Bloomberg Businessweek

September 27, 2021 ● ASIA EDITION

China's $300 Billion Real Estate Bomb

SOONER THAN YOU THINK ISSUE

The Evergrande debt crisis is the stress test no one wanted 26


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CAN SMALL STATES CONTRIBUTE TO A RULES-BASED ORDER IN CYBERSPACE?

Digitalisation should result in win-win outcomes where the global community leverages *innovation* and *interdependencies* toward an interoperable cyberspace that ensures we have a stake in one another's success.

For small States like Singapore, it is in our interests to develop a cyberspace that is rules-based, interoperable, and secure. Digital connectivity fuelled by data will allow small States to transcend limitations in natural resources, land, and manpower.

This also means that small States can have an outsized impact in shaping the rules, norms and principles of operating in cyberspace. There are three ways they can contribute: policy, partnerships, and platforms.

Forward-Looking Policy

Cybersecurity starts at home. States need to have the requisite domestic regulatory policies, regimes, and capacities to implement cyber best practices.

For example, Singapore's Cybersecurity Act establishes a legal framework requiring the implementation of mandatory cybersecurity measures and reporting of incidents by Critical Information Infrastructure owners.

Several plans and initiatives strengthen the resilience of our Critical Information Infrastructure and create a safer cyberspace. This includes the Safer Cyberspace Masterplan which articulates Singapore's vison to secure our core digital infrastructure, safeguard digital activities, and empower a cyber-savvy citizenry.

Amid the exponential growth of Internet of Things (IoT) devices, Singapore launched the Cybersecurity Labelling Scheme to enhance the security of such devices and improve transparency for consumers. We welcome international partners and industry to work with us to internationalise the labelling of IoT devices for a more secure global cyberspace.

"Small States can have an outsized impact in shaping the rules, norms and principles of operating in cyberspace."

David Koh,
Chief Executive of the Cyber Security Agency of Singapore (CSA)

Collaborative Partnerships

It is imperative for small States to collaborate to achieve common desired outcomes. This is where regional organisations, like the Association of Southeast Asian Nations (ASEAN), provide crucial platforms to exchange information on emerging and existing threats, implement Confidence-Building Measures, and build capacity.

ASEAN remains, to date, the only regional organisation that has subscribed in principle to the UN's 11 voluntary, non-binding norms of responsible State behaviour in cyberspace. ASEAN is also developing a concrete plan of action to implement these norms. Such an action-oriented approach working through strong and enduring partnerships among States allow us to collectively mitigate risks.

Public-private partnerships are also crucial to enhance global cyber resilience. The Singapore-U.S. Joint Cyber Security Working Group is one such platform for the Cyber Security Agency of Singapore (CSA), the U.S. government and the industry to collectively address dynamic cyber threats.

Inclusive Multi-stakeholder Platforms

A rules-based multilateral system with the UN at its core is our best hope to build a secure, resilient and interoperable cyberspace. This is why Singapore participated actively in the sixth United Nations Group of Governmental Experts (UNGGE) and the inaugural Open-Ended Working Group (OEWG) on international security in cyberspace.

Small and developing countries are increasingly keen to co-create a secure, resilient and interoperable cyberspace. However, States alone do not have all the answers for the dynamic cybersecurity problems we face. The private sector, non-governmental organisations and academia also have views that States should consider.

In recognition of the need to strengthen the multi-stakeholder nature of cyber discussions, Singapore has organised the Singapore International Cyber Week (SICW) annually since 2016 for both State and non-State stakeholders to collaborate on key cyber issues. The 6th SICW will be held this year from 4-8 October and is aptly themed: Living with Covid-19 – Reimagining digital security risks and opportunities.

David Koh is Singapore's first Commissioner of Cybersecurity and Chief Executive of the Cyber Security Agency of Singapore (CSA).

Bloomberg Businessweek

September 27, 2021

◀ Sarah Reinertsen wears a pair of the Nike Go FlyEase sneakers she helped develop

PHOTOGRAPH BY SAGE BROWN FOR BLOOMBERG BUSINESSWEEK

THE SOONER THAN YOU THINK ISSUE

■ COVER TRAIL

How the cover gets made

❶

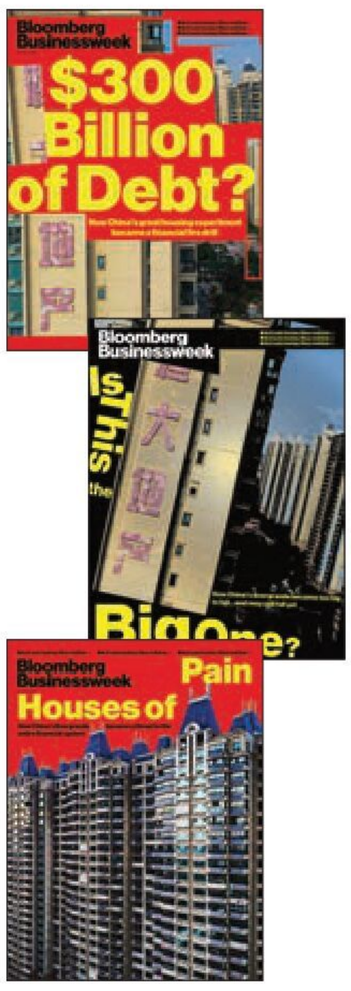
"Looks like this week we'll be covering Evergrande, a Chinese real estate developer that's on the ropes."

"China has a real estate problem?! I'm shocked. Shocked, I tell you."

"It's looking like the company could implode."

"Ominous!"

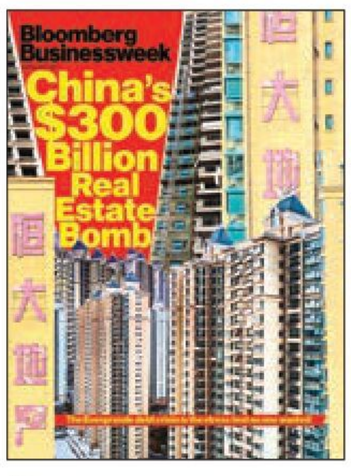
❷



"These are fantastic! It's hard to choose."

"Think of the one that would best represent a Gaspar Noe film about the decline of an important business, and we'll run with that."

"Let's enter that void!"



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IN BRIEF

By Benedikt Kammel

● Worldwide there have been 230 million cases of Covid-19, 4.7 million people have died, and more than

6b

vaccine doses have been given. Pfizer and partner BioNTech said their vaccine was safe for children age 5 to 11 and produced strong antibody responses.

● The U.S. Federal Reserve on Sept. 22 signaled it's ready to begin reducing its bond-buying program and indicated an increased willingness to start raising interest rates in 2022.

● About 14,000 Haitians are living in makeshift dwellings at a camp in Del Rio, Texas. U.S. border authorities have been broadly condemned after agents were spotted on Sept. 19 using horse reins to threaten the immigrants.

● China will stop building coal-fired power plants abroad, Xi Jinping announced at the UN General Assembly on Sept. 21. At the moment, more than 70% of coal plants being built around the globe rely on Chinese funding. The president's pledge is part of a plan to make his country carbon neutral by 2060.

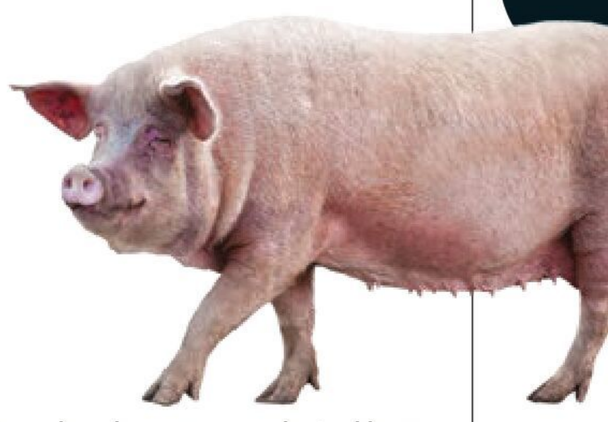
● Rising energy costs in the U.K. are driving some utilities, which are forced to sell to customers at a loss, out of business. About

1.5m

households have been affected and will need to switch to a new energy provider.

● Netflix purchased the works of the late British novelist Roald Dahl for an undisclosed sum. Dahl, who died in 1990, has sold more than 200 million copies of his books worldwide. Many of them, including *Charlie and the Chocolate Factory* and *James and the Giant Peach*, have already made it to Hollywood.

● Pig farms in the U.K. are stuck with 95,000 extra animals because of slaughterhouse staffing shortages.



The pileup has been exacerbated by a supply squeeze of the carbon dioxide used to kill most of the hogs.

● "For every one shot we've administered to date in America, we have now committed to do three shots to the rest of the world."

President Joe Biden, at a global vaccination summit he convened virtually as part of the UN General Assembly on Sept. 22, announced the start of a U.S. partnership with the EU to collaborate more closely to distribute shots worldwide.

● Video game giant Activision Blizzard said it's been subpoenaed by the Securities and Exchange Commission.

The SEC said it was investigating "disclosures regarding employment matters and related issues." In July a California regulator sued Activision for creating a "frat boy" culture that subjected female employees to sexual harassment and unequal pay. The company said it's cooperating with the investigation.

● The koala bear population has shrunk about

30%

in the past three years, according to the Australian Koala Foundation. The gentle creatures have been ravaged by wildfires, as well as deforestation for mining, agriculture, and housing.

HAITIANS: JOHN MOORE/GETTY IMAGES. XI: HUANG JINGWEN/GETTY IMAGES. PIG: GETTY IMAGES

The Last Thing Vulnerable Kids Need Is Their Own Instagram

Social media is a minefield of adolescent anxieties, as any parent can attest. Numerous studies have suggested a connection between excessive use of online platforms (and the devices used to gain access to them) and worrying trends in teenage mental health, including higher rates of depressive symptoms, reduced happiness, and an increase in suicidal thoughts.

Even in this context, Instagram, the photo-sharing app owned by Facebook Inc., stands out. Its star-studded milieu–glossy, hedonistic, relentlessly sexualized–seems finely tuned to destabilize the teenage mind. Studies have linked the service to eating disorders, reduced self-esteem, and more.

So perhaps it isn't surprising that an internal research effort at the company, recently leaked to the press, found that teens associate the service with a host of mental health problems. "Thirty-two percent of teen girls said that when they felt bad about their bodies, Instagram made them feel worse," the research said. "Teens blame Instagram for increases in the rate of anxiety and depression," it said. "This reaction was unprompted and consistent across all groups."

If Facebook was concerned about these findings before they became public, it didn't do much. Instagram rolled out several policy changes in July that it said were meant to protect teens, such as limiting how advertisers can target them and setting their accounts to private by default. "Instagram has been on a journey to really think thoughtfully about the experience that young people have," a company representative said at the time.

Unfortunately, all that thoughtful thinking yielded an incoherent result. In the very same post in which Facebook announced the changes, it conceded that it was moving ahead with a version of Instagram intended for children younger than 13. Dubbed Instagram Youth, the concept was so obviously distasteful that it earned the opprobrium of health experts and consumer advocates, lawmakers of both parties, and almost every state attorney general in the country.

A letter from health experts could hardly have been blunter. "The platform's relentless focus on appearance, self-presentation, and branding presents challenges to adolescents' privacy and wellbeing," it said. "Younger children are even less developmentally equipped to deal with these challenges."

Facebook justifies this plan on the (rather shameless) theory that, because it has largely failed to keep children off of adult Instagram, the kids' version will "reduce the incentive for people under the age of 13 to lie about their age."

One might ascribe all this to Facebook's standard-issue tactlessness. Yet the company's treatment of young people has been especially irresponsible. For years it refused to make changes that would prevent children from running up credit card bills on its platform. In 2016 it started paying young people–including minors–$20 a month to use an app that gave the company total access to their web and phone activity. That these schemes keep going horribly awry doesn't seem to affect Facebook's behavior.

One wonders what would. To start, lawmakers should pressure Facebook to scrap Instagram Youth entirely and make a more earnest effort to protect teenagers across its services. Congress should consider extending existing online protections for children to all users up to age 15, for example, and create a legal expectation that platforms do more to prevent minors from lying about their ages. Down the road, more stringent regulations–perhaps modeled on the U.K.'s age-appropriate design code–may be needed if platform companies refuse to take this problem more seriously.

Social media is hard enough on adults. It's no place for kids. Ⓑ *For more commentary, go to bloomberg.com/opinion*

■ AGENDA

▶ Back in Style

Paris Fashion Week is returning to runways after pausing for a year during the pandemic. Designers will stage physical shows beginning on Sept. 27, but Chinese shoppers, a crucial clientele, will remain absent.

▶ On Sept. 29, Japan's ruling Liberal Democratic Party decides on a new leader, who will then become prime minister. Four candidates are in the race, including two women. ▷ 35

▶ The ECB Forum on Central Banking takes place Sept. 28-29. Usually held in person in Sintra, Portugal, the online panel will include delegates from Japan, the U.K., and the U.S.

▶ Dubai Expo 2020 begins on Oct. 1 and runs through March. The show, which was postponed for a year, features exhibits on climate, space, and urban development.

▶ In the U.K., the Conservatives hold their party conference in Manchester Oct. 3-6. Prime Minister Boris Johnson just sought to reassert his power by reshuffling the cabinet.

▶ Italy will host meetings in Milan from Sept. 30 to lay the groundwork for the COP26 climate conference, set to take place a month later in Glasgow, Scotland.

▶ The U.K. furlough scheme, in which the government contributed to wages to keep people employed, ends on Sept. 30, spelling tough times ahead for families and businesses.

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Social media seriously harms you and others around you

● Is this Facebook's "Big Tobacco" moment?

● By Naomi Nix, David McLaughlin, and Anna Edgerton

Facebook Inc. executives have long boasted that its platforms are safe, even as they invested in ways to keep teenagers hooked and hid what they knew about the side effects. Sound familiar? Critics say Big Tobacco once used the same playbook, and it's fueling a whole new level of outrage against the social media giant.

Facebook consistently played down its own research that showed how photo-sharing app Instagram can harm the mental well-being of its youngest users, according to a report in the *Wall Street Journal*. Almost a third of young teen girls told Facebook they feel worse about their bodies after scrolling through the site, documents reviewed by the newspaper showed. Despite that knowledge, Facebook is dedicating more resources to reaching even younger consumers, including developing a children's version of Instagram.

The revelations are prompting some lawmakers to compare Facebook's actions to a decades-long campaign by the country's biggest tobacco companies to mislead the public about the cancerous and habit-forming effects of cigarettes. "Its executives knew about the addictive chemicals in tobacco and yet they did nothing to try and keep the product out of the hands of children," says Representative Bill Johnson, an Ohio Republican. "They knew that if they could get children addicted early, they'd have a customer for life. It's very much the same way—children, young people, are addicted to these platforms, and you can see report after report on the damage that's being done."

The long-term effects of social media are exactly what's driving concerns about Facebook's plan to build an Instagram for kids. The service, sometimes called Instagram Youth internally, is intended to give preteens an entrance ramp onto social media until they turn 13 and are allowed to join the main site. Facebook argues that kids are lying about their age to get on Instagram anyway, so a youth-oriented product—with parental controls—would be a safer alternative.

More than three dozen state attorneys general have already urged Facebook Chief Executive Officer Mark Zuckerberg to drop the project, arguing that Instagram Youth could contribute to conditions such as depression,

loneliness, and anxiety. So have U.S. lawmakers and a coalition of privacy and child welfare advocates. "If Facebook goes ahead with Instagram Youth, then really what we're saying is they're accountable to no one," says Josh Golin, executive director of Fairplay, a nonprofit dedicated to ending marketing aimed at children.

To understand how children's mental well-being is affected by Instagram, Facebook surveyed tens of thousands of users and mined its own data over the past three years, according to the *Journal*, which based its reporting on internal Facebook research that the publication obtained. The review found that users felt pressured to present an idealized version of themselves on Instagram, and that it often led them to make negative comparisons of themselves with others. Internal researchers warned that Instagram's design led young people toward potentially harmful content on the platform.

During a March 2021 congressional hearing, Zuckerberg wasn't as forthcoming about the evidence around the effects of social media on mental health, boasting that online connections can help people feel less lonely. When asked whether Facebook had internal research on the impact of its platforms on kids, Zuckerberg said it was something they "try to study" before adding, "I believe the answer is yes."

The research on social media and mental health can be ambiguous. Some studies show a link between heavy use and childhood depression, lower self-esteem, and suicidal tendencies. Other academics argue the correlation between social media use and poor mental health outcomes is weak and that other factors could be at work. Experts in both camps agree that Facebook is best positioned to conduct the highest-quality research, because it knows exactly what its users are doing on Instagram and for how long.

On Sept. 14, Karina Newton, Instagram's head of public policy, wrote a blog post highlighting the similarly inconclusive nature of the company's research. "Social media isn't inherently good or bad for people. Many find it helpful one day, and problematic the next," she wrote. Instagram is looking into ways to steer vulnerable users away from certain types of posts and "towards content that inspires and uplifts them," she added. A Facebook representative declined to comment beyond the contents of the blog.

Big Tobacco's strategy was, for decades, to cast doubt on public-health research. A full-page advertisement published nationwide in newspapers in January 1954 established the industry's public messaging for the next 50 years: Smoking wasn't a proven cause of lung cancer, and more research on cigarettes and health was needed. While the tobacco companies questioned and distorted scientific data, their own research recognized the risks. They also understood that nicotine was addictive, even as they publicly denied its effects to avoid regulation and thwart legal liability from smokers. It was a whistleblower—an executive from the Brown & Williamson Tobacco Corp.—who helped expose the industry's secrets.

Facebook's strategy is to make its platforms more addictive, just as cigarette companies did with additives, the company's former director of monetization, Tim Kendall, told Congress last year. Facebook relies not just on likes and updates to keep users hooked, but also on misinformation and conspiracy theories that provoke a strong reaction, he said. "These services are making us sick."

It took decades for the government to hold Big Tobacco to account. In 1998 a coalition of states reached a $246 billion settlement with the industry that required companies to make annual payments to the states and limited the visibility of cigarette advertising. A year later the U.S. Department of Justice sued the tobacco companies, accusing them of a racketeering conspiracy to defraud the public. In 2006, after a nine-month trial, a federal judge in Washington agreed, saying that the companies "marketed and sold their lethal product with zeal, with deception, with a single-minded focus on their financial success, and without regard for the human tragedy or social costs that success exacted." Dozens of states passed laws banning smoking at restaurants, bars, and workplaces.

The percentage of high school students who smoked frequently plummeted to 2.6% in 2017 from 16.7% in 1997, a report from the Centers for Disease Control and Prevention showed. Still, about 34 million adults in the U.S. remain smokers, according to the CDC.

Fixing social media's ills will require a similar shift in public awareness, says Asha Rangappa, who teaches a course on social media and information warfare at Yale University's Jackson Institute for Public Affairs. "The idea that information can actually cause harm is not something that we as Americans can get our head around," she says.

On Capitol Hill, Representative Johnson is working on a bill instructing the National Institutes of Health to study the mental health risks of social media and whether to apply a warning label to the tech platforms. Senators Richard Blumenthal (D.-Conn.) and Marsha Blackburn (R.-Tenn.) said they were in touch with a Facebook whistleblower and "will use every resource at our disposal to investigate what Facebook knew and when they knew it."

In recent days, Facebook executives have defended its actions but have yet to publicly release more internal studies. Nick Clegg, Facebook's vice president of global affairs and communications, pledged the company would continue to invest in research on complex issues and "improve our products and services as a result."

Blumenthal, chair of the Senate Subcommittee on Consumer Protection, Product Safety, and Data Security, plans to hold hearings on Facebook's knowledge of its harmful effects. "We're at a turning point, because the analogy to Big Tobacco is very apt," says Blumenthal. "It's not just that they were doing harm, but they knew it and they concealed it, which is what makes it all the more hideous because people became addicted and the harm was compounded." Ⓑ

PHOTOGRAPH BY SHAWN MICHAEL JONES FOR BLOOMBERG BUSINESSWEEK. SPORTSBOOK: EDUARDO MUNOZ/REUTERS. DATA: VIXIO

Winning a Wager on U.S. Sports Betting

Fantasy football app FanDuel converts players into gamblers

Edited by
James E. Ellis,
Rachel Evans, and
Elizabeth Fournier

Greg Bunnell has played fantasy football since he was a teenager. So when Indiana legalized sports betting two years ago, the 39-year-old project manager seamlessly switched from plotting his next player transfer to setting himself up to bet—all within the FanDuel app. Bunnell, who says he plans to wager as much as $100 a weekend, is one of a record 45 million Americans expected to legally bet on professional football this season, a 36% increase from last year. Thirty states are set to allow such wagering by the Super Bowl's coin toss in February, following a U.S. Supreme Court decision three years ago to strike down a federal ban on sports betting.

FanDuel Group Inc. has emerged as the top business in this new market, nabbing a 42% share of U.S. sports wagers in June, up from 35% only two months earlier, according to estimates from research company Eilers & Krejcik Gaming LLC. It's a meteoric rise for FanDuel, whose nearest competitor, DraftKings Inc., has a 23% share of the market. The two were neck and neck in the business of daily fantasy sports contests before FanDuel was acquired only a week after the court ruling by an Irish bookmaker in Dublin, now known as Flutter Entertainment Plc. For its part, DraftKings is looking to buy Entain Plc, which owns the Ladbrokes betting and gambling brand in Europe and other businesses.

"We've got momentum, and we have a huge amount of revenue," says Peter Jackson, Flutter's chief executive officer. "A lot of other people are almost in startup mode." Flutter, whose name is British slang for a bet, was formed after the merger of Paddy Power and Betfair, two of the U.K.'s largest betting brands. It owns 600 betting shops in Ireland and the U.K. and offers online wagering in many countries. Jackson, 45, had been CEO for just months when he pounced on FanDuel, spotting an opportunity to grab a piece of the nascent American market. The Cambridge-educated engineer bought a majority stake for $158 million in cash plus the contribution of Flutter's U.S. assets, which included the horse betting business TVG.

Founded in 2009 by five friends who knew next to nothing about American football, FanDuel helped pioneer the business of daily fantasy sports, where contestants pick a dream lineup of real players and compete to win a pot of money based on their team's performance in a single day or week, rather than over an entire season.

The company's millions of fantasy sports customers turned into a gold mine after it began offering more traditional sports bets, such as, say, whether the Tampa Bay Buccaneers will beat the Los Angeles Rams on Sunday. About 40% of FanDuel's sports-betting customers come from its daily fantasy business, a database that now includes 13 million names.

Soon after the acquisition and court ruling, Flutter tapped connections in horse racing to open a FanDuel sportsbook at New Jersey's Meadowlands Racetrack in July 2018. That position, in the heavily populated northern part of the state, gave the company a significant advantage, as New Jersey took an early lead fostering the new era of sports wagers.

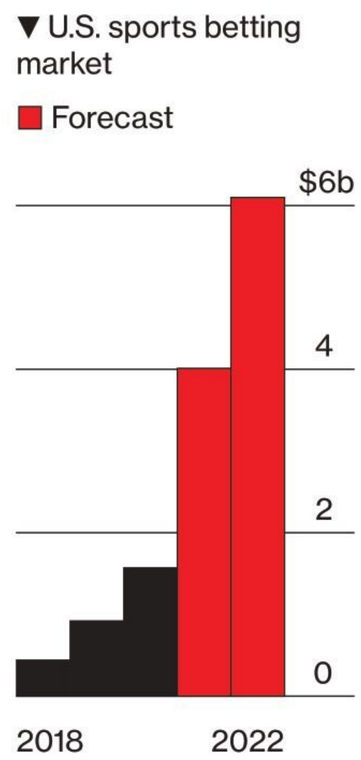
Flutter's experience with online betting overseas also gave it a leg up. FanDuel was able to introduce products such as same-game parlays, which allow customers to bet on multiple teams or events—whether the Patriots will win the game and if rookie quarterback Mac Jones will score the first touchdown, for example. These wagers proved particularly popular in Australia, where Flutter developed the product, and more than half of FanDuel's customers used the product last football season.

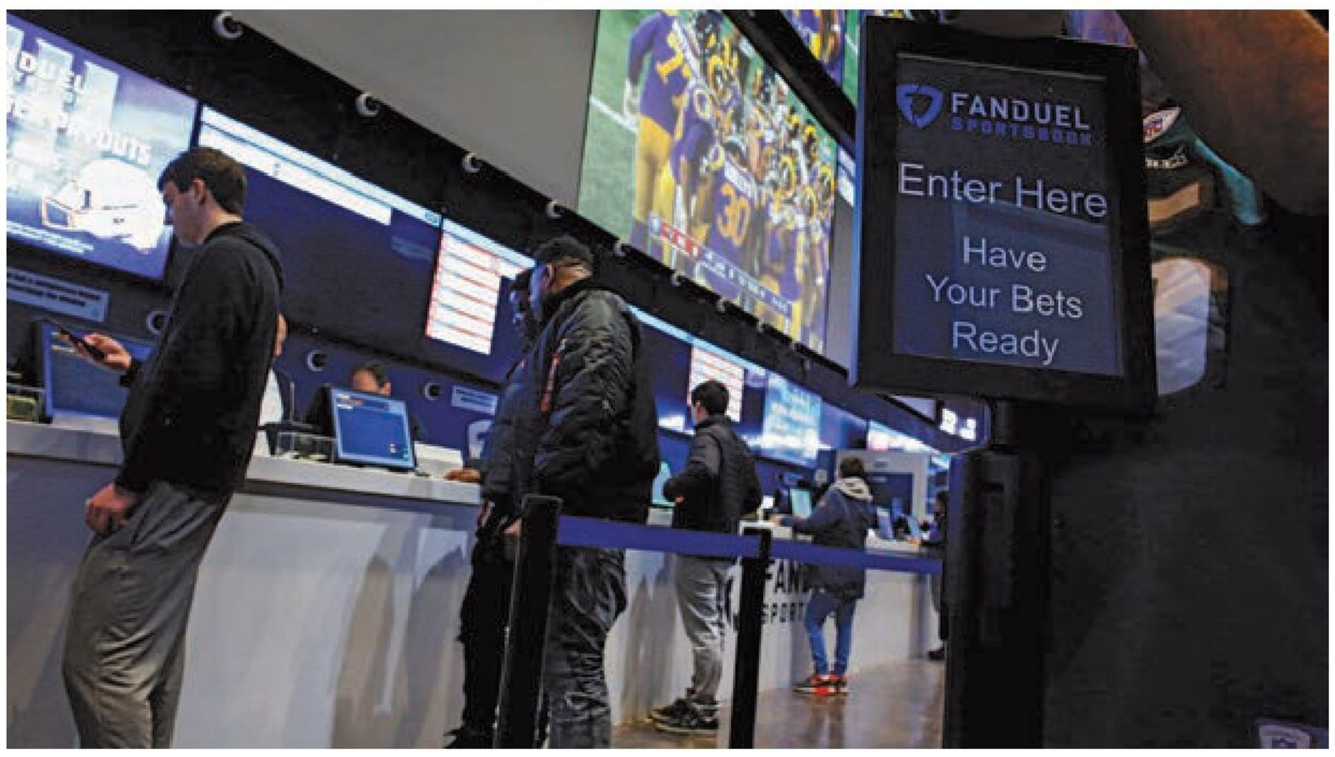
Such bets are harder to win, meaning the company keeps a larger chunk of wagers and can outearn rivals, says James Kilsby, a vice president at research company Vixio GamblingCompliance. "You're betting on two contingencies," he says. "That's really helped to grow its market share." Customers like these bets because the potential payoff is greater, and rivals are now introducing their own expanded selections of parlays after a slower start. FanDuel and other companies attempt to manage their risk by balancing bets on a certain outcome with bets against that outcome.

