the Roman Empire, the Abbasid Caliphate, and Song China held power over life and death. Yet even they were constrained by legal systems and individual rights they were expected to respect—though reminding the emperor of that could be risky, and best done only when he was in a particularly good mood.

Rewarding climate

Innovation is difficult, and success is never guaranteed. Progress, therefore, depends on a hopeful cultural climate: a belief that trying something new might be worth it, that it might work, and that you might be richly rewarded if it does—as was true during the Renaissance, the Industrial Revolution, and today.

In addition to patrons and patents, you need role models: people who show that the impossible can be done, to inspire, teach, and challenge. That's why creativity tends to cluster, from philosophers in Athens and artists in Renaissance Italy to tech pioneers in Silicon Valley.

In Renaissance Florence, Michelangelo mocked Leonardo da Vinci for being a procrastinator who never finished most of his works. Leonardo, meanwhile, thought Michelangelo's overly muscular figures looked more like sacks of walnuts than real humans. They both had a point—and rivalry pushed them to create even more impressive works.

Pessimism—the sense that everything is hopeless and that effort is futile—is self-fulfilling. And that is the key to understanding why golden ages eventually lose their luster and decline.

Signs of sickness

Over time, the vested interests Mokyr called out often regain their footing and strike back. Political, economic, and intellectual elites build their power

on certain ideas, classes, and modes of production. When these change too quickly, the powerful have an interest in stepping on the brakes.

As civilizations decline, elites who once benefited from innovation try to pull the ladder up behind them. Roman emperors seized power from locally governed provinces, and the elected leaders of Renaissance republics eventually made their positions hereditary.

Divided societies were less able to resist aggressive neighbors who tried to kill the goose that laid the golden eggs.

Outsiders can kill and destroy people and buildings, but they cannot kill curiosity and creativity. We can do that only to ourselves. When we feel threatened, we long for stability and predictability, shutting out what seems strange or uncertain.

Every great civilization experienced its own death of Socrates moment. Often in the wake of pandemics, natural disasters, or military conflicts, societies turned away from intellectual exchange, cracking down on eccentric thinkers and minorities. People began to rally behind strongmen who imposed controls on their economies and abandoned international openness.

In the crisis-ridden late Roman Empire, pagans began persecuting Christians, and soon after, Christians persecuted pagans. As the Abbasid Caliphate fragmented, its rulers forged a repressive alliance between state and religion. The Renaissance ended when embattled Protestants and Counter-Reformation Catholics each built their own church-state alliances to suppress dissenters and scientists. Scholars became cautious, literature introspective, and art backward-looking.

Not even the tolerant Dutch Republic escaped. In 1672, when the country was attacked by France and England simultaneously, a desperate population handed power to an authoritarian stadtholder and lynched the former leader who had contributed most to their golden age, Johan de Witt. Calvinist hard-liners took control and purged Enlightenment thinkers from their once-vibrant universities.

Closure and collapse

Hard times create strongmen—and strongmen create harder times.

As freedom of expression gave way to orthodoxy, free markets were replaced by economic controls. When states struggled to raise revenue, they undermined property rights and market exchange to seize what they could.

Roman, Abbasid, and Chinese rulers all tried to solve social problems by refeudalizing their economies. Peasants were tied to the land, and commercial relationships were replaced by commands.

"When new influences and combinations improved living standards and spread more widely, they sometimes generated a culture of constant, self-renewing creativity—a culture of optimism."

Spending more than they collected was a common sign of states' decline. They borrowed excessively and debased their coins, triggering inflation and financial chaos.

Often they abandoned the international trade that had brought them wealth and sparked creativity. Sometimes commerce collapsed because wars made roads and sea-lanes unsafe, as in Rome and during the late Renaissance. In a reaction against the openness of Song China, the subsequent Ming dynasty banned foreign trade altogether, and the militarization of the Roman and Abbasid economies extinguished commerce.

Such reactions reduced their ability to adapt locally to changing circumstances. Severed trade routes eroded economic and technological capacity, and new orthodoxies choked off the flow of ideas and solutions that might have helped them manage the crisis. They lost that spirit of curiosity that had once made them great.

Studying history can make us feel hopeful, but it is also humbling. Remarkable progress can appear unexpectedly in places with the right institutions, but it takes hard work to sustain them long term.