Flutter's U.S. revenue, mostly from FanDuel, is expected to more than double, to $1.9 billion, this year, according to analysts' estimates compiled by Bloomberg. The higher the revenue, the more the company can spend on marketing to acquire customers, Jackson says. He projects that the U.S. business will be profitable by 2023.

The FanDuel brand will be a frequent sight on TV this football season. The company hired ▶

▼ U.S. sports betting market





▲ Placing bets at the FanDuel sportsbook in New Jersey in 2019 during Super Bowl LIII

◀ Wieden+Kennedy, the ad agency behind Nike Inc.'s "Just Do It" campaign, and has rolled out a series of commercials featuring golfer Jordan Spieth. Flutter spent $300 million marketing the FanDuel brand in the first half of this year, more than in all of 2020.

Still, FanDuel's success has come with some acrimony. The company's founders and some employees have sued FanDuel and several of its early financial backers, claiming they got cheated when those investors sold FanDuel to Flutter. FanDuel says the suit is without merit. Fox Corp. is in arbitration with Flutter about how to fairly value FanDuel, after acquiring an option to buy 18.6% of the business when Flutter bought Fox's betting partner, Stars Group.

In spite of all that, Jackson, who cheers for his hometown Leeds United Football Club, isn't above trash-talking his competitors. "We're operating in a completely different level to anyone else in the U.S.," he says. —*Christopher Palmeri*

THE BOTTOM LINE FanDuel has parlayed its fantasy fan base into a lucrative clientele for its sports betting business, thanks to a canny acquisition by a storied Irish bookmaker.

Faux Meat Falters At the Drive-Thru

● Fast-food restaurants aren't switching up menus as quickly as expected

For some of the fast-food restaurants that peddled plant-based versions of their menus to appeal to meat-conscious consumers, the novelty is already wearing off. It could spell trouble for the makers of the products, who've hyped the partnerships as a major step to mainstream popularity.

The biggest restaurant chains are backing off—or at least slowing down—faux-meat plans after the Covid-19 pandemic and lockdowns upended dining and eating. Instead of trying new things, Americans have been eating at home or seeking familiar, comforting foods when they do venture out. Orders of plant-based burgers and sandwiches at fast-food restaurants were unchanged for the year ended in June, while beef burger orders climbed 12% over the same period, according to market researcher NPD Group Inc. "I don't think that plant-based meat is at the top of the list for many restaurant operators right now," says BTIG LLC analyst Peter Saleh. "It's more about, let's just sell the core menu items, and let's do it the best we can."

Inspire Brands Inc.'s Dunkin' has taken Beyond Meat Inc.'s breakfast sausage out of thousands of locations. Yum! Brands Inc.'s KFC, which ran trials of Beyond Meat's chicken nuggets, has yet to turn them into a regular menu item, and Burger King has notched down the marketing of its Impossible Whopper. At Little Caesars a trial of Impossible Foods Inc. sausage didn't work out; it just wasn't a popular enough topping to support an alternative. The pizza chain is giving faux pepperoni a shot, though only in large metro areas, including Miami, New York, and San Francisco.

Despite long-held investor expectations about national—and even international—fast-food tie-ups, it's the smaller chains that show the most enthusiasm. Faux chicken is selling better than expected at fast-casual companies such as Epic Burger, says the chain's chief executive officer, David Grossman. Epic, which gets its plant-based chicken from Beyond Meat, has seven locations in and around Chicago.

Beyond's shares jumped this February when McDonald's Corp., with more than 39,000 restaurants, shared details of Beyond being its preferred supplier for the McPlant patty. So far that product has been tested only in a few smaller markets, though it's slated for a nationwide rollout across the U.K. and Ireland in 2022. UBS Group AG

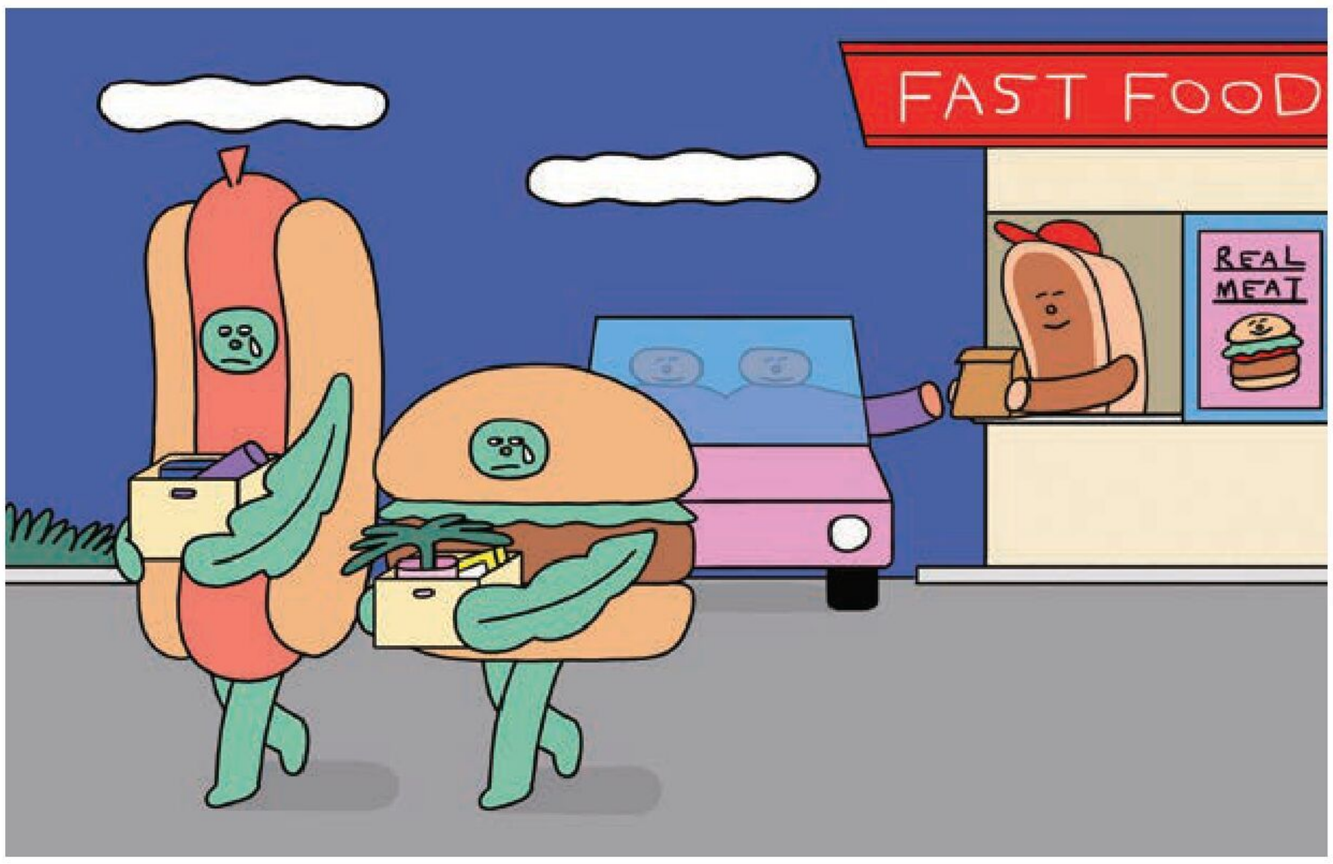


ILLUSTRATION BY SUJIN KIM. DATA: EUROMONITOR INTERNATIONAL

analysts Erika Jackson and Andrew Olsen said the announcement, along with other big name partnerships, signaled that plant-based meat "is not a fad"—but still cut their sales estimates for Beyond for fiscal 2021 and 2022. They'd been modeling sales based on a large national fast-food rollout for the second half of 2021 but are now expecting that to happen at least a year later. A representative for Beyond says the company is very proud of the partnerships it has with some of the world's largest restaurant brands.

Burger King, with about 18,000 owned or franchised locations, could've been a key launchpad for Impossible burgers. The chain, owned by Restaurant Brands International Inc., hyped the Impossible Whopper with an ad blitz and the claim of 100% Whopper, 0% beef. When management cut back on marketing spending last year, customer awareness plummeted, according to Bloomberg Intelligence analyst Michael Halen, based on data from Cognovi Labs, which analyzes social media outlets including Twitter. Discussions about Burger King's plant-based meats tumbled 67% from 2019 through 2020, the data show, outpacing a drop of about a third across the industry. Carrols Restaurant Group Inc., the biggest Burger King franchisee in the U.S., said late last year that sales of the Impossible Whopper had fallen by about half since its introduction in August 2019. Carrols and Burger King declined to comment on current sales.

The Impossible Whopper is "doing well," says Dennis Woodside, president of Impossible Foods, saying there hasn't been a marketing pullback and noting that it's still sold on the buy-one-get-one-free platform. "Our operators are very happy with repeat rate and attraction of new customers to the product," he says, though he declined to share specifics.

Sales of meat substitutes overall at U.S. restaurants fell more than 23% last year, according to Euromonitor International data. Volumes have rebounded this year but are expected to be only 4.4% above the 2019 level.

One place that restaurant tests and marketing are helping is in grocery store sales, with faux meat continuing to make its way into more home cooking. "A plant-based product can be viewed as something a little bit uncertain," says Jennifer Bartashus of Bloomberg Intelligence. "The trial at restaurants gives people confidence in the taste and their ability that they can prepare the items themselves."

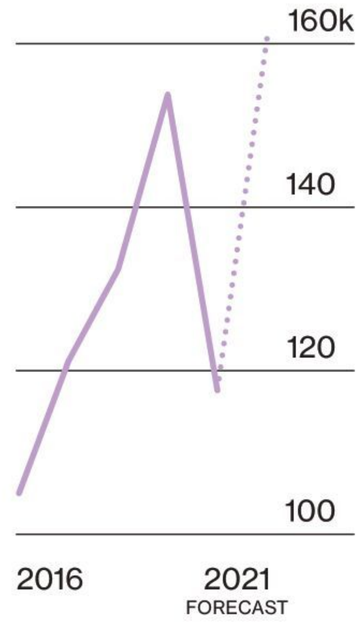
Restaurants are still trying to figure out what customers want, and some are doing it without the big faux-meat brands. In August, Chipotle Mexican Grill Inc. began selling vegetarian chorizo that's made in-house with pea protein, shunning both Impossible and Beyond. The fast-casual chain says lots of meat alternatives out there aren't healthy enough for Chipotle. "They're too processed for us," Chief Marketing Officer Chris Brandt said in an interview at the time, "and they contain a lot of ingredients we would never have in our restaurants."

Dunkin' franchisee Rob Branca, who owns 90 stores in Massachusetts, upstate New York, and Ohio, says the Beyond sausage didn't sell as he'd hoped. "I'm no expert, but I don't know who the customer is" for the plant-based meats, Branca says. At BurgerFi International Inc., CEO Julio Ramirez says he's figured it out: When a group of diners with varying tastes is choosing a restaurant, the availability of a vegetarian option can be the deciding factor. "One person says, 'I don't want to have a beef burger,' that's going to limit where you're going to go," he says.

Alyssa Smolen, a 22-year-old vegetarian, isn't convinced that meat alternatives are healthier than other proteins such as tofu. Smolen, from New Jersey, doesn't frequent fast-food chains, though she did try—and was underwhelmed by—the Dunkin' Beyond sausage earlier this year. When she does feel like having a faux burger or sausages, she buys them at her local ShopRite supermarket and cooks at home. She's also pretty agnostic on the brand, paying more attention to nutritional facts and price. "At the end of the day, it's a processed food. It depends on your mindset as to what you define as healthy," she says. —*Leslie Patton and Deena Shanker*

THE BOTTOM LINE Faux-meat makers need restaurants on board to help scale up their revenue. Early trials aren't yet translating into widespread adoption.

▼ Metric tons of alternative meat sold at restaurants in the U.S.



Asia's Skin Whiteners Won't Fade Away

● Cosmetics brands changed their marketing after global BLM protests, but the creams live on

The Black Lives Matter protests of 2020 also put a spotlight on marketing pitches and consumer products with racist or colorist legacies around the globe. Some companies in the U.S. responded by dropping Aunt Jemima, Uncle Ben's, and other racially charged brands. In the cosmetics world, however, not much has changed. A popular commercial on the YouTube channel of French cosmetics giant ▶

◀ L'Oréal SA's Garnier skin-care brand in Thailand shows how its Sakura White masks and creams can help women achieve "Korean pinkish skin" in only a few steps. "It'll transform dull skin to bright-pink color in just seven days," a woman says in Thai, her smile growing wider as her skin transforms from dark to light. The video has had 11 million views.

Skin whitening in Asia is big business. From Japan to India, pharmacies and department-store cosmetics counters peddle all sorts of body moisturizers, face creams, and serums that promise to whiten users' skin, playing off a traditional belief that a light complexion denotes status and wealth because people with fairer skin can afford to stay inside instead of toiling for hours under the sun.

Abandoning the whiter-is-better marketing pitch hasn't been as straightforward in Asia, largely because the products are so popular there. Skin whiteners accounted for about 80% of India's $1 billion market for moisturizers in 2019, reports Euromonitor International. The global market for skin lighteners was worth $8.6 billion last year, according to Global Industry Analysts Inc.'s StrategyR, a research company in San Jose, which forecasts demand reaching $12.3 billion by 2027.

"Individuals who have fairer skin are more acceptable when it comes to career or marriage," says Sujata Chandrappa, an aesthetic-medicine specialist and founder of R3 Clinic, a skin and hair treatment center in Bengaluru. "Desire to have fairer skin is deep-seated."

Some companies have tried to finesse the issue by getting rid of the offending brands while keeping the products. Unilever Plc last year dropped the Fair & Lovely name in India and replaced it with the more neutral-sounding Glow & Lovely. Neutrogena, the skin-care brand owned by Johnson & Johnson, dumped its Fine Fairness line and replaced it with Bright Boost. And last year, L'Oréal said it would remove words such as "whitening" and "lightening" from its skin products.

Yet many brands continue to market their products as skin whiteners. L'Oréal's Chinese-language website in Hong Kong assures consumers its products will give them skin that's "white and flawless," and the company's English-language site in Singapore has a special section for skin-care whitening "to give you the fair, flawless complexion you desire." Hamburg-based Beiersdorf AG still sells Nivea whitening body lotions in India.

L'Oréal is introducing the word "brightening" to describe its products, the company said in a statement. Beiersdorf has "started to cease products and communications which do not embrace the complexions of our diverse consumer base," says a spokesperson. In a statement, Johnson & Johnson said conversations last year showed that some of its product names or claims "represented fairness or white as better than your own unique skin tone. That was never our intention—healthy skin is beautiful skin." The company says it replaced its two fairness product lines with Bright Boost, which uses ingredients "to boost the skin's natural renewal process for brighter, more-even skin tone."

Despite promises of change, critics say, the continued marketing of such products shows multinationals are expecting to still profit by equating beauty with whiteness. Unilever's rebranding of its skin cream is "just a big farce," says Kavitha Emmanuel, founder of Dark Is Beautiful, an Indian advocacy group against colorism.

Hindustan Unilever Ltd., the Indian unit, didn't respond to requests for comment. But Unilever signaled it's made a pivot, announcing in March that it would refrain from digitally altering anyone's skin color in its advertising. "We are committed to tackling harmful norms and stereotypes and shaping a broader, far more inclusive definition of beauty," Sunny Jain, president of beauty and personal care for Unilever, said in a statement.

◀ Some whitening products in Asia, in new and old packaging

The company used to heavily market its fairness cream in India with promises of improving women's job and marriage prospects. A recent Olympics-themed campaign featured women doing parkour stunts and lifting weights. Another recent spot showed a dark-skinned rapper asking not to be judged for her complexion. And Glow & Lovely packages don't include the before-and-after comparisons of skin tones used on Fair & Lovely boxes.

Customers in India have stuck with Unilever's renamed brand. Sales of Glow & Lovely and its other beauty and personal-care brands grew 13% in the second quarter from a year earlier. *—Prim Chuwiruch, Malavika Kaur Makol, and Ragini Saxena*

THE BOTTOM LINE Cosmetics makers have been slow to change the way they market skin whiteners—an $8.6 billion global market last year—because of the products' enduring popularity in Asia.

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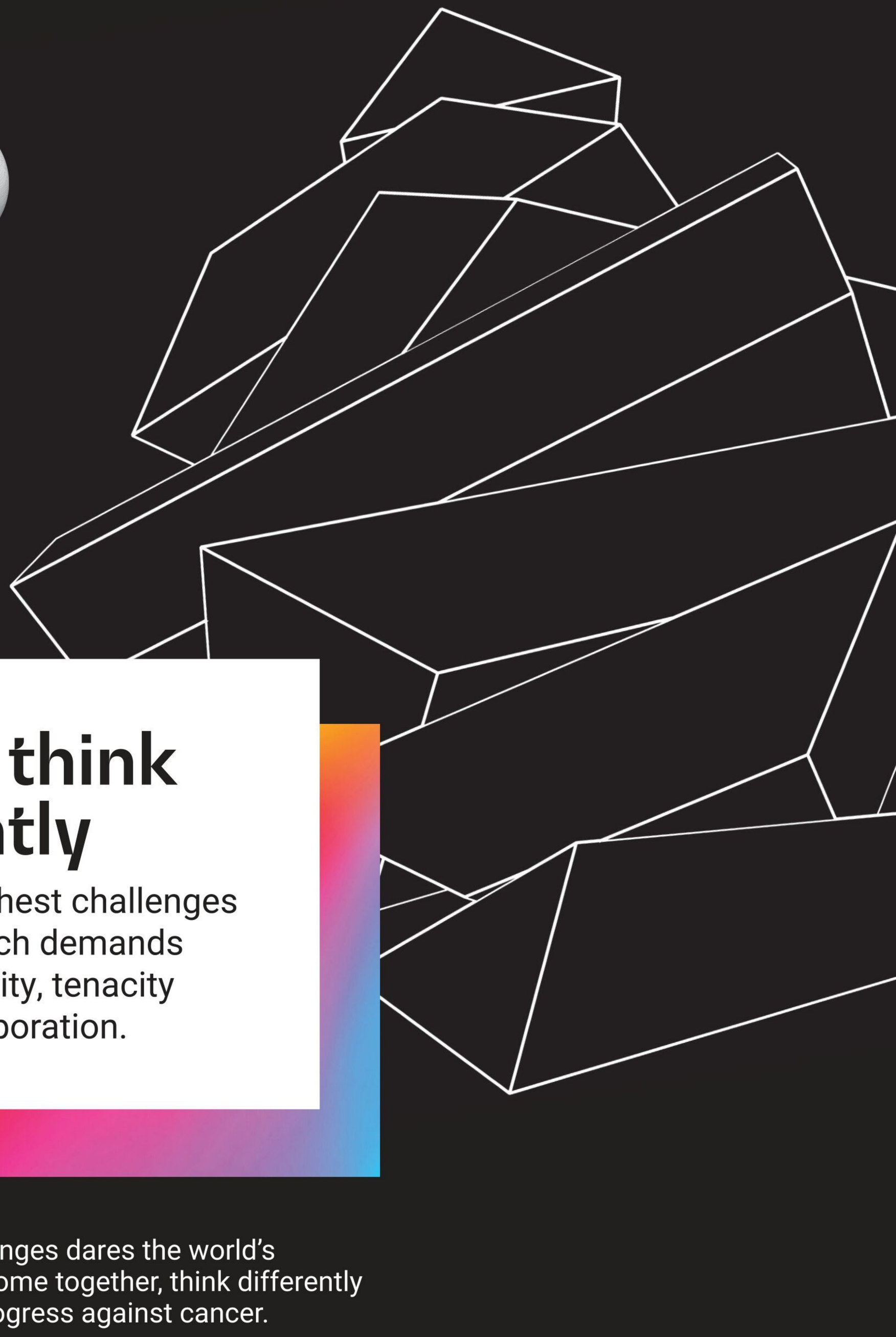

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When the Boss's Boss Is a Machine

● Amazon is using automation to overhaul its fulfillment centers and change the idea of what it means to be a manager

On a recent August morning, inside a cavernous Amazon.com Inc. fulfillment center outside Seattle, Evan Shobe positioned himself before a bank of nine computer screens. Known internally as the quarterback desk, or QB, the command center lets Shobe monitor the intricate workings of a building the size of about 15 football fields. Thousands of blue dots show robots ferrying products around the facility; yellow figures that look a little like restroom signs represent the humans who load and unload the robots. A maze of green lines shows conveyors speeding orders to stations down the line and, ultimately, to waiting delivery trucks. The system is running smoothly on this early morning, as it mostly does seven days a week at more than 900 Amazon logistics facilities across the U.S.

BFI4, located in exurban Kent, Wash., is Amazon's flagship fulfillment center and regularly hosts senior company leaders—Chief Executive Officer Andy Jassy dropped by recently—who want a better understanding of what happens after a shopper clicks "Buy Now." It was the first facility of its kind capable of processing more than 1 million items a day, three times what was possible at the company's state-of-the-art warehouses a decade ago. Improving technology means Amazon can stay several steps ahead of brick-and-mortar rivals Walmart Inc. and Target Corp., which are now adopting many of the practices Amazon has worked on for years.

More than the physical robots, the stars of Amazon's facilities are the algorithms—sets of computer instructions designed to solve specific problems. Software determines how many items a facility can handle, where each product is supposed to go, how many people are required for the night shift during the holiday rush, and which truck is best positioned to get a stick of deodorant to a customer on time. "We rely on the software to help us make the right decisions," says Shobe, BFI4's general manager. Automation has made it possible for each ▶

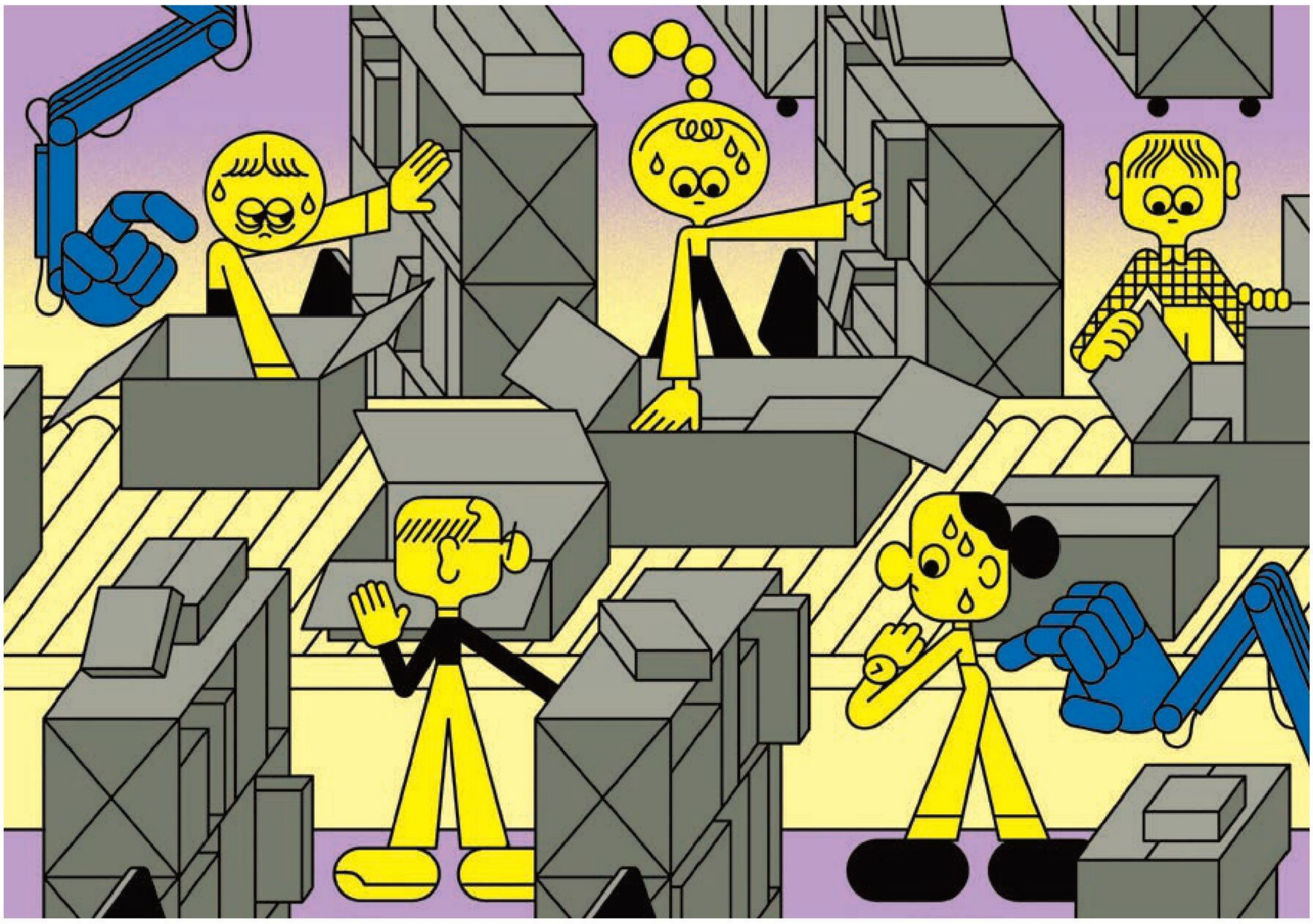


ILLUSTRATION BY ARNE BELLSTORF

Edited by Joshua Brustein and Robin Ajello

◀ fulfillment-center supervisor to manage dozens of employees, a factorylike operation becoming standard in the industry. In 2012 a logistics warehouse manager supervised about 10 workers, according to the U.S. Bureau of Labor Statistics. In 2020, after Amazon had become the industry's biggest employer, there were almost twice as many frontline workers for every supervisor.

The company's competitors strive to imitate its operations, but its approach to automation is also a focus of its critics, who bemoan the working conditions for hourly employees. Amazon's algorithms tell workers what to do on the warehouse floor, set productivity targets, and flag employees who fail to meet them. In interviews workers describe feeling like cogs in a giant machine that can spit them out with little more than an automated termination email.