The ancient Greek historian Thucydides identified two opposite mindsets: that of Athenians, eager to venture out into the world to acquire something new, and that of Spartans, shutting out the world to preserve what they already had. Only the first mentality is consistent with constant learning, innovation, and growth. Every civilization, and probably every human being, is a little bit Athenian and a little bit Spartan—but it's up to us to choose which one prevails. F&D

JOHAN NORBERG *is a historian of ideas. This article draws on his most recent book,* Peak Human: What We Can Learn from the Rise and Fall of Golden Ages.

PORTER GIFFORD

People in Economics

The AI Economist

Bob Simison profiles MIT behavioral economist **Sendhil Mullainathan**, who is leading his discipline into the age of algorithms

AI IS JUST TOO IMPORTANT to leave to computer scientists. So says MIT behavioral economist Sendhil Mullainathan, who has been applying artificial intelligence to economic research for more than a decade. Algorithms, he says, have the potential to dramatically improve human decision-making on things that matter, from conducting a job search to setting bail in court to understanding the signals in a cardiac test.

"Economics is uniquely suited to this moment," he said in an interview. "It's just not possible to build an algorithm without confronting the need to take the mushy, qualitative weirdness of life and put it up against the rigid formalism that is needed."

The 52-year-old India-born Mullainathan is "bridging economics from what we did in the last century to what we will be doing in the next century," said economist David Laibson, one of Mullainathan's professors in the 1990s at Harvard.

Mullainathan has led research into the psychology of memory, decision-making by judges, and the economics of scarcity. Jurists in New York City use algorithms based on his findings in setting bail. In 2002, at the age of 29, he won a $500,000 grant from the MacArthur Foundation, on whose board he served for 12 years until last June.

"His work is as much cited as anyone's" at a comparable career point, said Harvard economist Lawrence Katz, president of the American Economic Association. "I can't think of a more intellectually stimulating thing than a short conversation with Sendhil about whatever is on his mind."

Which could be almost anything. Friends and colleagues cite his extensive research into ice cream and espresso. He once led colleagues on a two-hour tour of Chicago's top ice cream sandwich shops. Mullainathan has also conducted his own research into nutrition and exercise.

"Sendhil dives so deeply into everything," said Bec Weeks, an Australian behavioral scientist at the University of Chicago who's been his research colleague and more recently life partner. "He always has a million good ideas. Understanding the ways that humans behave is the central puzzle his mind revolves around."

Mullainathan's research spans math, computer science, economics, and human behavior. He tells F&D how he's turned to algorithms in search of answers to philosophical questions.

Coming to America

That grows out of his life experiences. Mullainathan's path to the top of his profession began in a village with little electricity in the Indian state of Tamil Nadu, south of Chennai. His family owned land, making it one of the wealthier families in a poor town. His father, Mark, managed to get through college and work his way into a doctoral program in aeronautical engineering at Caltech. He left when Sendhil was 3. There were no phones in the village, so Sendhil's dad would send audiotapes with updates on what he was doing.

Four years later, the elder Mullainathan obtained visas to bring Sendhil and his mother, Sheila, to Los Angeles. That was the end of Mark's doctoral studies, as he went to work to support the family as an aerospace engineer at companies in Southern California, including McDonnell Douglas and Boeing.

When Sendhil was 10, President Ronald Reagan issued an order requiring a security clearance for such work, throwing Mark out of a job because he wasn't yet a US citizen. Although Mark and Sheila built a career as serial entrepreneurs owning and running video stores and selling computers, it was traumatic for young Sendhil.

"I learned that the world has no bottom, and I remember that distinct moment," Mullainathan said. "I became obsessed with the unemployment thing." In a way it led to his career in academia. "I remember hearing in high school that academics had this thing called tenure," he said. "You can't lose your job. I was, like, That's the job I want."

"I didn't do very well in high school," Mullainathan said, because "my mind's not very good with things like nouns and memorization." Math, on the other hand, was "all connected; it's reasoning."

After taking the PSAT college readiness test, Mullainathan got a flyer from the Clarkson School in Potsdam, New York, one of the oldest US early-college programs. He could finish high school there while taking advanced university courses in mathematics. He applied, got in, and informed his parents of his plan. While they were surprised, they agreed "because one thing they always did was to prioritize any education expenditure," he said. So, as a 16-year-old, off he went 3,000 miles away to a place where the temperatures often fall well below zero.