Amazon acknowledges its algorithms aren't perfect. It says most processes in its facilities allow for human oversight or intervention. Managers say they can accomplish more with the powerful software behind them, and the company continues to work on its operations. Maju Kuruvilla, a former Amazon engineering executive who left the company last year, says Amazon noticed several years ago that bosses sometimes became little more than "faces behind laptops," speed-walking through the facility on their way somewhere else. "Fulfillment-center managers were not engaging with associates," says Kuruvilla, who worked on automation tools designed partly to help foster human interaction. "If that doesn't happen, it can be a downward spiral for Amazon. This is when unions come in, when you're not taking care of people."

DREAMS OF AN ONLINE BOOKSELLER

Jeff Bezos has sought to supplant humans with software ever since he was a mere bookseller. In one famous episode, editors working on book reviews and recommendations were replaced by code that did the same work by mining shopping patterns. Similar programs would come to manage many aspects of Amazon's operations, from ordering and placing inventory to keeping tabs on the online marketplace, a long-term bet that algorithms could perform some tasks better or more consistently than human employees.

In the mid-aughts, Amazon made automation a focus of the massive expansion of its packing, shipping, and delivery division. Even small improvements were celebrated; résumés of Amazon logistics veterans are sprinkled with references to how they knocked a penny or two off the cost of shipping an item.

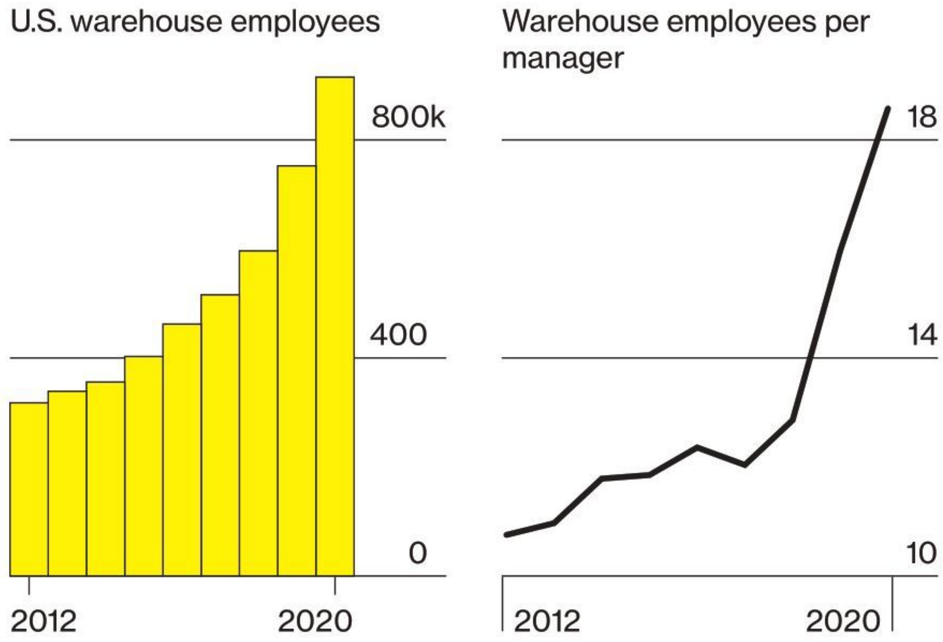
In 2012 the company bought Kiva Systems, a maker of squat, automated robots, based in North Reading, Mass. Up to that point, workers had walked the warehouse aisles, retrieving products from tall shelves, sometimes even using printouts to find certain products. Amazon wanted to use Kiva units to bring shelves of products to waiting employees, a plan that would require a complete redesign of its fulfillment centers.

BFI4, which opened in 2016, was one of the first facilities to be purpose-built for the little bots. It works like a giant assembly line, its 3,500 workers and 110 salaried managers laboring under the watchful eye of Amazon's precise productivity-tracking system. Workers wheel mobile conveyor belts to the back of trucks delivering inventory and, by pallet or box, feed products into a system that automatically scans incoming items, lists them for sale on Amazon.com, and triggers payment to suppliers. From there, workers stow items on shelves, standing alongside chain-link fences that separate them from the robots. The shelf is packed tightly inside the robots-only zone until, after an order is placed, a Kiva drives the rack to a picking station where workers pluck the right product, place it in a bin, and send it down the line for packing and shipment.

When managers wanted to figure out how many people they needed at each station to keep up with customer orders, they once used Excel and their gut. Then, starting in about 2014, the company flew spreadsheet jockeys from warehouses around the country to Seattle and put them in a conference room with software engineers, who distilled their work and automated it. The resulting AutoFlow program was clunky at first, spitting out recommendations to put half an employee at one station and half an employee at another, recalls David

"When you're so narrowly focused on solving a mathematical problem you forget that human element"

AI Means More Workers for Every Manager



DATA: BUREAU OF LABOR STATISTICS

CHONA KASINGER/BLOOMBERG

Glick, a former Amazon logistics executive who supervised initial development of the software. Eventually the system learned that humans can't be split in half.

In the spring of 2019, Amazon executives instructed the humans who ran BFI4 to rely on AutoFlow's recommendations, which refresh every 15 minutes. Managers could override the system if they saw something go wrong, but for the most part they were told to sit on their hands. "The message early on was to let the train run into the wall and let them learn from it," says Shobe, who then ran the warehouse's shipping department. "My team would operate better than the software. That was a really hard pill to swallow."

At first the software overreacted to modest shifts in demand, sending workers scurrying to new stations, only to order them back to their previous position after a couple of hours, a time-consuming and wasteful shuffle. But as promised, it got better over time. Instead of having someone based at each warehouse to troubleshoot, the company now handles that task from an office in Tempe, Ariz., where employees can monitor a handful of warehouses simultaneously.

Engineers have found other ways to make BFI4 faster and more accurate. Workers who stow products on shelves once physically scanned bar codes to figure out where an item should go. Now video cameras automatically identify what workers take from the bins as projected green beams illuminate cubbies where the products might fit.

A CHALLENGE FROM COVID

The pandemic presented a major challenge for Amazon, when Americans hunkered down at home and began shopping almost exclusively online. The company added 400,000 workers, a feat made possible by computers that scanned résumés for disqualifying factors, video apps that helped train recruits, and software that guided newbies through simple, repetitive tasks. Engineers had essentially created a plug-and-play workforce that can be adjusted almost instantly when circumstances change.

But Amazon's high-tech assembly line made life a grind for some employees. When workers at an Alabama warehouse tried unsuccessfully to form a union last year, they said they were being held to unreasonable productivity goals—metrics imposed by managers but also recommended by algorithms. One longtime Chicago-area worker, who asked for anonymity because he's not authorized to speak to the media, says typical guidance from his supervisor boils down to "get your rate, get your rate." A swing of a second or two in the average time to complete a task can make the difference between getting kudos from a manager or a warning about job performance. This month, California's legislature passed a bill that would give warehouse workers the power to fight so-called speed quotas. Proponents of the legislation, which the governor hasn't yet signed, say the pace of work pushes employees to skirt safety rules and skip rest breaks. One employee, who joined a Nevada warehouse during Amazon's pandemic hiring surge, recalls seeing colleagues piling so many items on shelves that they were in danger of collapsing. "You have to do unsafe things to make your numbers," says the worker, who asked for anonymity because she's not authorized to speak to the media. "It just feels like constant pressure." Regulators in Washington state fined Amazon earlier this year for its conduct at a warehouse in the city of DuPont, saying there was a direct connection between the fast pace of work and injuries at the facility. Amazon, which is appealing the fine, says it is modifying its productivity-tracking tools to better identify problems employees face.

▲ Shobe

Many workers, who spend their day taking orders from computer terminals or a smartphone app, say the environment leaves them feeling isolated from colleagues. In interviews frontline workers say they often struggle to name their facility's manager and describe it being tough to build relationships with colleagues, a dynamic made worse by the pandemic's masking and social-distancing mandates. Such criticisms frustrate Shobe, a people person who advises new hires to go out of their way and learn the names of everyone in their unit.

Alicia Boler Davis, a former General Motors Co. executive who runs Amazon's fleet of fulfillment ▶

▲ A system of conveyor belts at BFI4

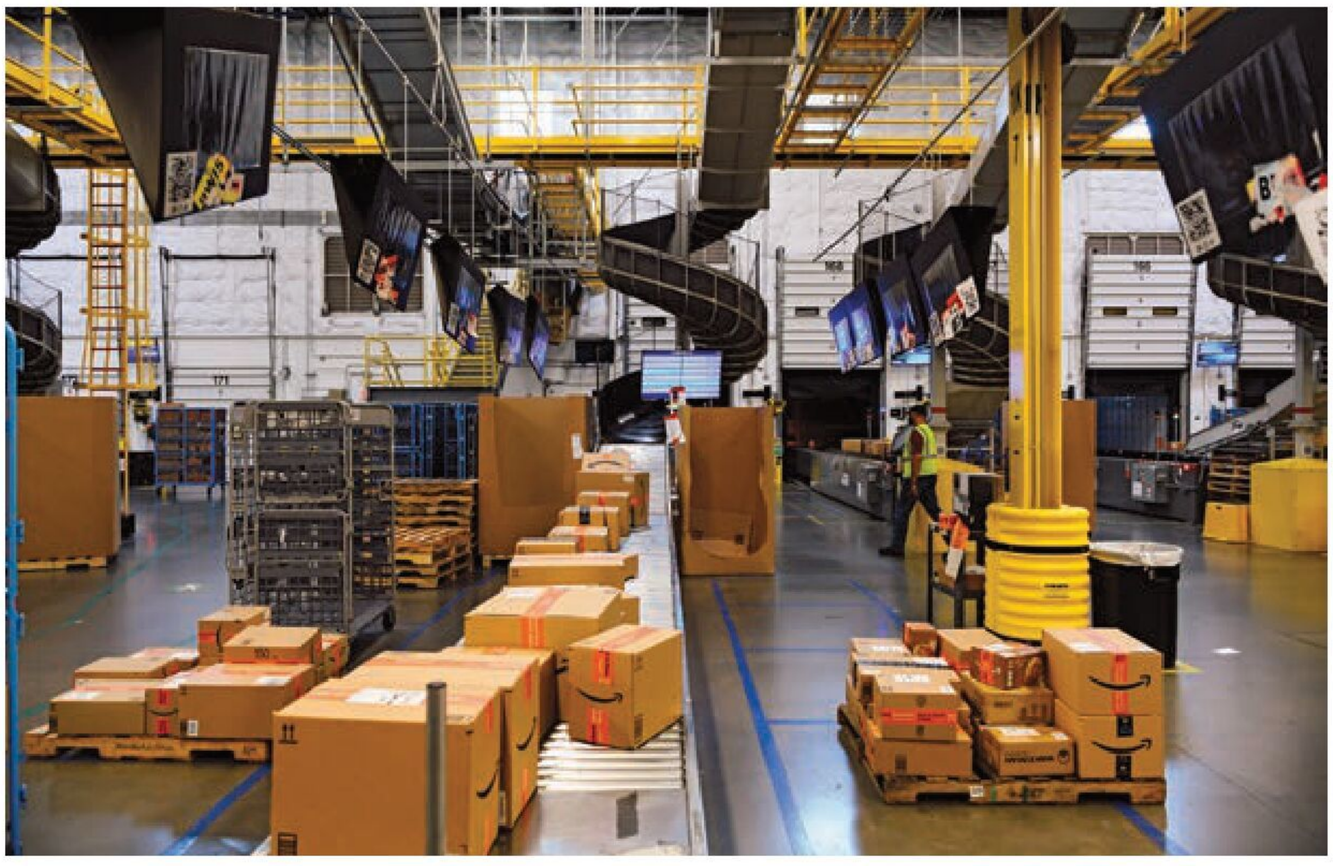
◀ centers, believes more automation will free up managers like Shobe to engage more with workers. "I'd love for them to spend the majority of their time on the safety and people side of the business," she says. "My mental model is, you know, where can we reduce the burden? To simplify things and make decision-making easier, but also to reduce the physical burden and have our people working on different things."

People who helped Amazon build its operation bristle at its reputation as a brutal workplace. "It's not that they're inhuman and want people to be treated poorly—never in a million years," says a former Amazonian, who worked on warehouse technology and requested anonymity because she's still in the industry. "It's just when you're so narrowly focused on solving a mathematical problem, you forget that human element and you need to be reminded." Like their employees, Amazon managers can find themselves at the mercy of a system built to run fast and lean. One former warehouse shift supervisor in Oregon says he wanted to get to know the hundreds of people who report to him, but time pressures kept him scrambling all day instead of talking with employees about career goals. Breaks, he says, "were never an option. It was almost like using the bathroom to *Jeopardy* music." The manager, who left the company last year and asked for anonymity because he signed confidentiality agreements, says he occasionally took naps in his car after 12-hour shifts so he could feel fresh enough for the drive home.

Amazon says such experiences aren't typical. In July it announced it was making employee welfare one of its guiding principles, pledging to become Earth's best and safest employer. The company recently said it would spend $1.2 billion on job training and coursework for its frontline workers, including paying the full cost of college tuition for some.

Shobe believes his employer could do a better job of educating entry-level employees about opportunities for advancement at the company. "Not

▼ Packages ready for shipment at the facility



CHONA KASINGER/BLOOMBERG (2). LEE: ANTHONY KWAN/BLOOMBERG

everybody is a career fulfillment-center person," he says. "We need to be much more thoughtful on how we're showing people, 'Hey, here's this new piece of equipment that we can teach you about if you're interested.' "

EVERYONE WANTS TO BE AMAZON

Amazon's assembly-line-like practices are already becoming commonplace in the rest of the logistics industry, which is racing to retool operations previously geared to sending pallets to retail stores. "Amazon's the platinum standard," says Glick, the former Amazon logistics executive, who's now chief technology officer for Flexe, a warehousing startup. "And then there's the silver standard. They're so far ahead there is no gold standard." Walmart is tacking highly automated warehouses onto existing stores. Kroger Co. is piloting robotic depots for grocery delivery. And Instacart Inc., which built its grocery delivery business with an army of gig shoppers, is building its own robotic warehouses. Even smaller operations like Cargo Cove, a 4-year-old warehousing startup with 80 employees, thinks it can replicate Amazon's automated efficiency. The company is planning in the coming months to introduce robots and software that automatically routes orders and monitors employee productivity. "It's the same kind of concept that Amazon has," says Robert McFaul, Cargo Cove's founder. "The only way to do that is to have standard processes that are very simple."

Back at the BFI4 warehouse, Shobe is speed-walking down a corridor to supervise workers freeing a yellow product tote that's gotten stuck on a conveyor. He taps a few keys on an app to note when the jam is cleared properly—part of a regular safety audit designed to decrease the number of injuries at the warehouses.

Amazon's technology teams have a long-term goal of building a fully automated fulfillment center that would make such human intervention less necessary. The aspiration is years away—held back mostly by the challenge of getting robotic arms to grasp objects of different sizes and textures—and executives say humans will remain necessary for the foreseeable future. In the meantime, the company's engineers are focused on moving ever more products through each warehouse. That's good news for customers expecting faster and faster delivery. The test for Amazon will be finding a way to make its workers think it's good news, too. —*Matt Day*

THE BOTTOM LINE Amazon sees automation as a way to increase the speed of e-commerce operations, but critics worry about the impact on the humans who work alongside the machines.

BW Talks Kai-Fu Lee

The head of Sinovation Ventures, one of the first Chinese venture capital firms to have a presence in the U.S., has a unique view into how artificial intelligence is changing the world's two largest economies. —*Tim Stenovec*

● Former executive at Apple, Google, and Microsoft ● Expert in machine learning and automation ● Co-author of recently published *AI 2041: Ten Visions for Our Future*, a book of science fiction stories about AI set 20 years in the future

Why is science fiction the best way to communicate what you envision AI doing to society in 20 years?

AI is perhaps the most important technology in the history of mankind, and yet it's sometimes viewed as rocket science, very hard to understand. So I wanted to see if there's a way to make it accessible to people.

Do you think the companies that deploy AI today are taking into account the pitfalls and the peril that you associate with AI?

They're trying, but the tools aren't there yet. None of the problems were intentionally created, but now we need training, regulations, and investigation into new technologies to combat them.

Do companies have incentives to do that work?

No, and the only way to fix it is to realign the incentives. In the short term that entails regulations or third-party AI audits. In the long term, it's encouraging the building of better applications and products. If there were a product that could make me more intelligent, knowledgeable, and happier, that would be a product I would want more than the Facebook news feed.

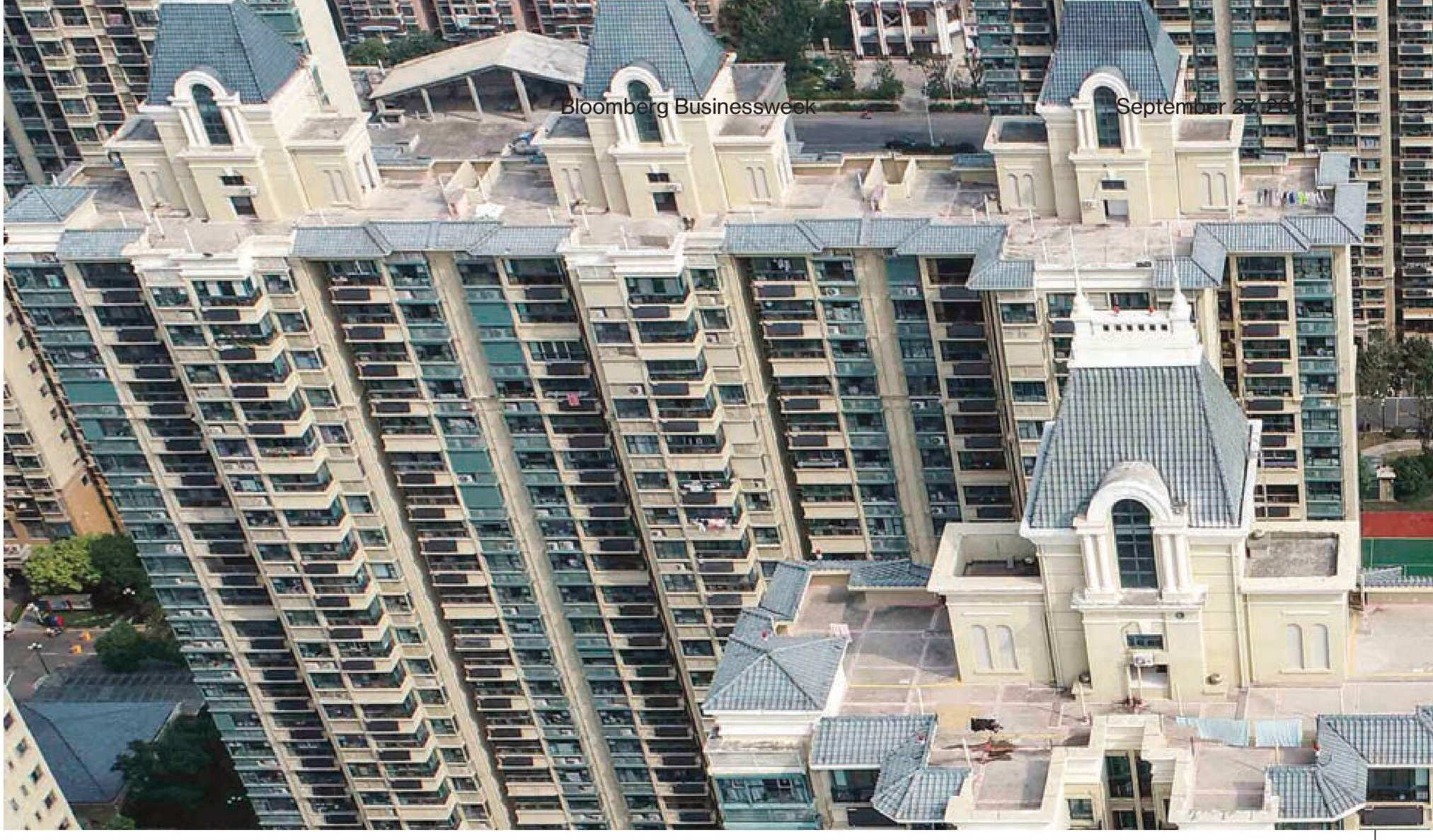
Has the Chinese tech crackdown changed the way you're thinking about investing in Chinese companies?

We've always been investors in deep tech, which hasn't seen as much growth as the internet giants but is going to generate the best returns going forward.

How will the pandemic affect the Chinese tech industry and its place in the world?

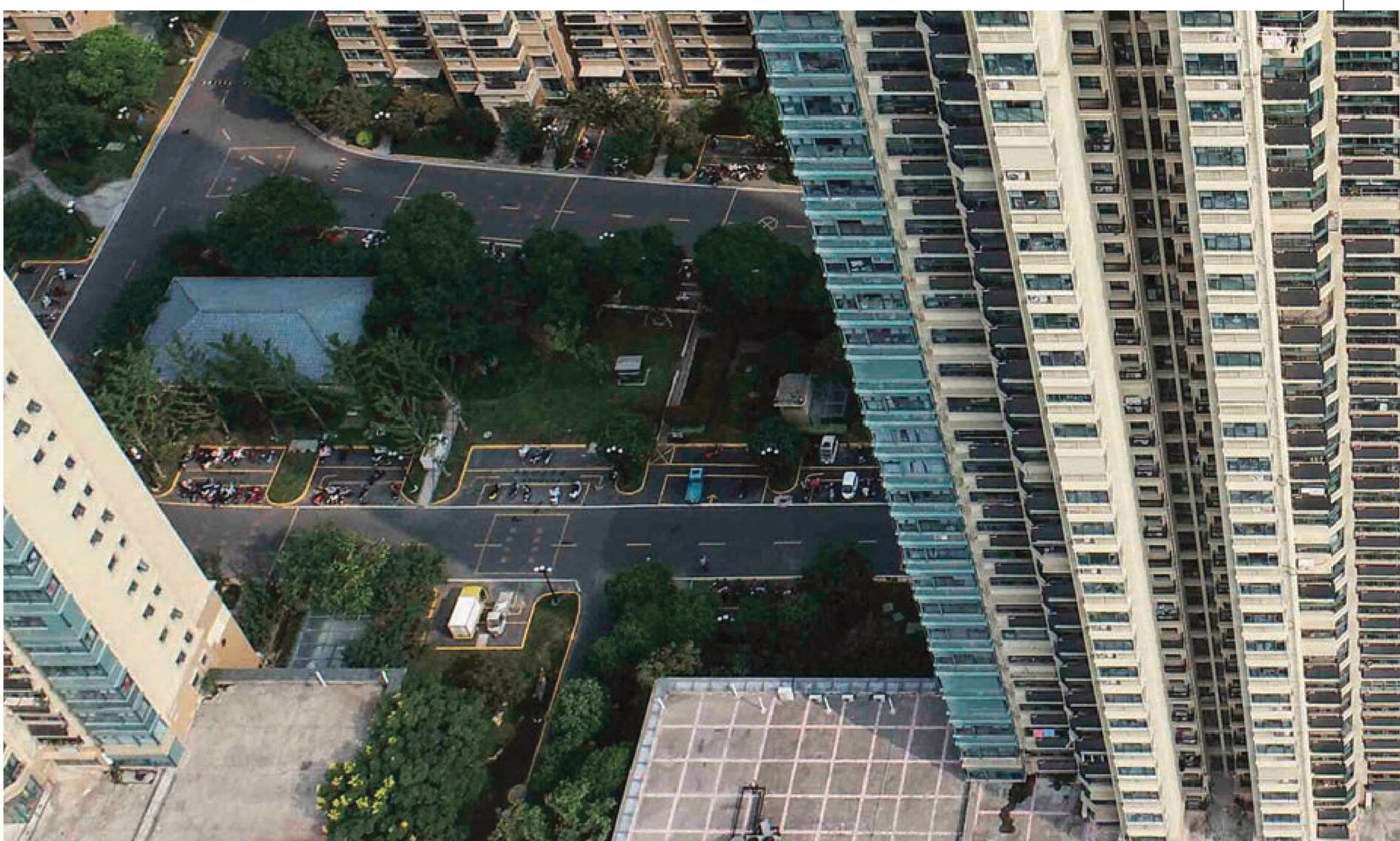
The pandemic pushed China further in the adoption of automation and robotics. On the flip side, remote work has enabled the use of AI and cloud technologies, an area where the U.S. has done the best job. So each country has gotten some benefits out of Covid, even though it's a terrible disaster for the whole world.

● Interviews are edited for clarity and length. Listen to *Bloomberg Businessweek With Carol Massar and Tim Stenovec*, weekdays from 2 p.m. to 5 p.m. ET on Bloomberg Radio.



Too Big. May Still Fail

As developer Evergrande faces a debt crunch, China tries to depend less on real estate



Edited by
Pat Regnier

Sunny Peninsula, a seaside development in the southern Chinese city of Guangzhou, was supposed to house 5,000 families in dozens of towers spread across an area the size of 30 soccer fields. Many of the buyers were white-collar workers benefiting from the fastest urbanization in human history.

But the project now looks more like the set of a disaster movie. Half-finished apartment blocks stand empty and abandoned. Untouched for months in the humid summer weather, piles of rebar and steel beams are accumulating coatings of rust.

China Evergrande Group, until recently the world's largest property developer, owns dozens of stalled sites like Sunny Peninsula across China. Buckling under more than $300 billion in liabilities, the company is close to collapse, leaving 1.5 million buyers waiting for finished homes.

The global financial markets are bracing for potential aftershocks. Evergrande is China's largest issuer of high-yield dollar-denominated bonds, and bills are coming due to an array of banks and suppliers. Given its footprint in the housing market, there's also a risk of a disorderly collapse triggering a broader decline in property prices—bad news in an economy where 27% of loans are for real estate. The stress isn't only being felt in bankers' offices: Earlier this month homebuyers surrounded a government office in Guangzhou to demand construction be restarted on their apartments, and unconfirmed videos circulating on social media depict similar protests in other cities. Furious retail investors who helped fund Evergrande's expansion have turned up at the company's Shenzhen headquarters to complain about delayed repayments on wealth management products it sold.

Evergrande's troubles are partly a familiar tale of an overextended, systemically important ▶

▲ An Evergrande development in the city of Huaian

STR/GETTY IMAGES

◀ company taxing its creditors' patience. That alone would make it a test for Chinese authorities. But its situation also reflects deliberate policy choices made by the ruling Communist Party under President Xi Jinping. Like the tech giants Alibaba Group Holding Ltd. and Tencent Holdings Ltd., which were the targets of sudden regulatory crackdowns that wiped out tens of billions of dollars in market value this summer, Evergrande found itself in the way of the party's priorities. For several years, officials have been taking steps to cool real estate prices, which they see as a potential source of risk, and signaling that they expect both house price growth and new construction to remain roughly flat. "In the central government, the view has shifted over how much China's economy can depend on the housing market," says Zhu Ning, a former adviser to China's central bank.

Instead, Beijing wants to steer China's economic resources toward areas it views as more central to national security—above all, high-tech manufacturing that can help it reduce its reliance on the U.S. and its allies. The party is also emphasizing financial and social stability over sheer growth. Leaders speak of the goals of "moderate prosperity" and "common prosperity," and households accumulating more debt to buy multiple or more luxurious homes doesn't necessarily fit with that vision. Nor does the wealth inequality that property booms can create. Xi's pledges to cut pollution and carbon emissions also require curbing construction.

China may be willing to let Evergrande fail if it thinks it can engineer a soft landing for the real estate sector. The $56 trillion domestic financial system is dominated by state-owned lenders, which give the government extensive power both to squeeze borrowers and to manage the impact of defaults. But the stakes are enormous. When industries such as construction and property services are included, real estate accounts for at least 15% of the nation's gross domestic product, and more than 70% of urban China's wealth is stored in housing. Countries such as Australia, Brazil, and Zambia depend on China's relentless demand for steel, copper, and other construction materials. And U.S. and European companies increasingly look to its consumer market for growth.

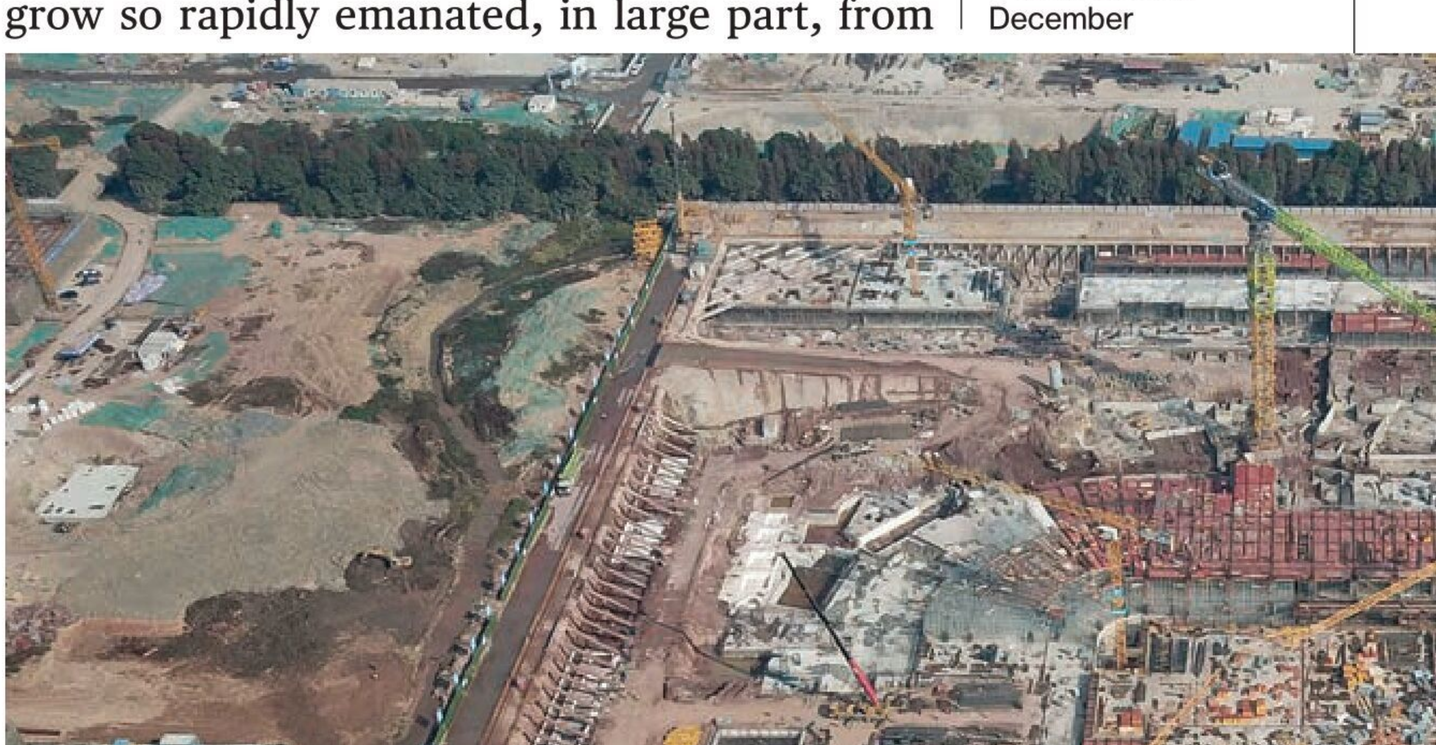
In 1998, when China created a nationwide housing market after tightly restricting private sales for decades, only a third of its people lived in towns and cities. Now almost two-thirds do, increasing the urban population by 480 million. The homes they've moved into are modestly sized by developed-world standards, averaging less than 40 square meters (431 square feet) per person. But about 90% of urban residents own those homes, worth more than $50 trillion in total, according to Goldman Sachs.

This is the wave Evergrande rode. Its founder and chairman, Hui Ka Yan, was born into grinding poverty in the central province of Henan in 1958. "In school, all I ate was sweet potato and steamed bread," he said in a rare speech in 2018. "I really hoped I could leave the village." He found his ticket out by becoming one of a tiny number of rural students to pass the university entrance exam, going on to study metallurgy.

In 1992, Hui came to Shenzhen, then a small town on the border with Hong Kong. After working as an importer-exporter, he dove into the property market, founding Evergrande in 1997. By 2016 it was China's biggest property developer by sales. "Everything for me and Evergrande is given by the party, the state, and society," he said in his 2018 speech.

Even making allowances for flattery, Hui wasn't wrong: The forces that allowed Evergrande to grow so rapidly emanated, in large part, from

"Everything for me and Evergrande is given by the party, the state, and society"

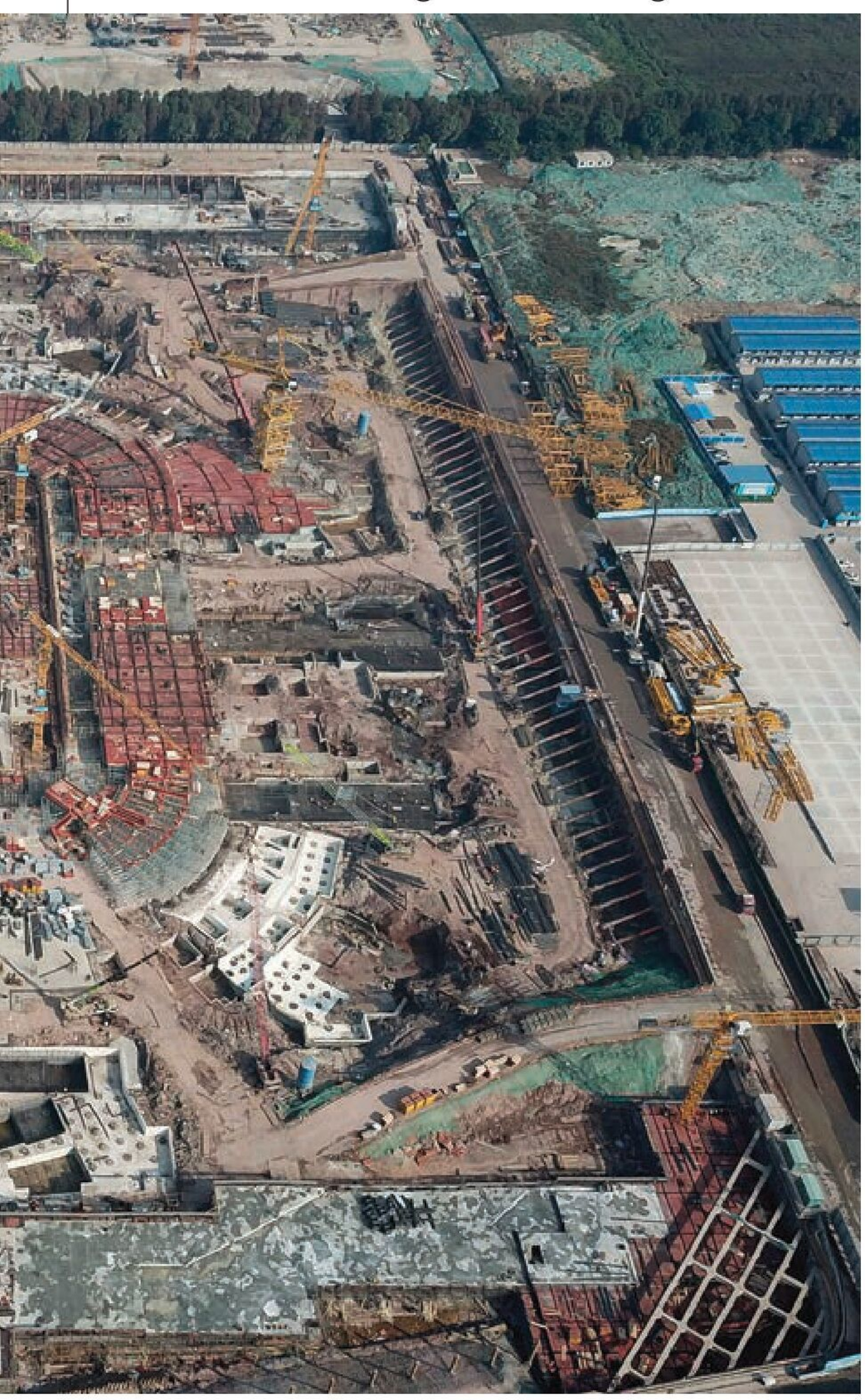


▼ Guangzhou Evergrande Football Stadium under construction in December

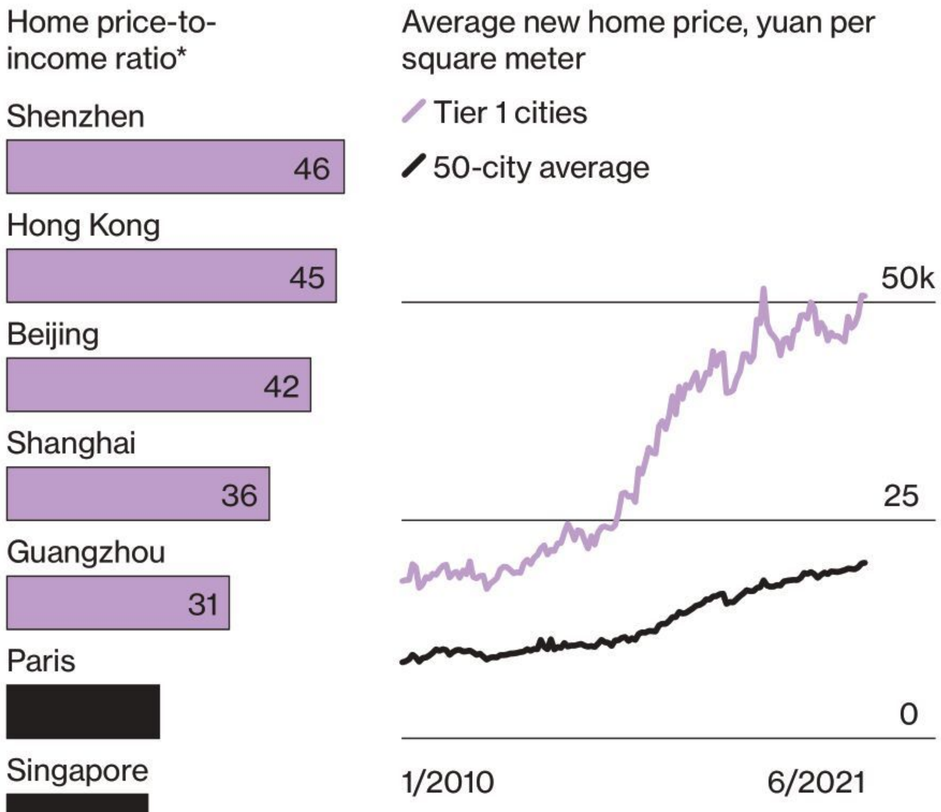
Beijing. When the 2008-09 global financial crisis cut demand for Chinese exports, the central government responded with a massive stimulus package that made borrowing easy. Land prices soared, in both coastal megacities and previously sleepy regional centers, and developing housing became a near-certain bet. The key to success was scale, achieved by borrowing with land as collateral. The bigger a developer became, the more it could borrow, and at lower interest rates, a cycle that could continue as long as property prices kept rising.

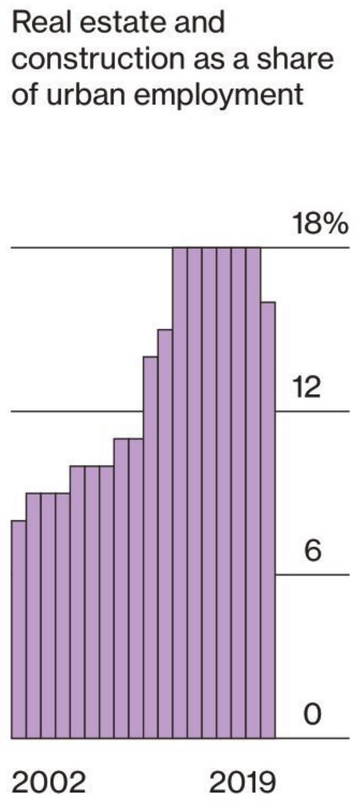
Supercharged by real estate profits, Evergrande expanded its reach into China's burgeoning consumer economy. Some ventures, such as theme parks, had at least a faint connection to property development; others, including mineral water and a quixotic attempt to build a world-class soccer club in Guangzhou, had none at all.

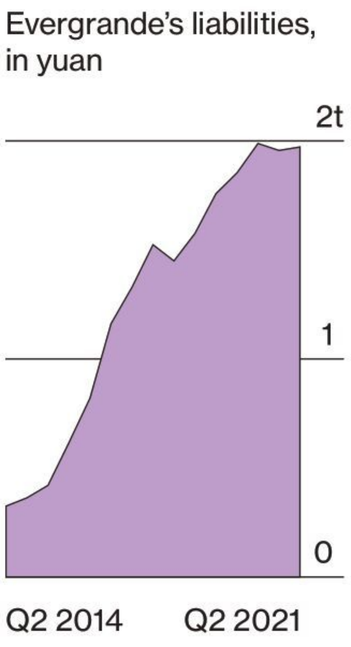
It didn't take long for analysts, particularly outside the country, to predict that Chinese developers in general, and Evergrande in particular, were building up far too much debt. As early as 2012, some argued that Hui's company would soon buckle under the weight of its leverage.

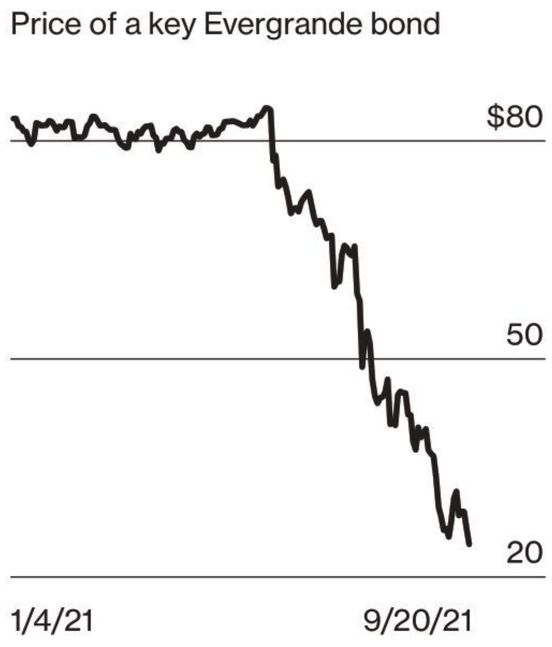


China's Property Stress









*MEDIAN APARTMENT PRICE TO MEDIAN FAMILY DISPOSABLE INCOME PER YEAR
DATA: NUMBEO, BLOOMBERG INTELLIGENCE, ROGOFF AND YANG (2021), NATIONAL BUREAU OF STATISTICS CHINA, COMPILED BY BLOOMBERG

But the day of reckoning never seemed to arrive. The increasing sophistication and profitability of Chinese companies meant more of their workers could afford new homes. Evergrande even weathered a steep drop in home sales in 2015, when a glut of unwanted apartments drove average prices down by as much as 6% year-on-year. Hui became China's second-richest man, behind only Alibaba's Jack Ma.

This resilience was partly a function of government policy, including a renewal of stimulus measures that helped prices recover. But policymakers in Beijing were haunted by the fragilities the 2015 slump exposed. At the end of 2016, the ruling party's Politburo unveiled a new slogan: "Houses are for living in, not for speculation." One policymaker complained the following year that the economy was being "kidnapped" by the housing sector.

Beijing began instituting a series of curbs on what's known as shadow financing—lending by entities other than banks or through practices such as selling wealth management products. ▶

IMAGINECHINA/AP PHOTO

◀ Among other things, it prevented companies from raising money by offering guaranteed returns to investors. There were also efforts by provincial and city governments to damp real estate speculation. On Hainan, an island in the South China Sea touted by developers as China's answer to Hawaii, nonlocals were effectively blocked from buying homes before spending two years in the province, and all buyers were barred from reselling a residence within five years of purchasing it.

Suddenly, Evergrande's sprawling property empire seemed out of step with the times, and not only because of its high debt load. The government wanted affordable housing for young people; at the time, Evergrande's marquee project was Ocean Flower Island, an extravagant plan to build a Dubai-style artificial archipelago on the Hainan coast, with one of its 58 hotels designed to look like a European castle and another offering "7-star" luxury.

Hui began a campaign to change Evergrande's image. The company plowed billions of yuan into building houses in poorer rural areas, and in 2019 announced that it intended to become the world's largest manufacturer of electric vehicles. Sunny Peninsula was a product of Hui's shift. Rather than luxury condominiums for investors, it promised relatively affordable apartments for manufacturing workers.

The acute phase of Evergrande's crisis began in 2020. It could have been a relatively good year for the company. Thanks to China's successful containment of the coronavirus, the economy contracted for only a single quarter, while looser monetary policy boosted the housing market. But for reasons that aren't entirely clear, Evergrande began struggling to cover its debts. It appealed to local government officials for help in averting a cash crunch; as investors lost confidence, its biggest bank creditor started to slow its lending. It didn't help that Hui's new ventures, like the EV operation, were sucking up much of its cash. Eventually strategic investors, some of whom were also suppliers, agreed to waive $13 billion the company owed them as part of a debt-for-equity swap. It ended 2020 with its profits down by half.

Then authorities, convinced by the pandemic that risk prevention was more important than

▼ Protesters outside Evergrande's Shenzhen headquarters

ever, ordered Evergrande and other top property developers to cut their debt. Guo Shuqing, China's top central bank official, in November called real estate "the biggest gray rhino" for China's financial stability—referring to a large yet overlooked threat. Relations with the U.S. also plunged to a new low. Fearful of being cut off from supplies of products such as microchips, the government declared improved scientific research and greater technological self-sufficiency its top economic goals. Housing construction would be no help there.

In March, Beijing signaled it might revive efforts to introduce a national property-tax system, which would reduce local administrations' reliance on land sales for income. The central and local governments also released some 400 separate regulations on homebuying, including rules preventing people from divorcing just to get around "one house per family" limits, and directed banks to slash mortgage lending and channel money to manufacturers instead. Outstanding mortgages as a share of GDP dropped for the first time in a decade.

The results have been dramatic in the booming coastal cities that previously powered China's property market. A broker in Shenzhen, who asked to be identified only by his surname, Li, says that inquiries from prospective buyers are down a third from a year ago. "The transaction volume looks pretty ugly, and the only homes sold were either due to the sellers urgently needing cash or worries that prices will drop further," he says.

The sales decline hit Evergrande harder than any other large developer, and it's spent much of this year seeking to raise cash by any means possible, including trying to sell its headquarters building in Hong Kong. To avoid admitting to buyers that the company couldn't deliver their apartments, Hui said he'd issued a "military order" for projects to be completed as planned. His efforts fell short. This month Chinese authorities told major lenders to Evergrande not to expect interest payments due on some bank loans.

In past Chinese housing slumps, this might be the moment when Beijing would step in to put a floor under the market, encouraging banks to lend to push up prices and boost revenue for property developers. But for now, policymakers seem willing to inflict economic pain to alter expectations that real estate prices will always rise. Many homeowners have gotten used to policymakers protecting their investments. "If prices fall, that means the economy is in a downturn, and that'll put huge pressure on the local government," says Jenny Wu, a financial worker in Shenzhen who bought an apartment last year. "So it's impossible that home prices would drop in Tier 1 cities." ("Tier 1" is shorthand for the megacities of Beijing, Guangzhou, Shanghai, and Shenzhen.)

▲ Hui, center, at an electric vehicle summit in 2019

Evergrande could avoid bankruptcy. Most analysts expect a restructuring in which some banks roll over financing, while other creditors receive assets such as properties and land rather than cash as repayment, and bondholders get some but not all of their investment back. The company's humbling may nonetheless mark a turning point in China's economy. Developers will still be needed: The government plans for 10 million people to move to urban areas every year through 2025. But the companies are likely to be smaller, and they won't benefit as much from runaway price rises.

Those who put their savings into Evergrande projects such as Sunny Peninsula are hoping their own slice of moderate prosperity has a place in Beijing's vision of a tamed property market. Last month a group of angry buyers gathered at the site. "We don't care about price cuts," said one, who asked to be identified by his surname, Cheng. "Our one and only demand is that Evergrande can deliver the project." —*Bloomberg News*

THE BOTTOM LINE With $300 billion in debt, a vast number of homes under construction, and an electric vehicle venture to support, Evergrande is trouble that Beijing may not want to fix.

PROTEST: NOEL CELIS/GETTY IMAGES. EVERGRANDE: VCG/GETTY IMAGES

Are We In For a Double-Dip Shecession?

● A child-care crunch could send women's job participation rates diving again

Edited by Cristina Lindblad

Shanique Green, a single mother living in Boston, had no trouble finding a part-time customer service gig this summer to supplement her income from her regular job at a call center. Lining up the child care she needed to make it all work has been much more of a challenge.

Green, whose 8-year-old son is in primary school, used to rely on government vouchers to pay for child care for her 2- and 3-year-old daughters. But now there's a long wait list at programs that accept them. And space is tight even at programs that don't take vouchers. After much searching, she was able to find a nursery with room for both girls, but the $600 a week it cost would have gobbled up half the paycheck from her new job, jeopardizing her plans to build up savings to buy her first home. "It's like a race. People have to go to work, so they're trying to get day care as soon as possible," says Green. "But the ones with better income take all the spots."

Parents across the U.S. have struggled through more than 18 months of virtual schooling, suspended pre- and after-school programs, and shuttered day-care centers. As kids head back to school in person and workers back to the office, the U.S. child-care industry—which wasn't able to meet the needs of all parents before the pandemic—can't accommodate the sudden spike in demand. That's left lower-income parents like Green competing for fewer seats.

The Covid recession pushed more than 2.1 million women aged 25 to 54—those most likely to have young children at home—out of the labor force last year. About half of them have come back, but the rebound has been led by mothers with a college education. Participation rates for those without a diploma, especially mothers of color, lag far behind, according to an August report written by Didem Tuzemen, an economist at the Federal Reserve Bank of Kansas City.

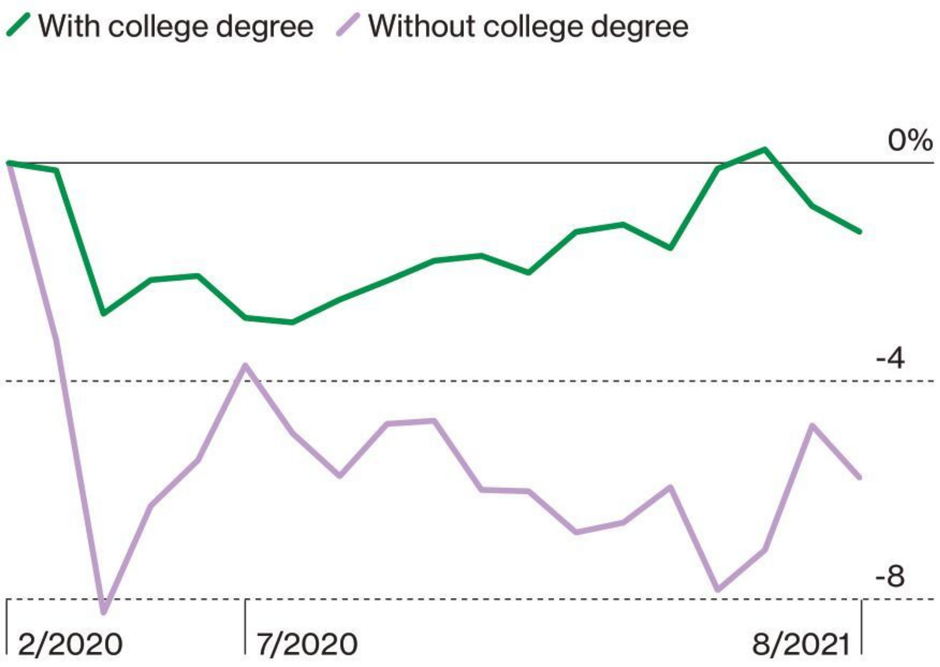
Americans without college degrees tend to work in such industries as education, health care, leisure, and hospitality—the ones most affected by the pandemic. They're also high-contact jobs, posing an additional challenge for people who may be wary of returning to work while the delta variant drives a surge in virus cases around the country.

Almost half of all child-care centers around the country closed in the early months of the pandemic. Many have reopened only to find that they

PHOTOGRAPH BY KAYANA SZYMCZAK FOR BLOOMBERG BUSINESSWEEK

Diverging Fortunes

Change in labor force participation rate among women with young children since February 2020



DATA: FEDERAL RESERVE BANK OF KANSAS CITY, BASED ON U.S. CENSUS BUREAU DATA

can't return to 100% capacity because they're unable to hire the staff they need. Some 80% of providers have reported staffing shortages and have therefore cut enrollment, according to a survey of 7,500 businesses conducted in June and July by the National Association for the Education of Young Children (NAEYC).

The industry's labor crunch predates the pandemic. Pay at child-care centers has always been low, averaging $12.12 an hour, which contributes to high turnover. In a report published Sept. 15, the U.S. Department of the Treasury wrote that in 41 states more than 15% of child-care workers live below the poverty line.

More than three-quarters of providers said that low wages were the main challenge to bringing on more staff. Child-care workers "are recognizing they can make more money working just about anywhere else," said an NAEYC report published in July, which noted that many were switching to jobs in public school education, retail, or warehouses. The child-care industry employed just over 1 million workers in February 2020. After losing more than a third of its workforce during pandemic closures, it's still down 126,700 jobs, or 12%.