Later, moving on to Cornell, Mullainathan continued to focus on mathematics but added majors in computer science and economics. "What made economics different from math and fantastic was that it was an attempt to try and understand the complexities of the world," he said. He was fascinated with trying to explain economic anomalies, such as why Los Angeles developers would sell houses by lottery rather than simply raising prices.

Behavioral economics

For graduate school, Mullainathan got into the computer science doctoral program at MIT but deferred starting for a year. He wanted to give Harvard's PhD program in economics a try. He stuck with it over the next five years and completed his doctorate in 1998.

In a field where the benchmark for a publication's influence is 1,000 citations by other scholars, Mullainathan's Google Scholar profile lists more than a dozen works with several times that many. His body of work has been cited almost 100,000 times, or nearly as often as Nobel laureate Esther Duflo's. Mullainathan has held academic appointments at Harvard, the University of Chicago, and MIT.

Behavioral economics may seem an anomalous focus for someone obsessed with math and computer science. But during his doctoral studies, Mullainathan said, he came to the conclusion that as an economist he had to develop an understanding of human psychology.

"How as economists are we supposed to take all the oddities, the quirks, the foibles, the richness, and the inscrutability of human beings and ultimately put that into our understanding of economics?" he asked. "We have to recognize that human beings are just incredibly complicated in ways that are unfathomable."

Mullainathan has devoted his career to delving into the complexities of human behavior, sometimes with unexpected results. It was long accepted that corporations designed pay packages to reward CEOs for increasing the value of a business. But in 2001 Mullainathan and his frequent collaborator Marianne Bertrand, of the University of Chicago, showed that "CEO pay responds significantly to luck," such as moves in oil prices.

Bertrand and Mullainathan later sent fictitious resumes in response to help wanted ads in Chicago and Boston, randomly assigning names they thought sounded White or Black. They found that those with White-sounding names got 50 percent more callbacks, they report in a 2004 paper, "Are Emily and Greg More Employable than Lakisha and Jamal?"

Mullainathan and Princeton psychologist Eldar Shafir spent almost a decade conducting experiments on the psychology and economics of scarcity, whether of time, money, food, or other resources. It resulted in their influential 2013 book *Scarcity: The New Science of Having Less and How It Defines Our Lives*.

To this day, the authors give talks on the book, Shafir said. The researchers found that scarcity dramatically affects the functioning of the brain, causing people to obsess about whatever is in short supply. This soaks up cognitive bandwidth so that the mind doesn't operate at full capacity, and people get trapped in a scarcity cycle, the authors found.

The completion of the book 13 years ago cleared the decks for Mullainathan to choose his next research focus.

Focus on AI

"I woke up on a Tuesday morning with nothing to do," he said. His response was to seek out a research direction that was well off the beaten path.

"I try and pick things that are very, very far from where people are," he said. "I have a principle that if you're close to where people are, it's just not that efficient, because there are a lot of smart people in this profession."

That approach makes Mullainathan unique, said Stanford economist Jann Spiess, a research collaborator and former student. "Every few years, he takes a step back and reevaluates what he is doing," Spiess said. It's part, he said, of what makes Mullainathan "one

of the smartest, most innovative people in economics."

In 2012, there was little excitement about AI outside of computer science, Mullainathan said. "It was on no one's list," he said. "I wanted to work on something that could meaningfully bend the curve."

Mullainathan began applying machine learning—a type of AI that deploys algorithms designed to learn from data—to study human decision-making. In 2017, he and four colleagues published a paper examining whether machine learning could improve bail-or-jail decisions by judges. They used an algorithm to analyze the risk that defendants would flee or commit another crime, applying it to a database of more than 700,000 people arrested between 2008 and 2013 in New York City.

They found that judges routinely made the wrong call, often releasing defendants on bail that the algorithm put in the high-risk category. "Judges are subject to the gambler's fallacy," said the University of Chicago's Jens Ludwig, one of the researchers. That is, like a gambler at roulette who predicts after four reds that the next result will be black, jurists who see four high-risk defendants in a row tend to release the fifth one on bail, regardless of the objective risk profile.

The researchers estimated that using a risk-assessing algorithm could help reduce crime by 25 percent, with no change in the number of people held in jail, or reduce jail populations by 42 percent with no increase in crime. The researchers built an AI tool that New York City judges use today to aid in their decision-making, Ludwig said.