Continued unpredictability in school and day-care schedules this fall may create a double dip in working parents' labor force participation. Almost seven in 10 parents said that they or their partner would have to quit their jobs if the current level of uncertainty continues into 2022. At 76%, the U.S. has the lowest rate of employment among its prime-age population compared with other wealthy, developed nations. Beyond perpetuating poverty, lower labor force participation rates also crimp a country's growth potential. "If we intend to fully compete on a global scale, we must ensure the full participation of women in the workforce," Vice President Kamala Harris said on Sept. 15 at an event where she called for further federal support for the child-care industry.

In a pinch, Green, the single mother in Boston, could have placed her two daughters in the care of their grandmother. But Green, who has an associate degree in child education, says she worried the girls would miss out on the instruction and socialization that give kids a head start going into kindergarten. Then some weeks ago, out of the blue, an old professor called to see how she was getting by. Once she heard about Green's predicament, she offered to foot the $600-a-week tab for child care while Green waits for spots to open up at a free program for low-income families.

Margot Gregory, a Pittsburgh native who had a son in November, hasn't been as fortunate. Earlier this year she put her name on wait lists at a few day-care centers, but when she finally heard back from one of them in April, the program's hours didn't work with those of the job she found managing a coffee shop. She's now at home caring for her son while job hunting, waiting for a spot to open up at a center with a more flexible schedule. "I'm kind of terrified to get offered a great job and it not work out because of child care," she says. *—Catarina Saraiva and Payne Lubbers*

THE BOTTOM LINE Some 80% of child-care providers have cut enrollment because of staff shortages. The intense competition for spots is penalizing lower-income families.

◀ Green is getting help with her child-care bill from a former professor

Mexico's Two-Track Recovery

● A U.S.-powered rebound along the northern border has left much of the country behind

Diana Rivapalacio didn't expect to be back on the factory floor two weeks after the pandemic hit. When the Tijuana facility of Tokyo-based SMK Corp. shut down in April 2020, quality-control manager Rivapalacio and the business's 800 machine operators, inspectors, and administrators headed home to uncertainty. But many returned to work that same month.

They had their city's location on the U.S. border to thank. Like many manufacturers, SMK avoided a longer lockdown by convincing Mexican authorities that one of its products, a tiny location ▶

◀ tracker, was essential since it could be used to trace shipments of vaccines or medical equipment.

Spurred by U.S. demand for Mexican-produced goods, which had been supercharged by stimulus payments, scores of companies across Tijuana found reasons to stay open—as did businesses in the rest of Baja California and other northern states. "On the border we're doing international business," Rivapalacio says. "They depend on us, and we depend on them."

Other parts of Mexico haven't been so lucky. "Every sector is having a very bad time," says Sergio Baños, mayor of Pachuca, the capital of Hidalgo, a state near Mexico City where wholesaling, retail, and services dominate. Hidalgo's economy contracted more than twice as much as Baja California's last year. Formal employment in Pachuca was down 12% in the second quarter of 2021 from the beginning of 2020. In Tijuana, it rose 8%.

"The economic recovery has been unequal among our regions," Mexican Finance Minister Rogelio Ramírez de la O acknowledged in a recent speech. By July this year, the northwest of Mexico had already moved far beyond its gross domestic product from 2018, the year before the country went into recession, according to Grupo Financiero Banorte, a Mexican bank. The center of Mexico, which depends much more on domestic demand than the north, was more than four percentage points behind its 2018 levels.

The lopsided rebound is the opposite of what President Andrés Manuel López Obrador was hoping for when he took office in 2018, promising to battle inequality and wean Mexico off its reliance on foreign companies. But his policies are partly to blame. Unlike many leaders, López Obrador didn't push through any significant increases in government spending to help shore up households and businesses during the crisis, arguing that a lower debt load would help the country bounce back faster.

López Obrador's fiscal rectitude has paid off in one important way: Colombia's credit has been cut to junk by two ratings firms this year, but few analysts see a risk of that happening to Mexico.

Pachuca's reliance on domestic demand meant it suffered from López Obrador's decision not to hike spending, says José Zaragoza, head of the local chapter of the business association Canacintra. "It would definitely have helped companies perhaps to maintain their payroll, perhaps not have to close, or perhaps to keep up their liquidity levels," says Zaragoza, who reports that business at his own construction company, Cayco Construcción, is down 40% compared with 2019.

Hildalgo's economy is set to grow only 2.8% in 2021, according to Banorte's projections, while Baja California's is expected to advance 8.2%. New factories are going up in Tijuana thanks to an influx of capital from international companies that elected to shift operations to closer to the U.S. market as their supply chains snarled up, first because of Trump's trade war with China and later because of the Covid crisis. Manufacturers said, " 'We have to make a change in our business, because we can't hold a product worth millions or billions because one component didn't arrive from Africa, Asia, or Europe,' " says Carlos Higuera, chief executive officer of PCM Corp., a Tijuana-based contract manufacturing company. Last year the floor space of Tijuana's industrial companies grew the most in at least a decade, says Edna Patricia Hernández, CEO of Tijuana EDC, which assists international companies working in the city.

▼ Projected 2021 GDP growth in Mexico by region

▲ SMK's factory in Tijuana

Growth along the border will power a 5.9% GDP expansion across Mexico this year, according to forecasts by Bloomberg Economics. Still, not all businesses in Tijuana are thriving. Smaller enterprises that aren't seeking to export are kneecapped by supply chain problems and low demand, partly because of the border closure. Juan Carlos Pérez, who for two decades has sold Styrofoam containers and paper bags out of his supply store in Tijuana, says his sales are running at 70% of normal levels. His workforce has dwindled from seven to three. "We've managed to survive because we have years in the business, but those who were just starting out—they didn't have the means to stay open," he says.

—Max de Haldevang and Maya Averbuch

THE BOTTOM LINE President López Obrador's decision not to ramp up government spending to fight the Covid recession has penalized Mexican states that rely on domestic demand.

MEXICO: ALEJANDRO CEGARRA/BLOOMBERG; JAPAN: BLOOMBERG(2). DATA: GRUPO FINANCIERO BANORTE

Fissures in Japan's Glass Ceiling

● Two women have entered the contest to become the next prime minister

Japan's ruling party is set to choose the country's next prime minister on Sept. 29. Although the leading candidate is a man, two of the four contenders are women, signaling potential cracks in the country's durable glass ceiling.

The candidacies of former internal affairs ministers Sanae Takaichi and Seiko Noda are significant. Only once before in the Liberal Democratic Party's 66-year history has a woman been able to line up the support of 20 fellow parliamentarians required to contest the leadership. That milestone was set by current Tokyo Governor Yuriko Koike in 2008.

Takaichi and Noda's entry into the race highlights how far Japan must travel to achieve gender equality, especially in the upper ranks of politics and business. It has never had a female prime minister, and women occupy only 10% of seats in the more powerful lower house of parliament. Not one company in the Topix 100 stock index is headed by a woman. And in senior management, just 15% of executives are female, according to the 2021 edition of the World Economic Forum's *Global Gender Gap Report*, which ranked Japan 120th out of 156 countries.

In 2019, Goldman Sachs posited that Japan could boost its gross domestic product by as much as 10% if it managed to increase women's participation in the labor force to the same level as men's. Yet the pandemic has reversed progress on this front, as it has in many countries, because women are overrepresented in the low-wage service industries that bore the brunt of the lockdowns, including restaurants and retail. About 700,000 Japanese women, many of them part-timers, exited the workforce in April 2020, compared with 390,000 men, according to the labor ministry. Some 50,000 of them are still without jobs.

Japan has tried to legislate its way to a better gender distribution: The country boasts one of the most generous parental leave policies in the world, and labor reforms that came into force in 2019 established equal pay for equal work and limits on overtime hours. But culturally ingrained sexism continues to hinder women's advancement.

Those who manage to make it to the top must often endure withering scrutiny. Exhausted from battling the spread of the coronavirus and the preparations for this summer's Olympic Games, Tokyo Governor Koike was admitted to a hospital in June. Instead of popular sympathy, she faced a barrage of criticism, including from former Governor Yoichi Masuzoe, who said that "taking time off for a week during a time of war with mere overwork means you're a failure as a politician."

Work-life balance is especially elusive in a nation that has historically valued face time with the boss and long hours at the office. Kazuko Hikawa recalls that, after joining the Ministry of Foreign Affairs in 1995, there were months when she clocked more than 300 hours of overtime. Among her young colleagues, the joke was "if you get three hours' sleep, you're winning."

Hikawa, a nuclear nonproliferation expert who accepted a position in academia last year, says she thinks one of the reasons gender didn't hold back her career is that she never married or had children. One of the candidates vying to become Japan's first female prime minister, Takaichi, remained unmarried until her 40s and has no biological children; the other, Noda, gave birth to a son at age 50 with the help of an egg donor.

Pressure from investors may achieve what government mandates have not. Institutional investors have had some success in prodding businesses to put more women on their boards. For the fiscal year ended this March, the number of female directors rose to 1,835, up 20.8% from the previous year, according to a review of the records of 2,220 listed corporations by Tokyo Shoko Research. Fidelity International has threatened that starting next year it may vote down a slate of directors proposed by management at any company with less than 15% female representation, approximately double what TSR reported among its universe of companies.

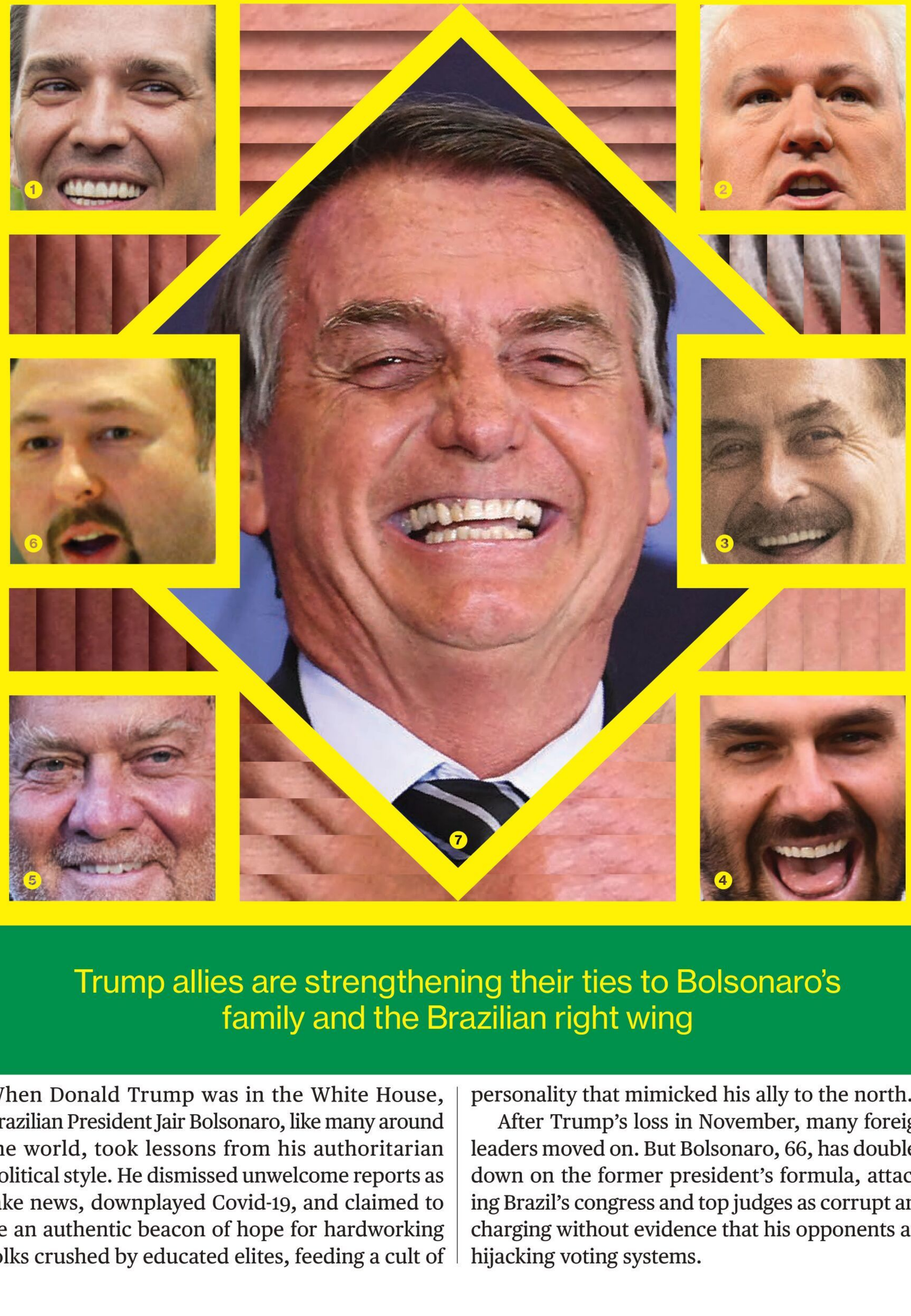
For Shoko Naito, a fourth-year student at the University of the Sacred Heart in Tokyo, it's all been too little, too late. An aspiring journalist, she has her mind set on leaving Japan when she graduates to pursue further studies abroad. "If I stay in Japan I'm afraid that I'd be swallowed up by that culture," she says. "I feel like it would be difficult to build a career here." —*Yuko Takeo and Michelle Jamrisko*

● Takaichi

● Noda

THE BOTTOM LINE Japan has tried to legislate gender discrimination out of the workplace, but the country is making slow progress in moving women into positions of leadership.

Brazil Takes The MAGA Pill



Trump allies are strengthening their ties to Bolsonaro's family and the Brazilian right wing

When Donald Trump was in the White House, Brazilian President Jair Bolsonaro, like many around the world, took lessons from his authoritarian political style. He dismissed unwelcome reports as fake news, downplayed Covid-19, and claimed to be an authentic beacon of hope for hardworking folks crushed by educated elites, feeding a cult of personality that mimicked his ally to the north.

After Trump's loss in November, many foreign leaders moved on. But Bolsonaro, 66, has doubled down on the former president's formula, attacking Brazil's congress and top judges as corrupt and charging without evidence that his opponents are hijacking voting systems.

Edited by Amanda Kolson Hurley

GETTY IMAGES (7)

As with Trump a year ago, Bolsonaro is facing a difficult reelection campaign. He's under criminal investigation and trails his likely opponent, left-leaning ex-president Luiz Inácio Lula da Silva, 75, in the polls. As he fights to maintain power, he and his inner circle, including his son Eduardo, a congressman, are drawing not just on Trump's tactics but also on many of his political advisers, too.

In August, after meeting with Trump in New York, Eduardo Bolsonaro flew to Sioux Falls, S.D., to participate in a conference focused on election fraud allegations that was organized by Mike Lindell, the pro-Trump conspiracy theorist and chief executive officer of My Pillow Inc. Introduced by Trump's former chief strategist, Steve Bannon, who's long cultivated ties to Brazil, Bolsonaro delivered a speech warning darkly of the alleged dangers of electronic voting machines used in his country. "We are exposing how ridiculous is this system," he said from the stage, showing videos claiming that rigged voting is as rampant in Brazil as Trump loyalists falsely claim it is in the U.S.

The Bolsonaro family's interest in Trumpworld has been eagerly reciprocated. With Trump exiled from Washington and the movement he led out of power for now, some Trump allies believe that Brazil under Bolsonaro has emerged as the world's foremost expression of Trumpist right-wing nationalism.

"In many ways, Brazil's movement is actually far more advanced than we are in the United States," Bannon says. He views Brazil as being among a handful of countries where Trumpist political forces could herald a global revival of right-wing nationalism—an outcome he's actively promoting. "In 2016 the Brexit win in June was inextricably linked to Trump's upset victory in November," Bannon says. "Bolsonaro's heavyweight-title fight against Lula next October," as well as the showdown in France between President Emmanuel Macron and his far-right challenger, Marine Le Pen, "will set the stage for the American midterm elections," he says. Many U.S. political experts expect Republicans to retake the House of Representatives in November 2022.

The Brazil-U.S. relationship on the right isn't new: Eduardo Bolsonaro, who advises his father on foreign affairs, regularly visits with Trump and his children in the U.S. Bannon has known Eduardo since 2018 and talks to top Bolsonaro aide Filipe Martins "a lot," according to a source familiar with the relationship. But recent weeks have seen ties appear to tighten and new connections form.

In 2019, Matt Schlapp, a prominent Trump ally who chairs the American Conservative Union, inaugurated CPAC Brasil, an offshoot of the popular Conservative Political Action Conference, traditionally held in Washington, which draws Republican luminaries and presidential hopefuls. This year's Brazil CPAC, held on Sept. 3 and 4, featured Trump's son Donald Jr. as the keynote speaker (via video, because Hurricane Ida grounded his flight).

Jason Miller, a former Trump spokesman who now runs the conservative social media outlet Gettr, spoke in person at the event. Appearing on Bannon's podcast, he said that he'd met with President Bolsonaro and that Brazil was Gettr's second-biggest user base. "In a lot of ways, President Bolsonaro has the same superpowers that President Trump does," he said.

Bannon has emerged as the key intermediary between Trumpworld and the Bolsonaros. The CEO of Trump's 2016 campaign and a top adviser at the beginning of his presidency, Bannon left the White House in disfavor after seven months. But after refashioning himself as a diehard Trump defender and promoter of pro-Trump conspiracy theories, Bannon worked his way back into the fold. In 2020 he was indicted on charges of defrauding investors in a border-wall-fundraising scheme. Bannon pleaded not guilty; just before leaving office, Trump issued him a pardon.

Following his stint in the White House, Bannon made high-profile efforts to foment a broad nationalist movement across Europe, attacking the European Union, cultivating Catholic religious conservatives in Italy and France, and publicly aligning himself with right-wing populist politicians such as Italy's Matteo Salvini. Those efforts mostly failed to gain traction, but Brazil under Bolsonaro appears more receptive to Bannon's entreaties.

Bolsonaro has sought to rekindle the anti-establishment fervor that propelled him to power in 2018, staging motorcycle rallies modeled on the huge rally in Sturgis, S.D. On Sept. 7, hundreds of thousands of green- and yellow-clad supporters of the president took to the streets in cities around Brazil. Bolsonaro told crowds that next year's elections will be a "farce," because voting machines will be manipulated by his opponents, and said he would disregard orders from the Supreme Court: "I'm letting the scoundrels know I'll never be imprisoned!" A couple of days later, he stepped back slightly, saying he'd spoken in the heat of the moment. In recent weeks, Supreme Court Justice Alexandre de Moraes has approved the arrest of some of Bolsonaro's most outspoken supporters as part of a sprawling probe into the spread of misinformation.

On the day of the demonstrations, Miller, Trump's onetime spokesman, was detained for three hours in relation to that probe before he flew out of ▶

◀ The Trump-Bolsonaro Friendship Society
❶ Donald Trump Jr.
❷ Matt Schlapp
❸ Mike Lindell
❹ Eduardo Bolsonaro
❺ Steve Bannon
❻ Jason Miller
❼ Jair Bolsonaro

◀ Brasilia. He declined to comment for this article, as did Eduardo Bolsonaro. Schlapp didn't respond to requests for comment, and neither did Jair Bolsonaro's office.

Bolsonaro was one of the last world leaders to recognize Biden's victory over Trump last November, echoing Trump's false claims that the election was rife with fraud. Trump contends that all probes of his affairs are political revenge, lacking any legitimacy. Similarly, Bolsonaro dismisses investigations into irregularities in the procurement of coronavirus vaccines and his efforts to cast doubt on Brazil's electronic ballot system.

The president's clashes with the court and his loose talk of an institutional "rupture" have spooked markets, where many see Bolsonaro channeling the kind of falsehoods that helped fuel the Jan. 6 assault on the U.S. Capitol. Polls show Lula easily beating him in 2022: Inflation in Brazil is soaring, hunger is spreading, and the inquiries are tarnishing the image of a man who promised to end political corruption.

Through it all, Bolsonaro has clung to Trumpworld.

"We're dealing with a government that's following their ideology," says Marcio Coimbra, a onetime Bolsonaro ally who heads the Economic Freedom Foundation, a right-leaning think tank in Brasilia. "When the ideology left power, they didn't stay with government but with the ideology."

Coimbra accompanied Eduardo on an official trip to Washington after Bolsonaro's election in late 2018. Although meetings were set up with top policymakers and legislators, "there seemed to be more interest in the Trump movement than institutions," Coimbra says. The Brazilian delegation attended Bannon's 65th birthday dinner in his home, where Eduardo was the guest of honor. In 2019, Eduardo joined Bannon's far-right group, The Movement, as its representative for South America.

Even the idea of the children of a democratically elected president playing a central role in government seems to borrow a page from the Trump playbook. In truth, as with many things the leaders have in common, Bolsonaro—who backs broad gun rights, opposes abortion, and has defended Brazil's military dictatorship—embraced such tactics on his own, honing them with the support of the Trumpist network around him.

But given Bolsonaro's declining popularity, it's worth asking what he thinks this bear hug of Trump will yield. Some close to him say he believes that it will keep his core base engaged and that with their support he can make it to the election runoff next year. (Presidential elections in Brazil have two rounds; if no candidate gains a majority of votes in the first round, the top two vote getters go to a runoff.)

Others say it goes beyond next year's race. Michele Prado, an expert on the rise of the far right in Brazil, says the ongoing links with Trump and his key advisers have given those around Bolsonaro a sense that they're part of something globally significant. "What is important is that ideas are shared and spread," she says. "For Bolsonaristas, it means they're not irrelevant to the world." —*Andrew Rosati, Joshua Green, and Daniel Carvalho, with Simone Preissler Iglesias*

THE BOTTOM LINE Steve Bannon plays intermediary between Trumpworld and Bolsonaro's inner circle, which have had extensive contact in recent weeks, including at Brazil's edition of CPAC.

The Great Subs Snub

● Australia's new security pact with the U.K. and the U.S. has left France seething

The way the French tell it, they never saw it coming. The first hint of the impending slight dropped on Sept. 15, when officials in Paris and the media got a whiff of the new security partnership on a late European afternoon.

The pact announced that day, known as Aukus, will see the U.K. and the U.S. share classified military capabilities with Australia, to help it develop more nuclear-powered submarines in the Pacific. It's a coup for the U.K., which has been on a quest to assert itself on the global stage after leaving the European Union.

The formal announcements, though, made no mention of France. A naval power with its own footprint in the region, it discovered that Australia was reneging on a previous deal to acquire a dozen French non-nuclear submarines. It had also been brutally cut out of a key strategic decision involving the containment of China.

France's fury was instant. The usually restrained Foreign Minister Jean-Yves Le Drian denounced the wheeling and dealing that had taken place for months without his country knowing. France focused its anger on the U.S. and Australia, recalling

BRENDAN ESPOSITO/GETTY IMAGES

its ambassadors in Washington and Canberra, but dismissed the U.K. as a bit player whose role as a "spare tire" didn't merit a diplomatic slap.

What Le Drian called a "stab in the back" predates the Group of Seven summit in June, a rare moment during the pandemic when the four leaders involved came together with others on an English beach. French President Emmanuel Macron blithely sparred with British Prime Minister Boris Johnson over Brexit, threw his arm over U.S. President Joe Biden's shoulders, and invited Australian Prime Minister Scott Morrison to Paris. He was, according to his own diplomats, unaware of the secret plan the other three were hatching.

Everyone had their own agenda, it seems, and now they have their own version of the events. The countries involved all belong to a post-World War II alliance, but they don't necessarily view the threat from an increasingly assertive China in the same light.

For Johnson, the pact is evidence that his country, once a great maritime empire, can still flex its muscles now that it's free of the EU. Details of the divorce from the bloc are still being negotiated, with financial regulation, trade in Northern Ireland, and other matters still unresolved. One promised benefit—a quick trade deal with the U.S.—remains a mirage. Nevertheless, the U.K. notched a success.

Johnson's new foreign secretary, Liz Truss, wrote an editorial 24 hours after the announcement praising the U.K.'s "readiness to be hard-headed." The *New York Times* and *Le Monde*, the establishment newspapers in the U.S. and France, saw it as a win for the post-Brexit U.K.

Aukus also sends a message to France from the U.S.: Under Biden, keeping archrival China in check is the foreign policy imperative, and if feelings get hurt along the way, so be it. There wasn't much consultation with the country's allies on pulling out of Afghanistan, either. Biden's team set up a clear-the-air phone chat with an upset Macron. In the meantime, Le Drian was appointed to replace the French president at the United Nations General Assembly gathering in New York.

Australia hasn't lost much sleep over ripping up the French deal, which was worth $65 billion. The country's long-term strategic needs have shifted. Morrison publicly acknowledged France's "disappointment," yet he also insisted his reservations about the project had been known to the French. France emphatically denies that: "The Australians have never told us of their desire to acquire nuclear propulsion, not even when we have explicitly asked them about it in recent months during our discussions," Le Drian told the newspaper *Ouest France*.

British diplomats have said that France's rage cannot be underestimated and that this moment could turn out to be as pivotal as the 1956 Suez Crisis, which led to the U.K. and France losing influence in the Middle East. Anger should inevitably make way for acceptance, but there will be a fight ahead over how Australia can compensate France for the canceled deal. France may also rethink its role in NATO, the military alliance that Macron once said was experiencing "brain death." It was partly a sense of unequal treatment that prompted Charles de Gaulle to pull France out of NATO's command structure in the 1960s.

▲ Macron with Australian officials on a Royal Australian Navy submarine in 2018

With an election coming next year, Macron has a domestic audience to cater to. His main rival, the nationalist Marine Le Pen, has decried France's "public humiliation" as the president tries to rally European support. European Commission President Ursula von der Leyen called the treatment of France "unacceptable," and high-level trade talks with the U.S. planned for late September may be delayed.

There's a limit to how much France can lash out and indeed how many of its 26 EU allies will be willing to get behind it. There is also, though, a wind of change. Le Drian drew an important distinction, describing how France sees the balance of power in Asia. He claimed that Aukus is "part of an Indo-Pacific strategy that prioritizes confrontation…and that does not bother with questions of sovereignty." France, he said, doesn't underestimate competition with China, "but we avoid prioritizing a military confrontation."

—Flavia Krause-Jackson, Ania Nussbaum, and Kitty Donaldson, with John Follain and Alberto Nardelli

THE BOTTOM LINE The Aukus pact is a diplomatic win for the U.K., but the French are unlikely to forget the insult of being cut out—and of Australia calling off a submarine deal—anytime soon.