"This is a behavioral economics revolution," Ludwig said. "Sendhil has the potential to transform our understanding of human decision-making and create tools for improving it. He is that kind of visionary."

In a 2024 paper, Ludwig and Mullainathan use AI to show that defendant mugshots can reliably predict judges' jail-or-bail rulings. Based on data from North Carolina, the researchers found that people who appear well groomed in their booking photos or who have wider or rounder faces are more likely to be released on bail than to be held until their trial.

"Mullainathan has devoted his career to delving into the complexities of human behavior, sometimes with unexpected results."

While the finding may seem intuitive, it was "a connection that no one noticed," including public defenders and judges themselves, Mullainathan said.

Algorithms sometimes spot "implausible connections" that people don't, Mullainathan said. "It's a scale at which the human mind can't operate, and a tediousness that the human mind can't manage," he said.

He cited an experiment using AI to compare electrocardiograms of people who died of sudden cardiac arrest with ECGs that looked similar to those of people who didn't. The algorithm detected minuscule differences in the tests that doctors missed. This could help identify people more likely to die of sudden cardiac arrest who might be candidates for a pacemaker, Mullainathan said.

Bicycles for the mind

After six years at the University of Chicago, Mullainathan returned to MIT in 2024 as a professor in the departments of economics and electrical engineering and computer science. He is leading an initiative called "The Bike Shop @ MIT," using algorithms to build "bicycles for the mind."

The image comes from a graphic published in the March 1973 issue of *Scientific American* comparing the efficiency of animals in motion. "Man on a bicycle" was by far the most efficient. The finding, Mullainathan writes, offered "a vision of what computers *should be*: bicycles for the mind."

Mullainathan and colleagues are conducting an experiment involving math students in India. "Teaching is a big leap of mind reading," said MIT's Ashesh Rambachan, a collaborator on the project. "Teachers don't understand what students don't understand. An algorithm might help them with that."

Rambachan, Mullainathan, and research collaborators in India are compiling thousands of examples of students' work on mathematics homework. They plan to use AI to identify where students go wrong so that they can create an algorithm mapping the "cartography of confusion." The goal is to help teachers help students find their way, Mullainathan said. It could, he said, "change how we think about the student mind."

"Economics," Mullainathan said, "needs to confront the patchwork nature of our models of the economy and of why people behave and make the decisions they do. Algorithms are the new factory floor of science. They have the capacity to help us stitch the models together. I think they will help us transform philosophical questions into definitive science in the next 20 years." F&D

BOB SIMISON *is a freelance writer who previously worked at the* Wall Street Journal, *the* Detroit News, *and Bloomberg News.*

Café Economics

The Dollar Game

Chess grandmaster-turned-economist **Kenneth Rogoff** talks about the moves that made the dollar king and those that could topple it

Dominance in the game of chess is about exerting control over critical squares that cover vital movement routes, not unlike the attributes of a dominant reserve currency. As a teenager, Kenneth Rogoff got his first look at the non-dollar-dominated world in 1969, when he dropped out of high school in Rochester, New York, to play world chess champions in what was then Yugoslavia. Rogoff went on to study at Yale University and was surprised to hear his professors anticipating the rise of the ruble, given the squalor he had witnessed in the Soviet-controlled Eastern Bloc.

Rogoff received a PhD in economics from the Massachusetts Institute of Technology and has published groundbreaking research on a range of topics, including central bank independence and exchange rates. He also served as IMF chief economist in 2001–03. He is currently the Maurits C. Boas Chair of International Economics at Harvard University. His latest book, *Our Dollar, Your Problem*, examines the rise of the US dollar and what might cause it to fall. He discussed its conclusions with F&D's Bruce Edwards.

Rising debt and high long-term interest rates are among the greatest dangers to dollar dominance, Rogoff tells F&D.

F&D: How did the US dollar become so dominant as a reserve currency?

KR: The short answer is two world wars. World War I crippled Britain's economy, but sterling remained, if not the dominant currency, then codominant with the dollar. After World War II, Britain was broke, and the US, with perhaps 40 percent of global GDP, became the only game in town. There was an agreement toward the end of the war—somewhat contentious with the British—that everyone had to peg their currencies to the dollar. The US could do whatever it wanted, but with one big caveat: We had to trade dollars for gold whenever official creditors asked, which constrained our behavior. The book's title originates from 1971, when President Richard Nixon shocked the world by saying, "You know what we said about trading your dollars for gold? Not anymore. We're not going to do it."

F&D: What's different now in terms of the US using the dollar's strength to bolster its position in the global economy?

KR: Let's start with 1971, when the US went off gold. At a meeting in Rome, the Europeans and other countries on the dollar standard asked US Treasury Secretary John B. Connally, "What are we supposed to do with all these Treasury bills?" And Connally replied, "Well, it's our dollar. That's your problem." I never liked that arrogance, but after dropping the gold standard, the US didn't have a plan to control inflation. It was our problem, too.

Fast-forward to today, when we're undermining the Federal Reserve's independence and have deficit and debt

Illustration by Sonia Pulido

problems that threaten financial stability. Yes, it's a problem for everyone, but also for the US.

F&D: Are there pressures on central banks to become less independent?

KR: Those pressures have existed for a long time. When I first visited the IMF in 1982, I wrote the first paper on why you should have an independent central bank and how it could be a way of dealing with inflation. Others later contributed, too. I believe central bank independence has been the most impactful policy innovation of the past 70 years. People can disagree, but it's been so successful that people have forgotten why they need it.

Even before President Trump, there were populist pressures, especially from the left, in advanced economies to have the central bank help with the environment, with inequality, and so on. The pandemic was a wake-up call—maybe we shouldn't have this mission creep. But there's still a lot of pressure, particularly in the US, where the Fed is in a somewhat unique situation. But central bank independence is under assault everywhere. It's worried me before, but never more than now.

F&D: Have other currencies threatened dollar dominance in recent history?

KR: The yen was once a big deal. There was a period when Japan's economy seemed to be overtaking the US. Some of my distinguished older colleagues at Harvard wrote books about how we all should imitate Japan. Back then, Japan had half the population of the US, but its stock market and real estate were worth more. They seemed to be crushing us in everything. But we came down hard on them, and they yielded in too many areas, ending up in a disastrous financial crisis. But things could have gone differently.

China's decision to basically peg the renminbi to the dollar worked for a long time. But there was a period, starting in the early 2000s, when I was chief economist at the IMF, when we said, You shouldn't do this anymore. You're a big country and should have your own monetary policy. If you peg your exchange rate, it tends to make the price of nontraded goods like houses go up too fast. You're going to get inflation.

I don't think I understood all the dimensions of the problem China was facing at the time, but had they not stuck to this fixed exchange rate—which distorted their development and after a while did not work for them—the dollar's footprint would be much smaller. Today, Asia is half the dollar bloc. It might have been more like a quarter or a third if China hadn't been circling around the dollar for so long.

There are competitors to the dollar at the margin—the euro, crypto, the renminbi—all of which are chipping away at dollar dominance. But the bigger problem is that maybe investors won't see the dollar as desirable as they used to, and to absorb the burgeoning supply, they will demand a higher interest rate. The dollar could keep its number one position but lose market share.

F&D: In the book you say debt is the biggest danger to the dollar's strength and reject the popular notion that US debt is safe. Why?

KR: So there's an idea everywhere, but particularly in the US, that debt is a free lunch: that interest rates are always going to be really low, so we shouldn't worry. Well, interest rates have risen. And I believe that long-term interest rates are going to stay high for a very long time, at least on average. Structural factors are making them high, not just in the US, but in the UK, France, Japan, everywhere.

Everybody knows it's brutal if your 2 percent mortgage suddenly jumps to 7 percent. US bond yields haven't jumped that much, but our interest payments have nearly tripled relative to GDP in a short period. They're bigger than defense expenditure. The US has to adjust to this big change and, at the moment, there's very little political will to do so. I don't blame any particular leader. We'd still have a giant deficit if we had a completely different president. It may be very hard to persuade Congress and the American people to rein things in until the economy reaches a cliff edge.

When the interest rate was zero, a lot of economists—including some very smart ones—thought advanced economies in general no longer needed to worry about debt. This bled over into the IMF's work. I gave talks all over the world warning that if interest rates don't stay low, debt service would soar. But I was told, No, they're not going up.

The dominant theme was Larry Summers' secular stagnation theory. Paul Krugman, too, seemed to argue that real interest rates would be zero forever. Olivier Blanchard, a great economist, came up with a similar argument. What if they're wrong? What if there's a war? What if we need a sudden military buildup? Maybe long-term interest rates will collapse again. But if it doesn't happen pretty darn soon—and if AI doesn't deliver politically sustainable growth, not just higher profits at the expense of labor—there could be trouble. F&D

"Central bank independence is under assault everywhere. It's worried me before, but never more than now."