SOONER THAN YOU THINK

THE BEGINNING IS NIGH

The pandemic has laid bare a great many problems that are past due for solutions, including some we already know how to fix. It's time to stop messing around and do it

The first techno-futurist bestseller, published in France in 1795 and quickly translated into English and other languages, envisioned not only longer life spans, increased agricultural productivity, and more efficient use of resources but also wiser citizens and better governance. Lending poignancy to this last prediction, the author of the *Sketch for a Historical Picture of the Progress of the Human Mind*, the Marquis de Condorcet, wrote it while he was in hiding from the Jacobin radicals who seized control of the French Revolution from mid-1793 to mid-1794. Condorcet, a mathematician-turned-scientific-administrator who'd briefly risen to political power in the middle stages of the revolution, died on the run not long after finishing the book. It was "a singular instance of the attachment of a man to principles, which every day's experience was so fatally for himself contradicting," quipped English clergyman Thomas Robert Malthus.

Malthus wrote this in the 1798 first edition of his famous *An Essay on the Principle of Population*, which name-checked Condorcet in the subtitle and set out to refute the late Frenchman's optimism. "Population, when unchecked, increases in a geometrical ratio," Malthus argued. "Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will shew the immensity of the first power in comparison of the second." (Example: 2, 4, 8, 16, 32, etc., vs. 1, 2, 3, 4, 5, etc.) The inevitable consequence: "misery and vice."

Thus began one of the great debates of modernity, one that continues to this day in altered but recognizable form. His untimely demise aside, Condorcet has been the clear winner so far. "Who would take it upon himself to foresee where the art of converting the elements to the use of man may one day lead?" he'd asked hopefully. Some interesting places, it turns out.

Population has grown exponentially, but so, with some fits and starts, has the food supply. Average global life expectancy has risen from about 30 years in 1800 to almost 73 in 2019. Although consumption of natural resources rose spectacularly during the Industrial Revolution and is still rising in the developing world, in recent decades rich countries have seen a steady fall in per capita energy use. Many of Condorcet's predictions about political and social change have also come true, with democracy spreading, slavery and colonialism withering, and women gaining more equal status. There's been quite a lot of misery and vice along the way, but on the whole, hope and ingenuity have won out over despair and simple math.

Which is where the stories in this year's Sooner Than You Think issue come in. Among other things, they describe attempts to build batteries and irrigation systems with smaller environmental footprints, improve our urban and rural infrastructure, and make sneakers for people who need alternatives to conventional lace-ups. Some of these efforts involve technological breakthroughs, whereas others are more about breaking through political barriers. Some are moonshots; others, deceptively simple tweaks. All require bringing some overdue willpower to bear against challenges big and small.

▲ CONDORCET

Tales of innovation and ingenuity have of course become a business-media staple in recent decades. Advances in computing, communications, medicine, energy production, and other fields have also helped create a generation of techno-futurists who can sound an awful lot like Condorcet, albeit often with a sales pitch attached.

Yet somehow or other, we haven't overcome all humanity's challenges. A deadly global pandemic—and the sputtering of U.S. life expectancy even before it arrived—have made clear that we're still a long way from "the end of infectious and hereditary diseases" that Condorcet foresaw. The rise of democratic governance has been stalled for a while now, with the Economist Intelligence Unit's Democracy Index showing declines in every region of the world in 2020. The internet, a communications advance that surely would have thrilled Condorcet, who attached great import to the rise of the printing press, has (like the early printing press, in fact) proved to be a disseminator of error and strife as well as knowledge. Global warming, the modern crisis most in line with Malthusian worries about humanity outstripping Earth's ability to sustain it, is looming ever larger as a threat to prosperity and even life and limb.

Malthus's own answer to such worries was a gloomy fatalism: Don't help the poor, because then they'll just have even more kids and increase the misery. His intellectual descendants through the centuries have tended to be more activist, with proposals ranging from the awful (the eugenic weeding out of society's "degenerates") to

PREVIOUS SPREAD: CLOCKWISE FROM TOP LEFT: PHOTOGRAPH BY ALEXI HOBBS FOR BLOOMBERG BUSINESSWEEK. PHOTOGRAPH BY ALEX BARTEL/ESTO. PHOTOGRAPH BY LIZ SANDERS FOR BLOOMBERG BUSINESSWEEK. PHOTOGRAPH BY SAGE BROWN FOR BLOOMBERG BUSINESSWEEK. PHOTOGRAPH BY MOLLY PETERS FOR BLOOMBERG BUSINESSWEEK. THIS PAGE: LIBRARY OF CONGRESS PHOTOGRAPH BY DONOVAN SMALLWOOD FOR BLOOMBERG BUSINESSWEEK.

the entirely sensible (regulation and taxation of pollution).

Amid a flareup of Malthusian concerns a half-century ago, the emphasis was on controlling growth of both population and economic activity. Mass starvation was imminent, biologist Paul Ehrlich warned in *The Population Bomb* in 1968. The Club of Rome's 1972 *The Limits to Growth* used computer models developed at the Massachusetts Institute of Technology to predict societal collapse as a result of famine, resource depletion, and/or pollution sometime in the 21st century. The subsequent oil crisis seemed to confirm that humanity was running up against a resource wall.

The oil shortages soon ended, and even though the world's population kept expanding at about the rate both books predicted, famines became rarer. *The Limits to Growth* didn't foresee big problems until well into this century and thus hasn't been entirely contradicted by events (yet). But Ehrlich had predicted a "substantial increase in the world death rate" in the 1970s and '80s; instead it fell 30%, which is what kept population growth in line with his projections even as birthrates declined. He lost a famous bet with economist Julian Simon over whether mineral prices would keep rising in the '80s.

These discredited predictions engendered something of an overreaction. Simon and his intellectual allies and heirs became increasingly dismissive of environmental concerns and convinced that market forces would solve all. The rest of us became more likely to tune out warnings of imminent doom.

But the Green Revolution in agricultural productivity that derailed Ehrlich's predictions wasn't some market-driven inevitability. It was pushed into reality by agricultural scientists, American charitable foundations, and governments around the world. It also hasn't come without costs. The ag boom in the developing world has led to the loss of lots of forests that used to store carbon. Heavy use of fertilizers and pesticides globally has brought other not-great side effects.

In other words, progress is complicated. This was actually a key point of Condorcet's *Sketch*, which consisted of a description of nine past ages of human development followed by a 10th epoch stretching into the future. It was the elimination of erroneous beliefs that had enabled humanity to move forward, he argued, and there were surely still many, many errors left to be corrected. It was precisely this that underlay his hopes for the future—humanity still had so much room to improve.

Condorcet was a semi-illustrious figure with quite illustrious associates. Voltaire was a mentor, Benjamin Franklin and Thomas Jefferson his friends, the Marquis de Lafayette a witness at his wedding. His writings before the French Revolution tended toward the dense and equation-filled and gained in prominence as social scientists embraced his zeal for applying mathematical and statistical reasoning to questions of human behavior, if not necessarily his techniques.

The hastily written *Sketch* appealed to a broader readership and attracted more criticism. "Condorcet! Thou wert as superficial in Legislation as abstruse in Geometry," harrumphed U.S. President John Adams in the margins of his copy. The historical analysis in the book is suspect, some of the language and attitudes dated, and the argumentation not always clear. It's possible that the book's remarkable success in predicting the course of the past two centuries was more about good timing than eternal truth. "There was virtually no growth before 1750," economist Robert Gordon wrote a few years ago, "and thus there is no guarantee that growth will continue indefinitely."

Still, Condorcet's book deserves at least as much attention as Malthus's more famous response. *Sketch* mixed faith in technological progress with an awareness that great turmoil often accompanies innovations, a preference for free markets with pleas for stronger governance. It preached neither complacency nor resignation but a sort of urgent, hopeful activism.

There's one thing the sudden, world-changing onset of Covid-19 has put in perspective: We really do need to deal with some of the problems that informed people have been worrying aloud about for decades. Expecting future generations to figure everything out reduces the odds of there being future generations. The pandemic has also made clear that individual action isn't enough to counter all the threats we face. We are in this together.

Innovations of the sort described in these pages cannot be expected to fix all the problems that ail the planet and the human race. Unlike gloomy fatalism, however, they're a start. Ⓑ —*Justin Fox*

EXPECTING FUTURE GENERATIONS TO FIGURE EVERYTHING OUT REDUCES THE ODDS OF THERE BEING FUTURE GENERATIONS

THE GOBLIN IN THE BATTERY

To deal with climate change and power the cars of tomorrow, we'll need to solve the cobalt problem

By Drake Bennett Photographs by Rahim Fortune and Alexi Hobbs

◀ A MATERIALS SCIENTIST IN THE LAB AT THE UNIVERSITY OF TEXAS AT AUSTIN ▲ GEOLOGIST DAVE FREEDMAN IN THE FIELD

Late in August, at a precisely specified point in the low Arctic, a geologist named Dave Freedman stood in a raw wind and a limitless expanse of tundra and began to thwack with a sledgehammer at a rock outcrop jutting up from the soil. Freedman, 29, works for a company called KoBold Metals, and the process that had brought him to this pair of GPS coordinates in Quebec's far north was complex. But the rock had had its own journey. Before it was rock, it had been magma in the Earth's mantle, part of a molten tongue tens of meters wide that had welled up as two tectonic plates spread apart 1.85 billion years ago. At first the magma had melted and eaten the layers of crust it flowed through, but, cooling as it rose, it eventually ran into resistance. The liquid pooled, like smoke along a ceiling, and then as the last of its heat bled out, solidified into a shelf of an igneous rock geologists call peridotite. Over the eons, it was lifted by tectonic collisions, tilted, folded, and broken. Glaciers ground it down. And then one day a helicopter descended from the sky and out jumped a slim, bearded man in Gore-Tex, with a high-visibility vest, a backpack, and a hammer.

After two ringing blows, a scone-size chunk of the outcrop broke off. Freedman hefted it up and blew on it. He grabbed the hand lens dangling from his vest and peered at the rock's freshly exposed face, holding it a few inches from his own. The coarse grain was a good sign. So were the seaweed-green crystals of olivine. Evidently the magma had cooled slowly here, giving it time to react with neighboring rocks and to dyspeptically exsolve out the metals it had carried up from the mantle. "When you change the composition of a melt," Freedman explained, "everything just goes haywire. Everything's boiling, and things are unhappy, and it's just a really chaotic environment."

In the middle of the face shone a cuprous M&M-size dot. Freedman, pointing to it, called it a "bleb." Somewhere nearby, within the confines of KoBold's 280-square-mile block of exploration claims, he was hoping there would be a much bigger one: an ore deposit the size of a car, maybe, or a house, rich with extractable nickel, copper, and, most valuable, cobalt. KoBold's existence is predicated on the idea that it can find high-grade ore such as that in places where others can't—and the idea that, once it does, the company will be feeding an exploding global demand.

◀ FREEDMAN BREAKS OFF ROCK SAMPLES TO FIND EVIDENCE OF COBALT

Twenty-five hundred miles south of KoBold's claims in Quebec, the other side of that bet was brewing up in a glass tank with the rough dimensions of an office water cooler, housed in a metal frame and fed by thin plastic tubes. Graduate students at the University of Texas at Austin, working under a materials chemist named Arumugam Manthiram, were flowing various dissolved metal sulfate salts into the solution in the tank to get them to combine into a solid with a specific microscopic structure. Processed further, the resulting material would power a rechargeable battery cell. But this one, unlike those currently used in both Teslas and iPhones, would need no cobalt at all.

There is a grandly prosaic term for what needs to happen to prevent the planet's climate from growing ever warmer, more extreme, and bizarre. That term is "the energy transition." This year's apocalyptic summer vividly illustrated the stakes of the energy transition, with unprecedented heat, unprecedented drought, unprecedented fires and storms and floods. All of that is because of the carbon we've already released into the air. But the grim news of the day has obscured that in the past few years there's also been dramatic technological progress in the effort to replace fossil fuels. Some of the greatest advances have come in batteries. Over the past decade improvements in energy density and reductions in manufacturing costs have combined to bring the price of

▶ SAMPLES UNDER EXAMINATION AT A MAKESHIFT LAB IN KANGIQSUJUAQ, QUEBEC

PHOTOGRAPHS BY ALEXI HOBBS FOR BLOOMBERG BUSINESSWEEK

electric vehicle batteries down almost tenfold. Analysts at Bloomberg New Energy Finance predict that within three years, the cost will drop below $100 per kilowatt-hour—the price at which electric vehicles become as cheap as gasoline-powered ones—and continue dropping. Those same advances have made it feasible to store the intermittent energy from solar cells and wind farms in "grid-scale" batteries, making renewable energy even more competitive, on price alone, with coal and natural gas power plants.

Because batteries are a technology like a microchip, rather than a commodity like oil, it makes sense that the trajectory of their capacity and cost will be closer to the former's steady exponential improvement over time. But batteries also rely on the specific qualities of certain elements to work. The highest-performing lithium-ion batteries on the market today require cobalt, and cobalt is hard to come by. Most of the known reserves lie under Congo, a country plagued by corruption and frequent wars, where mining often occurs in dangerous, deadly conditions, and not infrequently is done by children. Chinese companies own most of Congo's mines—clean energy, like dirty energy, has its geopolitics. The metal's price has fluctuated wildly in recent years.

Even if the electric vehicle industry stayed the size it is today (there are a little more than 12 million EVs on the road), it would behoove battery makers to find alternatives. Replacing the world's 1.2 billion internal combustion vehicles—as we will need to do in the coming decades to have any hope of cutting greenhouse gases—will require something much more dramatic. Solving the climate problem requires solving the battery problem, and solving the battery problem requires solving the cobalt problem.

Among the companies springing up to do that, some are focusing on recycling cobalt out of spent batteries. Others are rethinking ore processing to make once-marginal deposits more cost-effective. A few are trying to mine the ocean floor. But on the most basic level, the approaches are about finding more metal, as KoBold is attempting to do, or figuring out how to use less, like the Manthiram lab. They're complementary, of course, but they also rely on different conceptions of the future and different diagnoses of the problem. Balkanized, in parallel and at occasionally cross purposes, they're working against the same clock.

"My story is that I should not be here," Manthiram says, sitting in his ninth-floor office in Austin, below a bank of framed patents and bookshelves colorful with toylike, wood-and-metal models of molecules. Manthiram was born in 1951, to parents with no formal education, in a tiny village called Amarapuram, in Tamil Nadu, near India's southern tip. His father, who sold firewood for a living, died two months later—Manthiram doesn't know of what—and his mother never remarried. Instead she focused her energy on her only child. She heard about a Catholic school in the next village and sent him there. "Two miles going, two miles coming back, through the jungle!" Manthiram recalls. "There was no road. There was no weather forecast." When he graduated high school, his mother's ambition was for him to open a general store in Amarapuram. One of his teachers convinced her that her son had the potential for a different future. The three of them—teacher, mother, and son—took the bus to a small college 40 miles away where the teacher arranged for the gifted young man to be accepted. ▶

◀ In the late 1970s, when Manthiram was getting his doctorate in chemistry from the Indian Institute of Technology Madras, he focused on metal oxides, a class of materials whose molecular structure makes them useful across a wide spectrum of practical applications. At around that time, a young American physicist named John Goodenough was just starting to think metal oxides might be useful in a rechargeable battery. Goodenough happened to be one of the examiners on Manthiram's Ph.D. thesis and a few years later hired him as a post-doctoral researcher in his lab at the University of Oxford. When the University of Texas hired Goodenough away from England, Manthiram went with him.

One way to think about chemical reactions is as the trafficking of electrons. Elements that tend to shed electrons (sodium, for example) react with others that tend to gain them (like chlorine) and are transformed (in that case, into table salt). A battery is a technology for getting in the middle of a reaction like that and detouring the electrons to do work. The battery cell's negative end, or anode, is made of materials looking to get rid of electrons, and the positive electrode, or cathode, is made from materials looking to acquire them. Between the two is an electrolyte-soaked separator that, impervious to electrons, frustrates the two materials' desire to react. But when the battery is snapped into a flashlight or TV remote, that device's circuitry forms a loop placing the battery cell's two ends in contact. Electrons flow out from the anode and through the wiring, powering the device as they make their roundabout way to the battery cell's other, positive end. The now ionized atoms that lost those electrons make a parallel trip, migrating directly through the electrolyte membrane to balance out the charge of the cathode's accumulating electrons. (Otherwise the process would grind to a halt.)

When you recharge a phone, that process is reversed. Current from the charger forces the electrons back to the anode, and that draws the ions back through the electrolyte to reunite with them—ready to react once again, be separated, and sent on their different paths. The electrodes, both cathode and anode, are central to all of this. They have to deal with electrons and lithium ions, in the quadrillions, as the battery charges and discharges, while remaining chemically unchanged. And they have to do this over and over and over again.

In 1977 an English chemist named M. Stanley Whittingham, then at Exxon Research and Engineering Co., patented a rechargeable battery using lithium as the active mobile ion. Among the discoveries made by Goodenough and protégés such as Manthiram was that the sturdy layered crystal lattice cobalt forms when bonded to oxygen is almost uniquely effective as cathode material. Layered nickel oxide works similarly, but it's much harder to work with and will degrade more quickly. And cobalt-based cathodes have a further advantage: Thanks to the element's thermal stability, they're less likely to light themselves on fire. Sony Corp. adapted Goodenough's cobalt-oxide design and, in 1991, released a camcorder that was the first of many consumer electronic devices to run on it. (It's difficult to imagine the iPhone ever catching on if you had to keep replacing the batteries.) In 2019, Whittingham, Goodenough, and Sony's Akira Yoshino shared the Nobel Prize in chemistry for their battery work. Goodenough, who was 97, asked Manthiram to give his Nobel lecture for him.

"THERE'S ENOUGH COBALT IN THE UPPER 1 KILOMETER OF THE EARTH'S CRUST ON THE CONTINENTS TO BUILD A MILLION ELECTRIC VEHICLES FOR EVERY PERSON ON THE PLANET"

Manthiram, for his part, has been worrying about cobalt since the early 1990s, when he took over his own lab at the University of Texas. That lab is now considered one of the world's leaders on lithium-ion battery research. That list also includes Jeff Dahn, a physicist at Canada's Dalhousie University, and Yang-Kook Sun, a chemical engineer at Hanyang University in Seoul. Their work has already made its way onto the road: Different electric vehicles use different battery chemistries, but in general the amount of cobalt in them has declined with each new design. Customers less concerned about power and range can buy electric cars with a different cathode design using lithium iron phosphate, a concept Manthiram and Goodenough developed in the '80s. For years, though, attempts to remove cobalt entirely without degrading battery performance failed.

▶ BAGS OF ROCK AWAITING ANALYSIS

Before it was sought out, cobalt was feared. Medieval miners in Saxony found an ore that, on first glance, resembled silver but gave off toxic fumes when smelted. Technically those were from the arsenic and sulfur that cobalt combines with, but the miners can be forgiven for eliding the distinction. They named the worthless, poisonous rock after the kobold, a type of goblin believed to haunt the mines. In the 1730s, when the Swedish chemist Georg Brandt isolated the metal, he borrowed the name. When Kurt House and Josh Goldman, who first met as physics doctoral students at Harvard, founded their company in October 2018, they, too, borrowed the name. The price of cobalt, which had approached $100,000 per metric ton earlier that year, was in the midst of collapsing by two-thirds before eventually climbing back to around $50,000. The startup raised money from the venture capital fund Andreessen Horowitz, as well as Breakthrough Energy Ventures LLC, the Bill Gates-founded clean energy fund whose investors include Jeff Bezos, Ray Dalio, and Michael Bloomberg (owner of Bloomberg LP, the parent of *Bloomberg Businessweek* and an investor in Andreessen Horowitz). KoBold hasn't disclosed how much capital it's raised, but researcher PitchBook puts the number at about $23 million. House, KoBold's chief executive officer, says the company has "funded and committed funds well in excess of $100 million."

House is at pains to emphasize that his company isn't only looking for cobalt. Doing so wouldn't make any sense. Cobalt is almost always mixed in with larger deposits of other ores, including nickel, copper, and sometimes platinum group elements. And though cobalt is currently the most valuable battery metal, and the one with the most concerning supply chain, building enough powertrains for a global post-internal-combustion car fleet is going to require a lot more of a lot of metals: nickel and lithium for the cathodes, copper for the wiring, rare earths for the powerful magnets that turn the battery's electrical energy into torque. Add up all of that, and subtract the world's known reserves, and you get $10 trillion in what House calls "missing metals."

It's important to understand exactly what that means. Cobalt isn't actually rare. "There's enough cobalt in the upper 1 kilometer of the Earth's crust on the continents to build a million electric vehicles for every person on the planet," House points out. But processing the trace amounts in which almost all of that exists would be economically ruinous. Minerals exploration is about finding the places where the twists and turns of geology have created ore concentrations freakishly large enough that it's profitable to mine them at today's metal prices and with today's extraction and refining methods. "What you need is that nature goes and scavenges the copper and cobalt from a large volume of rock, then creates new rocks that are more like 1% copper or 1% nickel or 1% cobalt," says Goldman, who serves as both KoBold's chief financial and chief technology officer. "That's a really unusual thing."

What makes finding those deposits difficult is the same fundamental problem metal hunters have faced since the Bronze Age, namely that the Earth's surface is opaque. Up until modern times, mineral discoveries were made by spotting deposits that were sticking out of the ground: outcrops colored red from oxidized iron or malachite green from copper. Such finds are still in production. North central Europe's massive Kupferschiefer deposit has been continuously mined since at least 1200 A.D. and likely for thousands of years before.

Today's explorers have an arsenal of newer tools for divining what lies underground, whether it's fleets of satellites gathering spectral imagery and gravitational field data or giant metal detector coils towed by helicopters. Even with all that, however, the vast majority of discoveries up until now have been at or near the surface. And in recent years, no matter how much money has been spent on exploration, the trend in discoveries has been steadily downward. "We're just at this point," Goldman says, "where the exploration methodologies ▶

PHOTOGRAPH BY ALEXI HOBBS FOR BLOOMBERG BUSINESSWEEK

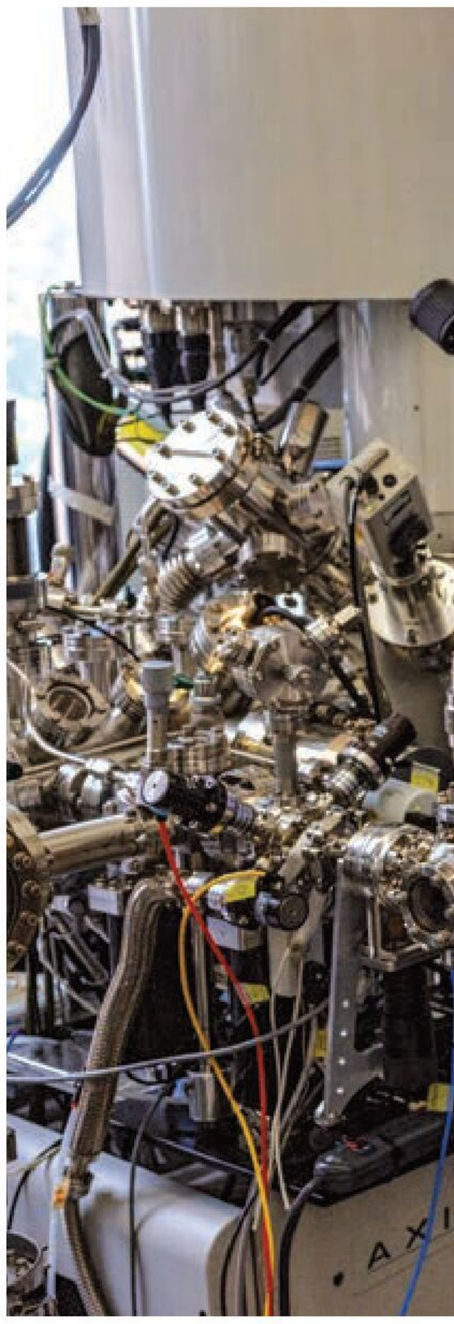
◀ that allowed us to discover the easy-to-find ore deposits have been nearly exhausted."

The limited resource, in KoBold's diagnosis, isn't ore but human cognitive power. As deposits get farther from the surface, the signals from below get too sparse and faint to be pieced together by even the best geologists. Metal deposits tend to be in remote, hostile places, and existing information about the subsurface is fragmented, inconsistent, and frequently wrong. Collecting new data by sending up an airplane with a magnetometer or shipping a drill rig to the Arctic to drill exploratory boreholes can be slow and very expensive. "These are sparse data environments," House says, even for a data science company. "This is hugely different from a social media company where people just give them information all the time and they're awash in it."

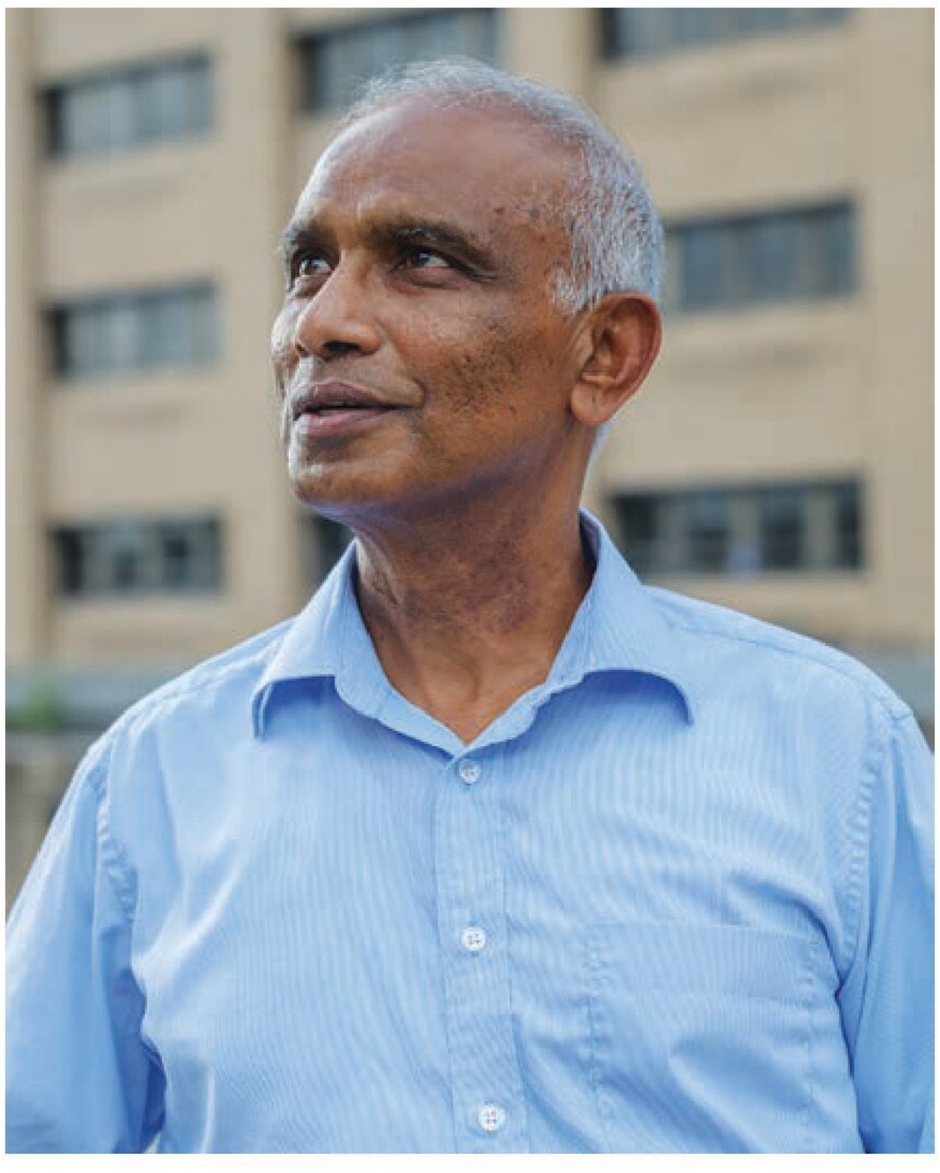
KoBold's approach is to take the kind of geologists who traditionally lead exploration efforts and yoke their expertise to the methods of data science. The company has created a database for itself out of geological information hoovered up from public and private sources all around the world: everything including academic papers, drill hole chemistry results, airborne and satellite measurements, and barely legible hand-scrawled field reports deciphered by optical character recognition. "People aren't trying to make these easy to mine for data or easy to consume," says Joanne Wood, the company's director of data engineering. "Because essentially if they found something interesting, they would prefer not to share that with the general field." The trove is searchable by KoBold's geologists and data scientists, and it forms the corpus on which the company is training a powerful machine-learning algorithm to look for ore.