This interview has been edited for length and clarity. Visit www.imf.org/podcasts to hear the full interview.

Book Reviews

A New Progressive Paradigm

Christoph Rosenberg

"Throughout the book, Rodrik emphasizes experimentation over grand design."

THE PILLARS OF GLOBAL ECONOMIC THINKING are wobbling. Voters around the world are no longer buying into the well-worn paradigms of the past 80 years, whether the free market Washington Consensus, the government-led Keynesian welfare state, or the rules-based liberal international order.

Dani Rodrik's *Shared Prosperity in a Fractured World* seeks to fill this void. Over eight well-argued chapters, the Harvard economist outlines a new approach to tackling what he identifies as the triple challenge of our day: restoring the middle class, addressing climate change, and reducing global poverty. Such ambition should be saluted, even if the book arguably falls short of developing a new narrative that will capture the imagination of anxious populations around the world.

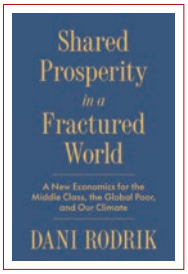
Rodrik's criticism of economic policies, especially those of the hyperglobalization period that followed the Cold War, is scathing and often to the point. Some global norms may have indeed taken too little account of developing economies' needs, and unfettered financial flows may have done more harm than good. The guardians of the global economic order, including the IMF, have long recognized this problem and have adapted support programs to country circumstances (including social safety nets) or modified guidance on monetary and exchange rate policy (including capital controls). At the same time, certain economic truths will hold irrespective of national conditions—something the book could have emphasized equally. Persistent fiscal deficits or overvalued currencies, for example, will create problems down the road, no matter where or when.

When analyzing global cooperation—or the lack thereof—Rodrik focuses on the relationship between the United States and China, arguing that self-interested policies are not as detrimental as they may seem, and that the past focus on multilateral governance was misplaced. But what applies to these large and divergent economies may not be true for the rest of the world. Many countries in Europe and Asia have not given up on the old order and are seeking to preserve it on a regional level, for example through plurilateral trade agreements.

Rodrik is most convincing when he identifies a misguided fixation on manufacturing jobs as a costly mistake, in advanced and developing economies alike. The future, he argues convincingly, lies in enabling workers to take up well-paying jobs in services. To get there, Rodrik advocates a host of micro-level state interventions already proven to work, as illustrated by compelling examples from a public-private partnership in western Michigan to vegetable sellers in Colombia's Bogotá. Throughout the book, he emphasizes experimentation over grand design and local over national—let alone global—solutions.

Can such nitty-gritty long-term policies really address the malaise that has gripped so many people around the world and constitute a "new progressive agenda," as he claims? For starters, the book is largely silent on some key sources of anxieties today, such as migration flows, rising debt, and the rapid advance of artificial intelligence. Moreover, by framing his approach as an agenda for the Left's return to power (notably in the United States), Rodrik unnecessarily risks politicizing his many sensible insights and solutions.

Developing a new economic consensus will take time. Yet it is a necessary endeavor: Policymaking that is entirely ad hoc and principle-free can hardly lead to a better world. Rodrik's thought-provoking book makes a valuable contribution to a long-overdue debate. **F&D**



SHARED PROSPERITY IN A FRACTURED WORLD
A New Economics for the Middle Class, the Global Poor, and Our Climate

Dani Rodrik

Princeton University Press

Princeton, NJ, 2025, 280 pp., $27.95

CHRISTOPH ROSENBERG *is a former deputy director of the IMF's Communications Department.*

The Economists Who Shaped Development

Kalpana Kochhar

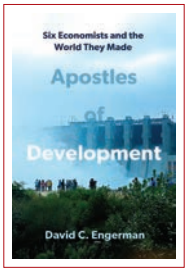
DAVID ENGERMAN'S LATEST BOOK is a thrill to read for any practitioner of development economics, but especially those who have studied or worked in South Asia. The Yale University professor of international history sheds light on the lives of economists who were the intellectual beacons of international development's formative years. It's a masterful intellectual and policy history, told through the lives and accomplishments of six South Asian economists: Amartya Sen, Jagdish Bhagwati, Manmohan Singh, Mahbub Ul Haq, Rehman Sobhan, and Lal Jayawardene.