To a data scientist, these kinds of problems have a special appeal. KoBold's 35 employees come from places like Google, Microsoft Corp., and Slack and tend to be coders who also have doctorates in the physical sciences. Asked why they joined the startup, they mention the satisfaction of speeding the energy transition, of course, but they also mention the opportunity to see if they're really right about something. KoBold isn't making software to sell to someone else. It's staked claims, either solely or in joint ventures, in around 20 areas across Australia, Canada, the Central African Copperbelt, Greenland, and the U.S. In early September it announced an exploration alliance with BHP Group Ltd., the world's second-largest mining group. Those ventures will either turn up ore or they will not. "What I love about KoBold," says Jef Caers, a Stanford geophysics professor who is a research partner and shareholder in the company, "is that they will face the consequences of their machine learning."

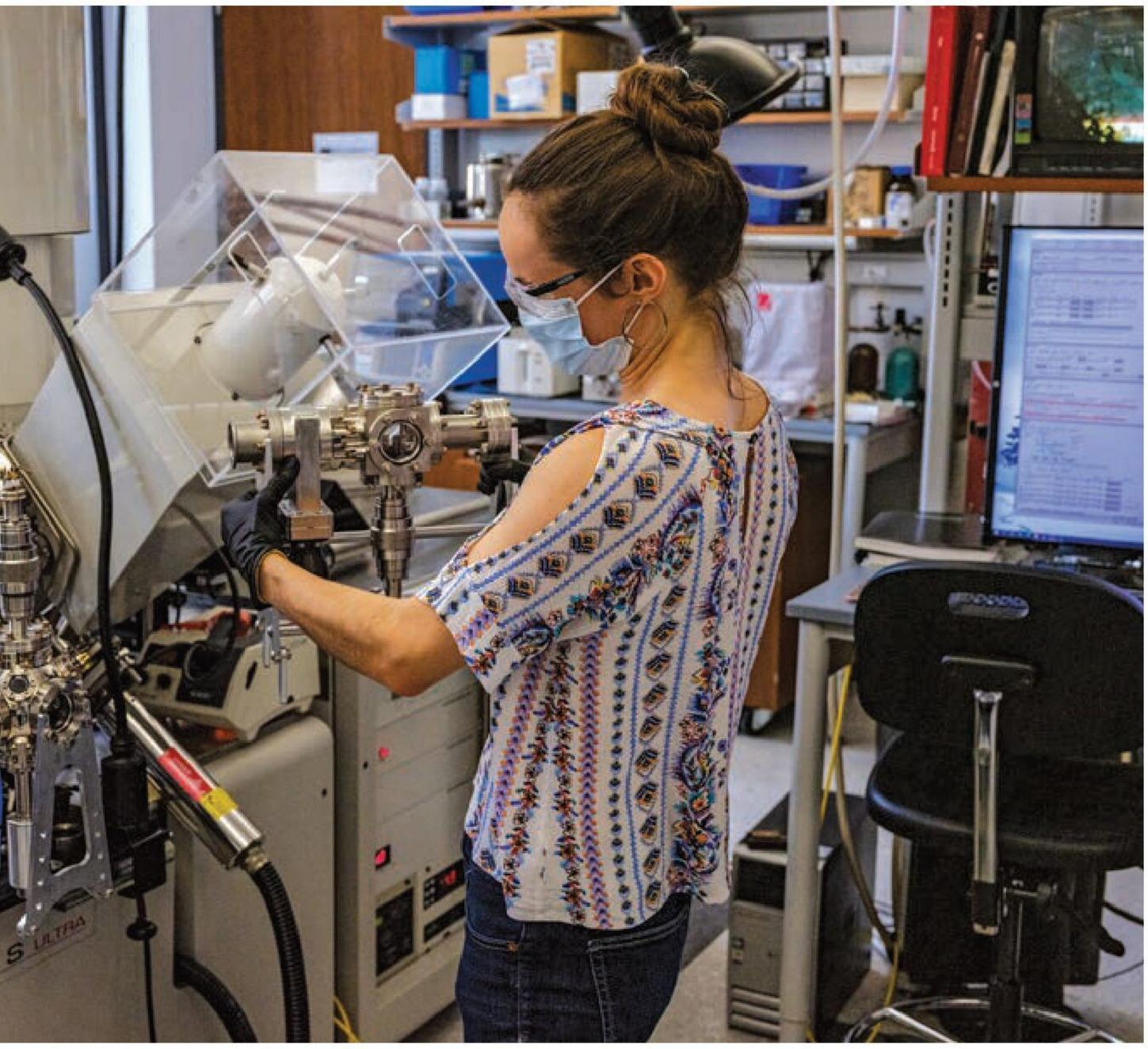
Caers has worked with KoBold to develop an algorithm for determining the size and shape of an ore body using the fewest possible drill holes. Jake Edman, an atmospheric physicist who's the company's director of machine learning, has developed a similar algorithm to choreograph the flyovers of its airborne electromagnetic surveys (the helicopter with the giant metal detector), based on what it does or doesn't find as it goes. "I know their approach works, because I've done it by hand," says M. Stephen Enders, a 45-year industry veteran who heads the department of mining engineering at the Colorado School of Mines. "I've gone into parts of West Africa and South America and other parts of the world with teams of geoscientists and all this data. It's just really labor-intensive that way." The speed and scale at which KoBold can explore, he argues, "is potentially very powerful."



The second-to-last full day of Freedman's summer in northern Quebec dawned with a dense fog. Neither of KoBold's chartered helicopters—one for the geologists, the other for the electromagnetic coil—could



◀ MANTHIRAM



▲ A GRAD STUDENT HANDLING A SAMPLE AT THE UNIVERSITY OF TEXAS

go up. Freedman spent most of the day in the second-floor conference room of the small hotel KoBold had rented out in the Inuit village of Kangiqsujuaq. From time to time the fog would thin for a few minutes, revealing the snow-flecked highlands across the bay. Laptops and handheld magnetic-susceptibility meters were strewn around the conference table, and a box of Energizer alkaline batteries occupied one chair (zinc anode, manganese dioxide cathode, if you're wondering). Sledgehammers rested on the floor. Jagged, dark rock samples were everywhere: on windowsills, under a microscope, along the walls in the white grain bags in which they would be sent south to be chemically analyzed.

Early in the evening, Freedman was speaking with Mark Topinka, KoBold's principal scientist, about the latest predictions from the company's machine-learning algorithm, "the ML," as they called it. Topinka was in the Bay Area, like many of the employees of the now fully remote company (others are spread all over the U.S. and as far afield as Zambia), and the Zoom conversation was stilted by a latency lag created by the Auberge Kangiqsujuaq's spotty internet. The two were discussing a ragged sickle on the map that the algorithm had highlighted as promising.

"Yeah, I think it's an esker," Freedman said. An esker would not be promising; as a formation created by a glacier dumping out rocks carried from elsewhere, it would have little to divulge about what was under the earth where it currently sat. Topinka thought it was worth checking out, if only to see why the ML had zeroed in on it.

Late the next morning, the fog lifted. The geologists' helicopter went up, pounding west along a river toward an area of the claim block 60 miles away. The landscape below was wrinkled, dun-colored, and dotted with meltwater lakes. Caribou had been everywhere a couple weeks before, but now they had migrated south. Keeping an eye out for polar bears, Freedman dropped off two members of his team to traverse a long ridge. A few miles away, the pilot set down by a small lake rimmed by ice floes. Not long ago, it might have stayed frozen all summer. Freedman worked his way around it, squinting at samples through his hand lens and entering the details into a Samsung tablet.

The next stop, over a low pass, was a wedge-shaped patch of ground that had befuddled the ML; Freedman examined and bagged rocks there to try to determine why. After that was a hillside that glowed a promising red in the ML's predictive map. When Freedman got there, he grew excited. Multiple samples he took had metallic ore minerals in them—dusted in among the grain or gathered into blebs. In the afternoon, he had the pilot fly by the formation he and Topinka had discussed. "Definitely an esker," he said into his headset.

The last stop of the day, and the summer, was within sight of an outcrop that Freedman had previously confirmed as "prospective" for ore. He wanted to see how far the formation went. He walked down and back up a shallow slope, his GPS readings forming a polygon that would be fed back into the algorithm, one more data point among billions. Two arctic fox pups emerged from their den to watch, drawn by the incongruous noise of human activity.

Should KoBold find what they're looking for, that noise will increase. The company would either form a partnership with or sell its find to a mining giant; the biggest, Glencore Plc, is already mining nickel and cobalt in the region. Canada's mining regulations are far stricter than Congo's, but the process is similar. The mine would be an open pit if the ore is close ▶

PHOTOGRAPHS BY RAHIM FORTUNE FOR BLOOMBERG BUSINESSWEEK

◀ enough to the surface, or a deep hole if not, ringed by an industrial village and fed by roads cut through the tundra. Extracting the ore would leave a lake of highly acidic tailings that could poison the surrounding soil and water if not carefully sequestered. "Every new mine's a good mine because you haven't seen the impacts yet," says Payal Sampat, the mining program director at the environmental watchdog Earthworks. "Digging mines is actually a massive enterprise."

Back in Kangiqsujuaq that night, the team packed up, and late the next morning they flew out to the city of Saguenay, Quebec, 900 miles due south, where they'd go their separate ways. One chartered King Air turboprop took the researchers, another took the rocks. It had been a successful month: Freedman and the ML had found lots of prospective rock. House says it's almost certain that next summer they'll be back up there drilling algorithmically optimized boreholes.

If all goes perfectly, metal from KoBold's Quebec claims might find its way into its first battery within a few years of discovery. But often that span is more like a decade or two. "It takes a very long time, even in a success case, to convert a discovery into an operating mine," says Enders at the Colorado School of Mines. By then, Manthiram says, he hopes to have helped change the fundamental chemistry of cathodes. In July 2020 the chemist, along with a graduate student of his, Steven Lee, and a postdoctoral researcher, Wangda Li, published a paper showing they could make cobalt-free cathodes—from nickel, manganese, and aluminum—that performed as well as the nickel-cobalt-aluminum and nickel-manganese-cobalt models widely used today. The cobalt-free batteries stored as much energy, charged as quickly, and had the same thermal stability. "This study," the authors wrote, "opens a new space for cathode material development for next-generation

PHOTOGRAPH BY ALEXI HOBBS FOR BLOOMBERG BUSINESSWEEK

"EVERY NEW MINE'S A GOOD MINE BECAUSE YOU HAVEN'T SEEN THE IMPACTS YET"

high-energy, cobalt-free Li-ion batteries." Manthiram has started a company, TexPower, to try to commercialize the chemistry.

The new design replaces the remaining cobalt in the cathode with nickel. To do so, Manthiram had to figure out a way to compensate for the latter's stubborn limitations. At the most fundamental level, the metal oxides that go into cathodes aren't constructed so much as grown. To the naked eye, a few precursor powders go into the mixing tank, then a different powder settles out. But seen through an electron microscope, each grain of the new powder is an aggregate of smaller particles. Zoom in further, and the porous structure of those particles emerges. That's what allows the lithium ions to come and go, while also forestalling, for as long as possible, the degradation that comes with repeated charging and discharging. Getting the multiple elements to precipitate out of the tank at the same time, in exactly the right proportion and shape, is devilishly hard. It took years of tinkering with every aspect of the process to get it right—how fast the ingredients were fed in, how fast they were stirred, the temperature and pH balance of the solution, what reagents were added. And, of course, what mix of metals to use in the first place.

Once it's dried, the cathode precursor salt goes into a furnace with lithium and oxygen. But whereas cobalt is easy to "cook," nickel is more finicky. The temperature has to be precisely monitored and the oxygen flowed over the powder at just the right rate and pressure for it to react properly. When it does, it forms still another powder (now black) that, pasted onto aluminum foil, forms a cathode. "Lithium nickel oxide was known in the '80s when Goodenough did lithium cobalt oxide," Manthiram says. "But everybody discounted it, saying we can't make it, it doesn't work. It's taken 40 years to slowly learn."

Because cobalt and nickel are found and extracted together, replacing one with the other wouldn't much hurt KoBold. Manthiram's ultimate ambition might, however. What the world really needs, he says, are batteries made from elements that don't have to be mined at all. The oceans are full of sodium, and sulfur is a ubiquitous industrial byproduct. There are batteries on the market whose two electrodes are made with those materials, but their temperature sensitivity and tendency toward corrosion make them impractical for many uses, including cars. Manthiram may not have another 40 years to figure that out, but he's patient.

Ultimately, the difference in the two approaches comes down to which limits one believes are vulnerable to human ingenuity and which are not. "Cobalt is really good," House says. Speaking into his laptop camera from his backyard in California's North Bay, he holds up his iPhone. "There's no nickel in there at all," he points out. Given the liberty not to worry about battery costs—unlike in an electric vehicle, they're a tiny fraction of the overall cost of a phone—Apple Inc. chose an all-cobalt cathode. "They're clearly going to optimize for performance, for energy density, longevity, charging rate capability, all that kind of stuff," House says. "We should by all means try to find substitutes," he concludes, "but the physics are what they are. It's still better."

"Really the bottom line is it would be highly helpful for us to have a new periodic table with some more elements to choose from," says Dahn, Manthiram's fellow battery researcher, with a laugh. "You have to think about, 'OK, what elements can I work with that are on the planet at the scale required?'" Dahn says. "And then the periodic table that you can actually use becomes pretty darn small."

Of course, a future where we run down the world's currently known reserves of cobalt—and nickel and lithium—to build billions of electric cars is, in many ways, the best-case scenario. It assumes an ability for rapid, sweeping, concerted adaptation that our species has not always demonstrated. And it sounds particularly optimistic coming from the ruthlessly probabilistic minds at KoBold. When I mention this to House, he responds, "I don't know whether we will fully electrify the vehicle fleet, or fully electrify the economy. I know we absolutely have to if we're really going to solve climate change." He would like to be part of that. Still, he points out, "I don't have to solve global warming to be a successful company," KoBold is going to fail more than it will succeed, but if it is really right just once, "we make billions of dollars." Of that, he is more confident. Ⓑ

—With Akshat Rathi and Danielle Bochove

▼ KANGIQSUJUAQ

HOLD STILL, SKYSCRAPERS

New York's tallest, most opulent residences can also be headaches to live in. Is that a problem for everyone else, or an opportunity?

By James Tarmy

Every apartment at 432 Park Ave. in New York City has a phenomenal view, but there's one direction none of its residents can look: straight down. The 1,396-foot-high, 85-story supertower was designed that way, according to its architect, Rafael Viñoly, because anyone capable of looking directly groundward would be terrified. Viñoly didn't have any outsize concern for those with a particular fear of heights. He simply knew that his ultraluxury apartment building, the unofficial team captain of Midtown Manhattan's Billionaires' Row, was going to sway like crazy in the wind. "If you saw the facade, you'd have not one, but two heart attacks, because the thing does move," Viñoly said during a lecture while the skyscraper was under construction. "Don't tell the tenants."

The tenants found out for themselves. At 432 Park, chandeliers often sway with the building, and creaking sounds can be heard on gusty nights. Elevators have been shut down in high wind because their cables were shaking too much to be safe. Right before Labor Day, the entire building had to clear out for about two days during extensive repairs to the building's electrical systems. It's hardly what residents thought they'd be getting for their $20 million-plus investments. (That sound at the edge of your hearing is the world's smallest Stradivarius.)

Neither New Yorkers nor visitors need to worry that 432 Park or its fellow concrete-and-steel metaphors might actually fall down. The companies that designed and engineered the buildings, all of which qualify as "supertall" towers of at least 300 meters (984 feet), are global leaders in this niche. They had to hew to city, state, and international standards that ensure the world's elite skyscrapers stay right-side up. As long as they can meet those safety requirements, developers have broad discretion over how much their buildings can move. Swaying is considered a matter of personal motion sensitivity; comfort, subjective.

More important for the rest of us, each generation of supertalls is a proving ground for the next, says Kate Ascher, the author of *The Heights: Anatomy of a Skyscraper* and a professor of urban development at the Columbia Graduate School of Architecture, Planning, and Preservation. "These buildings, just given their size, you can't test in a lab," Ascher says. "You put it in the field, and it operates differently."

Although that's far from soothing, advances in materials science and construction technology, along with experience, are starting to help residents' day-to-day comfort levels climb along with buildings' heights. Experts are constantly refining ideal structural shapes, masses, and weights, as well as more obscure ▶

EQROY/ALAMY

▶ 432 PARK AVE.,
NEW YORK CITY
● 1,396 FEET

“IF YOU SAW THE FACADE, YOU’D HAVE NOT ONE, BUT TWO HEART ATTACKS, BECAUSE THE THING DOES MOVE”

◀ features like the multi-ton machines known as tuned mass dampers, which are designed to limit a building's sway.

For the rest of us, it's tempting to dismiss the upshot as merely cool—or gauche, depending on your taste—because the breed of supertalls along Billionaires' Row isn't exactly making a dent in New York's affordable housing crisis. Yet as supertalls pop up around the globe in increasing profusion, including as mixed-use developments, lessons learned by the vertiginous 1% will likely apply elsewhere, too. Ascher compares the process to the way that some advances in automaking, such as heads-up displays and lane departure alerts, made their way from Mercedes limousines to Toyotas. "There's pieces that work when folks try out new things, and there's pieces that don't," she says. "And the next generation takes those things, and they become standard."

The modern history of supertalls began in 1931, when the Empire State Building, then the world's tallest at 1,247 feet, opened after barely a year of construction. The building's art deco grandeur became, over time, a symbol of American ingenuity. In the 1970s the World Trade Center towers took the title, followed by Chicago's 1,450-foot Sears Tower (now the Willis Tower) a couple of years later. In Chicago rudimentary wind tunnel analysis helped engineers guard against leaks, but the structural work relied to some degree on intuition.

What architects couldn't yet anticipate were wind vortexes. When people think of wind hitting a skyscraper, they think of it hitting a building head-on. But noticeable movement at extreme heights often occurs from wind moving around a building's sides. Think of a rock in a fast-moving stream: Directly behind that rock is a negative space, which water fills with swirling eddies. Wind works in roughly the same way, with the result that, at extreme heights, buildings are pushed and pulled sideways in a fluttering motion.

Architects' ability to mitigate these vortexes improved drastically in the early 2000s as wind tunnel modeling advanced, by which point the Petronas Towers in Kuala Lumpur had edged out the Sears Tower in height, with Shanghai's Jinmao Tower close behind. These projects depended largely on American architects and engineers, but they were often training on the job. "My first supertall was the Jinmao Tower," says Adrian Smith, a former partner at the architecture firm Skidmore, Owings & Merrill, which also designed the Sears Tower. "I quickly realized that there was not a lot of engineering history about supertalls."

While designing a planned 2,000-foot tower in Chicago that was scuttled by financing issues, the team at SOM discovered a way to reduce the force hitting the building by roughly 25%. By narrowing the facade to only the building's core at various heights, like a wedding cake with gaps between the tiers, they could diffuse much of the vortexes' power. By the late 2000s, when Smith and his team were building a tower that's currently the world's tallest—the Burj Khalifa in Dubai, which stands 2,716.5 feet—they had some new tools. The two technologies most critical to that project, he says, and the ones that laid the groundwork for slimmer supertalls, were computational modeling and the advancement of structural materials.

Concrete isn't the sexiest part of building design, but a slow, concerted series of tweaks to its material composition have allowed for buildings to grow much taller and thinner over the past couple of decades. "The neat thing about concrete is if you increase its strength, the resulting material is also stiffer," says Leonard Joseph, a principal at the structural engineering firm Thornton Tomasetti. Steel, in contrast, which is what the Empire State Building uses, will always have the same stiffness, which means you need a lot more of it as a tower gets higher. "So for high-rise steel, if you need more stiffness than strength alone, you're spending considerable extra money and material just to buy that stiffness," Joseph says.

Another component of concrete innovation is how high up mixers can send the material before it sets in the tube. During Burj construction, crews had to pump concrete up almost 2,000 feet—and the pumps' limits put an upper bound on the structure. Now tweaks to the substance's composition and improvements in pumping have made it possible to send concrete up more than 3,000 feet. "There are all these technical issues that are constantly challenged," Smith says. "Once you reach a solution you say, 'OK, can we go higher?'" Similarly the Dubai building's elevators maxed out at 123 stories a decade ago, because of the limits on the strength of the

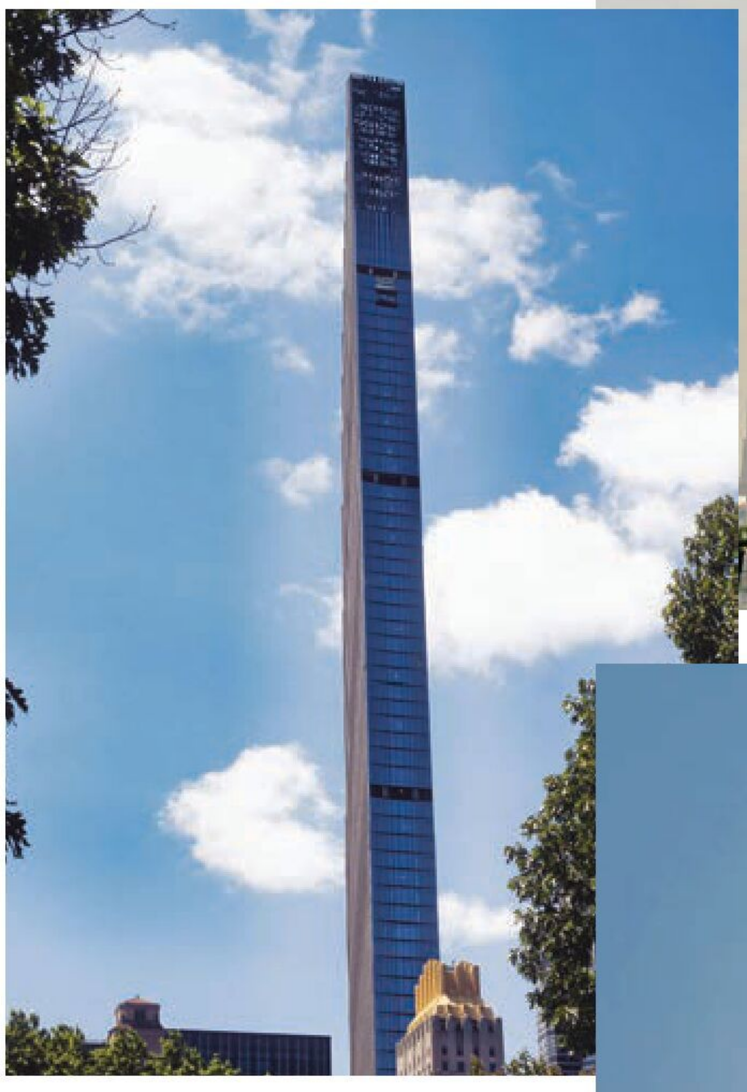
▶ WILLIS (SEARS) TOWER, CHICAGO
● 1,450 FEET

▶ JINMAO TOWER, SHANGHAI
● 1,380 FEET

▶ 111 WEST 57TH ST., NEW YORK CITY
● 1,428 FEET

▶ JEDDAH TOWER, JEDDAH
● 3,280 FEET

SEARS: EZRA STOLLER/ESTO. JIN MAO: SUEDDEUTSCHE ZEITUNG PHOTO/ALAMY. 111 WEST 57TH ST.: PATTI MCCONVILLE/ALAMY. KINGDOM: LEO MORGAN/ALAMY



elevator cables. Carbon-fiber cables now enable elevators to travel 160 stories.

The principal structural engineer for 432 Park, and most of New York's other contemporary supertalls, says his projects have been shaped profoundly by the pace of technology. "In 1980, when I did the Palace Hotel on Madison Avenue, we produced the strongest concrete ever used in New York City," says Silvian Marcus, a director of property and building structures at the engineering firm WSP. "That was maybe 6,000 psi. Today we're using concrete with 15,000 to 16,000 psi." The twin towers, considered quite slim for their day, were 9.5 times as high as they were wide. Marcus's firm is working on 111 West 57th St., which will be completed this year and has a ratio of 24:1, making it the world's slimmest. His firm also engineered Central Park Tower, currently the tallest residential building in the world at 1,550 feet, with a design from Smith's new company, Adrian Smith + Gordon Gill Architecture.

The past two decades have seen an explosion of tall buildings. From 1991 to 2001, an average of twelve 200-meter-plus structures went up around the world each year. From 2011 to 2021, the annual average was 112, according to a report by the Council on Tall Buildings & Urban Habitat, an industry-funded nonprofit. Supertalls have proliferated, too. The average height of the 100 tallest buildings in the world has increased 41% since 2001, from 284 meters to 399. Many of these structures aren't only homes for the wealthy; they're office buildings, hotels, and shopping centers.

Little can be done at 432 Park to mitigate its existing annoyances. But Smith, who also designed the future world's tallest building, the 3,280-foot (that's 1 kilometer) Jeddah Tower in Saudi Arabia, says some of the wisdom gained from those projects will translate to structures that are much taller still.