Apostles of Development is much more than a historical treatise; it appears at a time of great tension in the global development system over who sets priorities, how ideas travel, and what "development" should mean in an era of inequality, debt, and climate crisis.

The "Apostles" pushed—often from within—to democratize the IMF and World Bank and to channel new resources to poorer countries. That push continues today in the debates over developing economies' voice and voting rights at the Bretton Woods institutions, and over special drawing rights (SDRs), international reserve assets created by the IMF to supplement the official reserves of its member countries. The book reminds us that developing economies' aspirations for a greater voice are not new but a continuation of an older struggle, led by figures such as Sen, Haq, and Singh.

Haq pushed for the World Bank to shift from a singular focus on GDP to a broader concept of human development, including poverty alleviation and human welfare. The Human Development Index (HDI), born of Haq's and Sen's collaboration, remains central to how the development community measures progress. The book reminds us that debates over the quality of growth—not just the quantity of finance—have deep historical roots. Measures like the HDI could inspire new metrics for climate equity or social inclusion today.

Engerman traces how Sen, Haq, and Sobhan shifted focus from national to global inequality—linking redistributive justice with reform of international finance. This echoes in current conversations about global inequality traps, debt justice, and the need for redistribution through SDRs or loss-and-damage funds.



APOSTLES OF DEVELOPMENT
Six Economists and the World They Made

David C. Engerman

Oxford University Press

Oxford, UK, 2025, 576 pp., $39.95

Sobhan's institution building in Bangladesh illustrates how Southern think tanks can improve the quality of domestic policymaking. His Centre for Policy Dialogue launched the Independent Review of Bangladesh's Development in 1995 as a domestic counterweight to analysis produced by international financial institutions. The Delhi School of Economics, India's leading postgraduate institution for the social sciences, where Sen and Singh served as faculty, strengthened Southern scholarship and trained cadres that later ran ministries and held senior positions at the IMF, World Bank, and other international institutions. This directly parallels today's calls for "mission-oriented finance," as advocated by economists such as Mariana Mazzucato, and human-centered investment frameworks in climate finance and social policy.

Finally, and perhaps most important, Engerman's portraits of these economists show how they humanized and democratized development thinking—but also became part of a technocratic elite. This raises an important question: Who defines global development expertise today? Washington Consensus economists, or more dispersed local communities? F&D

"Portraits of these economists show how they humanized and democratized development thinking."

KALPANA KOCHHAR *is director of development policy and finance at the Gates Foundation.*

The Discretion Dilemma

Fabio Natalucci

"Bank supervision emerged not from deliberate design but incremental adaptation."

BANKING OVERSIGHT IN THE UNITED STATES developed through a process of institutionalized discretion and layering. Rather than rigid rules or improvised interventions, each crisis, reform, and political compromise added new layers of authority and responsibility. The result? A system in which public power negotiates continuously with private finance—a dynamic that ultimately defines financial governance.

So say Peter Conti-Brown and Sean H. Vanatta in *Private Finance, Public Power*, a fascinating historical account of how bank supervision has evolved over the past two centuries. This historical lens is valuable for policymakers grappling with today's complex and fast-evolving financial ecosystem.

The authors trace how the architecture of US supervision—from the Office of the Comptroller of the Currency to the Federal Reserve, Federal Deposit Insurance Corporation, and state regulators—emerged not from deliberate design but incremental adaptation. Although often messy, this begot institutions capable of exercising discretion while remaining accountable to democratic authority. Institutionalized discretion—supervisory judgment embedded in an institutional structure—gives oversight its resilience and flexibility.

This adaptability has proved its strength, say Conti-Brown, an associate professor of financial regulation at the University of Pennsylvania's Wharton School, and Vanatta, a lecturer in financial history at the University of Glasgow. Institutionalized discretion enabled supervisors to respond to emerging risks, tailor interventions to institution-specific conditions, and interpret evolving norms and practices. It enhanced legitimacy of policy: Discretion is not arbitrary, but grounded in transparency and politically supported institutions. It can support both financial stability and market dynamism.

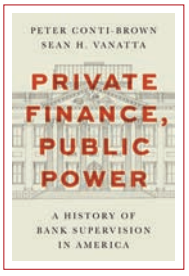
Yet there are limits to this model—limits that have become apparent in the contemporary financial landscape, where market structure, technology, and financial innovation evolve rapidly. A growing share of financial intermediation has shifted in recent decades beyond the regulated banking system to nonbank financial institutions (NBFIs)—asset managers, pension funds, insurance companies, private equity and credit funds, fintech lenders, and others. Banks, however, continue to provide liquidity, credit, and other crucial fee-based financial services to NBFIs. The fragmentation of regulatory and supervisory agencies compounds the challenge.

Risk taking has also been shaped (directly and indirectly) by the Federal Reserve's expanded crisis-management role, which has drawn the central bank deeper into financial markets over the past two decades, from backstopping markets during the 2008 global financial crisis to emergency interventions during COVID-19 and the 2023 regional banking stress.

Fundamental changes in market structure and rapid technological innovation point to emerging vulnerabilities: Fast-moving global financial flows, the rise of digital finance, and data gaps in the NBFI world make it difficult to monitor the migration of risks beyond the traditional supervisory and regulatory perimeter. Without better data, discretion could become guesswork. The rapid growth of private credit illustrates the tension between innovation, evolution of market structure, and the current approach to supervision.

This raises a question policymakers can't ignore: Is institutionalized discretion enough? In today's era of bank disintermediation, digital finance, and global capital mobility, maintaining the delicate balance between public power and private finance may require rethinking the supervisory and regulatory perimeter, expanding the supervisory tool kit, and clarifying policy objectives.

The book's historical insights remind readers that effective oversight depends not only on the wisdom of discretion but also on the strength of the institutions that wield it. **F&D**



PRIVATE FINANCE, PUBLIC POWER
A History of Bank Supervision in America

Peter Conti-Brown and Sean H. Vanatta

Princeton University Press

Princeton, NJ, 2025, 424 pp., $39.95

FABIO NATALUCCI *is managing director and chief executive of the Andersen Institute for Finance and Economics.*

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Symbols and Progress

Jeff Kearns

Papua New Guinea's new banknotes honor 50 years of independence

New banknotes reflect the country's culture and natural beauty.

AS PAPUA NEW GUINEA faced the challenge of introducing a new currency while gaining independence from Australia in 1975, it chose a name with specific cultural and historical meaning: the kina, a shell used as a traditional kind of money into the 20th century. Each kina was divided into 100 toea, named for a smaller shell.

Among more than 800 languages spoken by its people—the most of any country—"kina" is used in two: Tok Pisin, one of three official languages, and Kuanua. Kina are gold-rimmed pearl oyster shells once used widely for trading, as a traditional store of wealth, and for adornment. Toea are shells once used for trading and are valued because they're found deep in the ocean and only at certain times of the year, according to the central bank's official history.

The nation of 10 million in the southwestern Pacific marked its first half century of independence in September with commemorative 50 kina banknotes. They feature the founding prime minister, Michael Somare, and the national emblem, the Raggiana bird-of-paradise, which is native to the island's tropical forests and known for elaborate courtship displays and colorful male plumage. The note shows other examples of the country's biodiversity: a Queen Alexandra's birdwing—the world's largest butterfly, with wings spanning 25–28 centimeters—and a blue orchid, another national symbol. A new 50 toea coin, showing the country's flag, also marked the anniversary.

"The kina and the toea remain symbols of independence," Bank of Papua New Guinea Governor Elizabeth Genia said in an August speech announcing the new designs. "The unfinished business of independence is to ensure every kina and every toea earned brings real benefits for our people. Our sovereignty is measured not only by symbols, but by the progress we make as a nation."

Next year, Papua New Guinea will introduce a new 100 kina note to honor Julius Chan, who shaped early economic policies as the first finance minister and second prime minister. Born on Tanga Island, New Ireland Province, to a Chinese father and Indigenous mother just before World War II, he overcame discrimination to become one of the country's longest-serving politicians, representing his home province in Parliament until he died in January at age 85.

Chan, knighted by Queen Elizabeth II in 1980 for his service to the former British colony, was known by many Papua New Guineans simply as "Sir J." The new banknotes bring him full circle, appearing on the currency he helped introduce to a newly independent nation. **F&D**

JEFF KEARNS *is on the staff of* Finance & Development.

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A Raggiana bird-of-paradise, Papua New Guinea's national emblem, perches atop a branch.

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