"Material technology is going to be far better than it is now," says Smith, who's pondering ways to account for the low-oxygen air on the top floors of a mile-high building. The unknowns, such as the effects on human health, are worthy of experimentation, he says: "When you design the world's tallest building, there should be an expectation that you're going to find out you don't know everything." Just don't tell the tenants. Ⓑ

NARROWING THE BY ANY MEANS

▲ A 180-FOOT RADIO TOWER IN ARKANSAS CITY, ARK., IS PART OF A PLAN TO FILL GAPS IN U.S. BROADBAND COVERAGE

E DIGITAL DIVIDE, S NECESSARY

With help from Washington, the 120 million Americans without high-speed internet access have their best shot in a generation at getting it—so long as they're flexible on how

By Austin Carr Photographs by Liz Sanders

As Elizabeth Bowles zooms down Route 65 in her black SUV, she's pointing out possible "vertical assets" on the flat horizon of browned cornfields and the occasional Dollar General. Out here in the Arkansas Delta, the rural area west of the Mississippi River, a vertical asset could be a tall flagpole, or a granary, or the smokestacks of a paper mill—anything high enough for Bowles's scrappy broadband company, Aristotle Unified Communications LLC, to rig up with telecommunications equipment so it can zap the internet to far-flung customers. "See that water tank up above the pine trees?" she asks. "If you put a radio antenna on top, you can hit everything that it can see."

Bowles is showing off her whatever-it-takes strategy for narrowing the digital divide between people with reasonably speedy internet access and those without. This gap has remained stubbornly persistent for decades, even as the internet has become steadily more inextricable from daily life, business, health care, and education. Research group BroadbandNow estimates that 42 million Americans have no broadband access, while a depressing 120 million people in the U.S. are without any connection fast enough to even call the internet, according to an October 2020 study by Microsoft Corp. These disparities are particularly severe among Black, Hispanic, Indigenous, and rural communities.

The Delta is what government officials refer to as a "high-cost area," a remote spot with a sparse population, high poverty rate, and topography that makes everything complicated. In denser towns, it's more economical for Aristotle to deliver broadband over fiber-optic cables, the industry's gold standard for speed and reliability. But Bowles says it gets way too expensive in these parts. At about $9 a foot, she notes, every mile we drive deeper into the Delta would cost $50,000 or more to snake fiber through.

To augment coverage, Aristotle is turning increasingly to Citizens Broadband Radio Service (CBRS), a wireless spectrum historically used by U.S. Navy aircraft carriers for radar transmissions. In recent years the Federal Communications Commission has opened a slice of this spectrum for commercial use, enabling Aristotle to beam broadband as far as 6 miles to distant Arkansans over signal stations—installed atop cell towers, barns, even a prison—that are sort of like massive Wi-Fi routers. The network is

◀ BOWLES IS USING FIXED WIRELESS TECHNOLOGY TO DELIVER BROADBAND TO RURAL ARKANSAS

fast enough to stream movies and costs a fraction of what fiber costs to build. "We are one of the poorest states in the country, and the Delta is the poorest area of the state," Bowles says. "If we can solve the problem here, we can solve it anywhere."

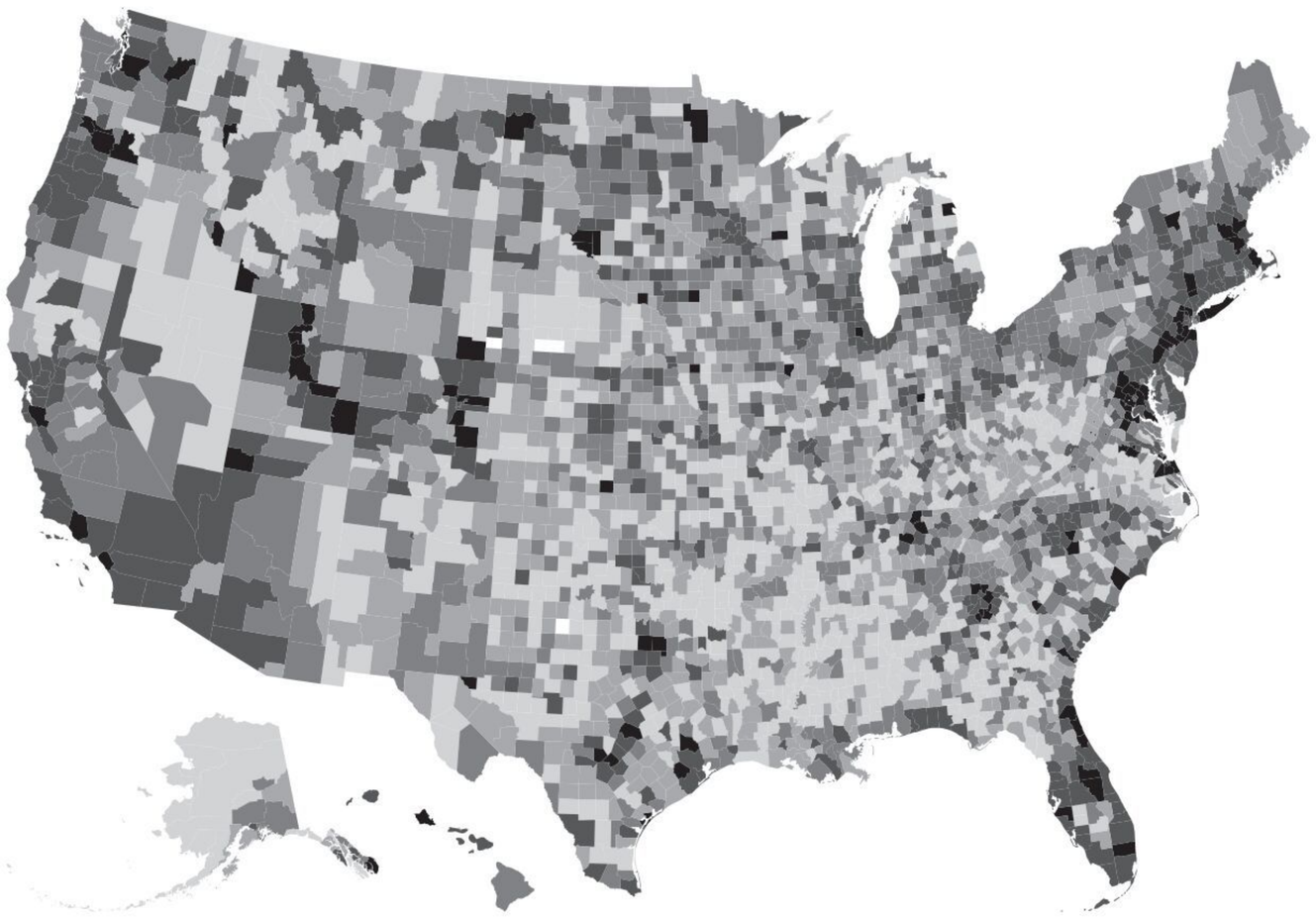
Although Bowles is an evangelist for so-called fixed wireless systems such as CBRS, she's adamant that no single technology can solve the whole problem. Fiber proponents believe unspooling cables to every address in America is the only "future-proof" option capable of handling pretty much any bandwidth-heavy application of tomorrow, a premise Bowles finds ridiculous given the price tag and the scale of terrain. Silicon Valley, meanwhile, has long gone after unproven moonshots to blast internet to the masses, from Facebook Inc.'s solar-powered plane project (killed in 2018) to Alphabet Inc.'s stratospheric balloons (scrapped this year).

The messy reality on the ground in places such as Arkansas suggests that a mix of physical and wireless networks would be cheaper and more practical than some one-size-fits-all solution. Now states are looking at the feasibility of everything from CBRS to Elon Musk's Starlink satellites to 5G home internet depending on their geographic challenges. Like Bowles, Vickie Robinson, general manager of Microsoft's Airband Initiative, a philanthropic program to bring 3 million more rural Americans online by next July, says her team advocates making use of whatever technology

is on offer. “What’s going to give you the most bang for your buck? That should be the guiding principle,” says Robinson, who’s provided Airband grant money to Aristotle for several wireless deployments.

With the Biden administration pushing ahead with its infrastructure bill, including $65 billion in broadband-related subsidies in the plan that passed the Senate, there’s a great debate playing out over which technologies the U.S. should bet on. Tom Wheeler, a former FCC chairman under President Barack Obama, is a fervent fiber-first advocate, but he acknowledges that the country will have to use every tool to connect the most isolated citizens. “I don’t care if they’re using a string and tin can if they can get the right throughput,” Wheeler says of locations fiber can’t reach. “The question becomes, where do you draw the line?”

Around lunchtime during our Delta drive, Bowles pulls into Arkansas City, a dead-quiet town of 409 residents. Aristotle’s fiber presence ended nearly 8 miles back, the point at which its network switches to CBRS and hopscotches from antenna to antenna to reach customers wirelessly. In a grass field behind the local post office, Bowles and Rick Hales, the mayor of Arkansas City, who incidentally works for Aristotle as its director of community partnerships, walk me to a 180-foot radio tower the company lit up earlier this summer. “The first customer we turned on in the county was the county judge,” Hales recalls. “His wife called and said, ‘Rick, Netflix is running good!’”



*BROADBAND SPEEDS GREATER THAN OR EQUAL TO 25 MBPS. DATA: MICROSOFT, OCTOBER 2020

Aristotle was able to expand this far sooner thanks to $31 million in grants stemming from the Trump-era federal stimulus package in response to Covid-19, which marked a major turning point in broadband investment. In past decades the U.S. government’s efforts to close the digital divide were mostly sporadic and poorly funded. In 1996, President Bill Clinton committed to wiring up every classroom and library by the new millennium; the Bush administration called for universal broadband by 2007; and President Obama set a goal of giving 20 million additional Americans coverage by last year. None of it was enough.

The pandemic exposed the consequences of such buck-passing. “Nobody gets it on that visceral level until their employees can’t work or their kids can’t do homework,” Bowles says. That disparity was obvious in Arkansas City, where locals complain of past internet service from horrendously slow old-school satellite dishes and DSL connections, pricey cellular hotspots, or Vyve Broadband, a telecom that abandoned the town during the pandemic. (Vyve President Andrew Parrott says that a pilot wireless system struggled in the area’s “excessive foliage” and that the company decided to discontinue service following a severe storm in April that damaged its equipment.)

Geoffrey Wright, an assistant superintendent for Arkansas State Parks, whose office is a stone’s throw from Aristotle’s new signal tower, recalls a half-dozen students who didn’t have internet at home frequenting the picnic tables outside last fall to use the facility’s taxpayer-funded AT&T Wi-Fi for remote schooling. He’d bring out a couple of fans to cool them in the 90F heat. Wright says AT&T Inc. ran a fiber line to the parks center, but the company never offered residential service. “When the AT&T guy was here, I asked if he could run the line another 30 feet to my house,” Wright tells me. “He essentially said, ‘Nope, can’t do it. We won’t get enough customers for it to be worth it.’” An AT&T spokesperson says, “Our decisions to build and expand our networks are based on capacity needs and demand for our services, nothing more.”

Bowles is a pro at writing grant proposals—“I crank ’em out,” she says—but the disconnect between Washington and rural Arkansas makes the task a bureaucratic pain. The FCC’s broadband maps are notoriously inaccurate, because they rely on amorphous census blocks instead of address-by-address ▶

◀ data. If internet providers report service at just one home in a vicinity, the whole area is considered covered, which has forced Bowles to challenge the government's false positives to be eligible for certain subsidies. Microsoft, which analyzes national broadband data as part of its Airband Initiative, reported in 2020 that eight times as many Americans as the FCC then estimated didn't have access to the internet at modern baseline speeds.

There's also a strong sense that Beltway officials don't grasp what it takes to install fiber in backcountry. Steven Porch, who doles out federal grants to state recipients as head of the Arkansas Rural Connect program, says that in rocky regions the trenching alone for cables could cost a quarter of a million dollars per mile, and stringing lines across telephone poles is risky with storms an ever-present threat. He needs to include fixed wireless as an alternative when considering how to budget for connecting the entire state. "Do I spend over $1 million to get fiber to 15 people?" he asks. "Will those 15 people sustain that network?"

Bowles says it's been "all hands on deck" to build the 133 signal stations now dotting the state, tackling the raft of unique Arkansas hurdles, from intense humidity and pine needles interfering with radio signals to electricity shortages at rustic antenna sites to dealing with land rights for installing equipment. "One of the easements we've been waiting on is from a guy who's been in Colorado elk hunting," Hales says. "That's not a big infrastructure problem—it's a daggone huntin' problem!" Even maintaining the network has been a particular challenge given the raccoons, hornets, and other creatures that burrow into its electrical systems. "We've fried quite a few squirrels," says business development specialist Jonathan Duncan.

When Aristotle's service went online in July 2021, Wright says his $60-a-month plan proved a godsend for family FaceTime chats and helped his wife manage her business from home. Jennifer Tice, owner of Mama Carol's, a ribs-and-burgers joint across the street from the tower, became an Aristotle enterprise and residential customer. "I'm just glad my security cameras are working," Tice says, referring to a set of web-connected devices monitoring the restaurant. "And my son, he loves it. He's an Xbox gamer, and if it's down, he's like, 'Call Rick and see why the Wi-Fi isn't working.'"

Of course, as Tice's kid suggests, Aristotle's system is not perfect. An administrator for C.B. King Memorial, a special-education school, says internet connections have been slow and inconsistent, to the point where the school has been unable to upload billing files online. A weekday speed test shows the school at 35 megabits per second for downloads and 11 Mpbs for uploads, above the minimum broadband standard but below the 100/20 ratio government officials are moving toward. (Bowles says that the company's network can deliver 100/20 speeds, but that C.B. King had purchased a slower plan and Aristotle's technicians concluded the school's old computer software is likely causing the problems.) Elsewhere, residents tell me they either weren't aware of the service, can survive on DSL and 4G, or simply don't see the point of the internet.

Still, considering that Aristotle only shuttered its dial-up service this past January—which the Little Rock-based company had been offering since 1995 for 50¢ per hour—the faster it can offer more connectivity options, the better for Arkansas. Other states will have to figure out their own blend of solutions. In Alaska's icy expanses, that might mean low-Earth-orbit satellites like the ones Musk and Amazon.com Inc. are pursuing will fill in fiber gaps. In urban areas, shorter-distance 5G technology, similar to what Boston-based Starry Inc. deploys, could offer a boost where other solutions aren't scalable. Alphabet is investing in optical systems that transfer huge amounts of data through the air using lasers. Microsoft is betting that television white space, which uses idle TV channel signals to beam internet service, could play a role, too, though the technology is nowhere near ready for prime time. "If you want ubiquitous coverage, we have to use every technology available to us," Bowles says.

"THE PATH TO FIBER IS NOT DUMPING TENS OF BILLIONS OF DOLLARS INTO THE MARKET AND BUILDING IT HALFWAY"

If she had her way, Bowles estimates, Arkansas could close the digital divide in five years. It'd be extremely difficult, she admits, but far faster to roll out than fiber alone and drastically less expensive. An oft-cited FCC analysis from 2017 projected that the U.S.

▲ TICE DEPENDS ON ARISTOTLE'S INTERNET COVERAGE FOR HOME AND BUSINESS

could achieve 100% fiber coverage for approximately $80 billion. Microsoft Airband's Robinson stresses that that forecast was based on the agency's faulty data. "It would be a dangerous proposition to use this finite amount of money [from Congress] to get fiber everywhere," she says. "It won't work, because you just don't know where all the gaps exist."

Of the $65 billion of broadband subsidies in the Senate's infrastructure bill, about $42 billion is allocated for equipment and service deployments, a figure Bowles finds "absurd" if the U.S. plans to push for a fiber-everywhere approach nationally. "The path to fiber is not dumping tens of billions of dollars into the market and building it halfway," she says. Researchers at Tufts University have said a fiber-only network would cost the Biden administration at least $240 billion.

The financial distributions are particularly important, because infrastructure is only part of the problem. One important shift in the Senate's bill is that it includes $14 billion in internet subsidies for low-income Americans, a focus on affordability that's crucial to narrowing the gap. The more efficiently a national network can be built, presumably the more money would be available for these sorts of subsidies. For one of its grants, for example, Aristotle spent $1.9 million to deploy CBRS and a ring of fiber around the town of Hazen, bringing broadband to about 1,860 households. Bowles says a fiber-to-the-home alternative would've cost $5.5 million, taken at least four months longer to construct, and covered just over 600 homes.

The federal government is in the process of updating its broadband map, which is likely to change the calculus of where infrastructure spending flows. If Arkansas pandemic stimulus allocations offer any preview, the $87 million in Trump-era grants were split 50% to fixed wireless and 46% to fiber, with some of the leftover funds going to coaxial cable. A December 2020 state report said those funds are expected to cover 30,385 Arkansas homes out of the 44,874 households in the coverage footprint, a sign of how expensive this gap is to bridge even with a mix of broadband tools.

Inevitably, opinions on how to close the digital divide are available at gigabit speeds. Musk has said Starlink's satellites can scale the gap, and cable and 5G players might claim they'll eventually be able to deliver broadband at fiber speeds. Shirley Bloomfield, the chief executive officer of NTCA-The Rural Broadband Association, an advocacy group representing 850 small telecom companies, has reviewed everything out there, but she still thinks fiber is the only real future-proof solution today. Fixed wireless networks, after all, feed off fiber backhauls, the sort of physical broadband highways that link up the world's internet exit ramps.

"We are pound foolish if we don't use the right technology the first go-around," she says of fiber. "I'm not saying you have to build it out to every igloo. But at the end of the day, and maybe it's not the first year, but certainly in the first three to five years, it's going to become a much better investment."

The big concern among fiber hawks is that any alternative will consign the most disadvantaged populations, predominantly minorities and rural communities, to a slower digital lane. Bowles, however, sees a toolkit approach as the fastest way to getting more folks on the ramp to fiber speeds. Eventually, she says, the mapped lines of transition from fiber to fixed wireless will move deeper, pushing fiber backhauls closer to the homes only wireless internet can reach now. Until Aristotle can afford to go under the pine trees rustling across the Arkansas Delta, Bowles has no choice but to go over them. Ⓑ

EASE OF SHOES

Nike's Go FlyEase sneakers mark a big step for hands-free, accessible footwear. The underlying technology has more places to go

By Kim Bhasin

Earlier this year a curious sneaker popped up on Nike Inc.'s website. Instead of lying flat on the ground, the shoe has a band that squeezes it so its sole bends in the middle, creating an unusually large opening for a person's foot. Just slide your toes down into the gap and press down with your heel, and the band contracts to close the shoe into its

proper shape and hold the foot firmly in place.

This is the Go FlyEase, a breakthrough in Nike's attempts to make a sneaker that's effortless to put on and take off. Removing the shoe is a little more complicated than putting it on—wearers use a hand or the other foot to engage a built-in kickstand—but the band system makes a big difference for many people with disabilities who struggle to lace up Air Jordans. If its technology can be integrated into other sneaker designs, the Go FlyEase could open up all sorts of possibilities.

▲ REINERTSEN

"The North Star for us was creating something that was hands-free," says Sarah Reinertsen, who worked with Nike's innovation team to develop the shoe. "We just couldn't get there right away."

After her left leg was amputated almost four decades ago, when she was 7, Reinertsen spent much of her childhood wearing a clunky medical boot over her prosthesis. Today she's an accomplished distance runner and triathlete who's represented the U.S. at the Paralympic Games and set marathon records. She started with Nike as a sponsored athlete before becoming a full-time staffer and now works at the company's headquarters in Beaverton, Ore., developing more accessible footwear with athletes and the innovation team.

Normalizing fashions that make things easier for marginalized groups isn't easy, but it's happened before. Eyeglasses are medical devices worn right on the face, made ubiquitous so long ago that we don't think of them as technology. Canes are part of this family, too. But almost everybody wears shoes, so sneakers that improve accessibility should also be able to blend in if that's what the wearer wants.

Nike's work in this vein began in earnest during the mid-2000s, when Tobie Hatfield, who now runs design and special projects, started tinkering with custom gear for a colleague who'd suffered a stroke. The focus on ease of use coalesced in 2012, when Hatfield read a letter from a teenager with cerebral palsy who wanted to be self-sufficient but couldn't tie his shoes. Three years later the first FlyEase hit the market in the form of a LeBron James high-top that used a wrap-around zipper to open up the rear of the shoe.

The latest model took years to develop. Designers started by dissecting a Nike Roshe sneaker and experimenting on it with some surgical tubes. For the key bendable piece, they settled on a bi-stable hinge, meaning that the component can rest either open or closed, without the shoe threatening to snap shut. This proved tricky, because the designers had never put such a component in a shoe before. And they knew the final design would have to be able to be mass-produced and sold at a price people would actually pay.

The finished product retails for $120 and has three main components: the hinge, the band, and the kickstand on the heel. The Go FlyEase looks a bit odd when open and empty, but once a pair snaps onto a wearer's feet, it's unmistakably a set of Nike kicks. Early styles sold out quickly. "Aesthetically speaking, the Go FlyEase is the best compromise between fashion and utility," says Chad Jones, co-founder of Another Lane, a shoe resale website. Ryan Jans, a sneaker aficionado who was born with cerebral palsy, reviewed the shoes for the site WearTesters and gave them average marks for cushioning but strong ones for traction and fit. (His caveat: You can't adjust the band, so make sure you get the right size.)

While this latest iteration is a major advancement, there are plenty of people who can't take off the Go FlyEase without using their hands, including Reinertsen. She says it's still far preferable to a conventional sneaker. She and her colleagues are continuing to work on FlyEase designs for people with different types of disabilities, though she declined to elaborate.

Nike is studying how to incorporate FlyEase technology into performance shoes. The high-tops iteration, for example, started on the basketball court and made its way to running tracks and football fields. Pro athletes are now asking when they'll be able to compete while wearing a pair of Gos, according to Reinertsen. For now, though, the sneakers are meant for everyday wear, not Ironman triathlons. Reinertsen says the pressing demand for high-performance versions isn't lost on her. "I want this technology to hit the market sooner," she says. "We also want to get it right." B

FLYEASE: PHOTOGRAPH BY ALEX WALLBAUM FOR BLOOMBERG BUSINESSWEEK. REINERTSEN: PHOTOGRAPH BY SAGE BROWN FOR BLOOMBERG BUSINESSWEEK

CAME THROUGH DRIPPIN

Most of the world relies on flood irrigation to water crops. A more efficient alternative hasn't been widely adopted because it's so expensive. One Israeli soil physicist has the answer: a tiny plastic widget

By Elizabeth G. Dunn
Photographs by Molly Peters

On the bone-dry western flank of Arizona, where the Colorado River Basin meets the Mojave Desert, sit 11,000 acres of alfalfa, sorghum, wheat, and Sudan grass belonging to the Colorado River Indian Tribes (CRIT), all destined to be harvested and sold for animal feed. For anything to grow here, irrigation is a must. Less than a quarter inch of rain has fallen so far this year, according to Josh Moore, who manages the farm on behalf of his tribe.

"The reservation is set up on a pretty outdated flood irrigation system," Moore says. A network of canals built in the 19th century delivers water from the Colorado River, a system that seemed like a better idea before the watershed entered a persistent and increasingly dire state of drought. Although the canals supply enough water to meet CRIT's farming needs for now, the tribes are planning for a hotter, drier future. This season, black plastic tubing can be seen snaking down hundreds of rows of sorghum: an experiment with microdrip irrigation that could radically reduce the farm's withdrawals from an overtaxed watershed.

Around the world, most crops depend on rain alone for their water, but in places ▶

▲ N-DRIP SYSTEM FEEDING WATER INTO A FIELD OF COTTON IN TONOPAH, ARIZ.

◀ where rainfall isn't sufficient, we're forced to irrigate. Despite all the innovation that's made its way into agriculture in recent years, from GPS-guided tractors to genetically engineered seedlings, 85% of all irrigation is still done by releasing vast quantities of water across the surface of a field, pretty much the same way it was handled 4,000 years ago in Mesopotamia.

Flood irrigation has hung on because it's cash-cheap, but from a natural-resource perspective, it's staggeringly expensive. As much as 70% of the water goes to waste, and overwatered crops can fail to reach their full potential. Excess fertilizer is carried away by the runoff, contaminating streams, wetlands, and lakes.

Microdrip irrigation was supposed to solve all that. In the 1930s, a young engineer named Simcha Blass noticed a tree that had grown much taller than the others in the same row; when he looked closer, he found that its roots were being fed by a tiny leak from a nearby irrigation pipe. Years later, the Israeli used the concept to create a plastic drip irrigation system that went on to be sold under the brand name Netafim. It remains the global leader in its sector.

Today, there are hundreds of drip irrigation companies, but the technology is being applied to less than 5% of irrigated acres globally, usually to big-ticket crops such as almonds, wine grapes, and tomatoes. The limiting factor is cost. As the systems are currently designed, pushing water through hundreds of feet of pipe requires a lot of force, which farmers supply with pumps; electric ones if they have power in their fields, carbon-belching diesel versions if they don't. The dripper lines are also prone to getting clogged by silt particles or algae found in natural water, so it must be filtered, which adds another expense. The whole setup amounts to at least $2,000 an acre, plus energy bills. For lower-value crops such as cotton or alfalfa, drip irrigation simply doesn't pay.

The microdrip setup being used by CRIT Farms, however, cost less than $400 an acre to install, and the required pressure is supplied entirely by gravity, which has the advantage of being free and carbon-neutral. To the casual observer, the system doesn't look like much. But to Moore, the idea of drip irrigating crops for animal feed is nothing short of revolutionary. Assuming, of course, that it actually works.

"When the well's dry, we know the worth of water," Benjamin Franklin wrote in a 1746 edition of *Poor Richard's Almanack*. He didn't know the half of it. Today's global population is 10 times what it was back then, and freshwater sources are in decline. The biggest water hog by far is agriculture, which accounts for almost three-quarters of global use.

Signs of water scarcity are all around us, growing more alarming with each passing year. In August, for the first time in history, the Colorado River was declared by the U.S. government to be in a state of shortage, triggering

supply cuts to some of the 40 million people who depend on it. Five million of them get their water courtesy of the Central Arizona Project (CAP), a public utility that delivers river water by canal from the western edge of Arizona to 80% of the state's population.

Chuck Cullom, the Colorado River programs manager at CAP, has spent the past decade exploring options for increasing Arizona's water supply, including wastewater-treatment technologies and gadgets that help urban customers curb their use. In 2019, at a conference in Tel Aviv, Cullom met an executive from an Israeli irrigation startup called N-Drip, which was developing a system that promised drastic water savings without the prohibitive costs. "I was superskeptical," Cullom says. "It sounded like a unicorn solution."

▼ FARMERS COMPARE WATER USAGE AND CROP OUTPUT BETWEEN TRADITIONAL FLOOD IRRIGATION AND N-DRIP ON ADJACENT COTTON FIELDS

But agriculture accounts for the vast majority of Arizona's freshwater use, so Cullom was willing to try N-Drip. In 2020, CAP provided the system to CRIT Farms for use on 40 acres of sorghum. They found that it cut water use in half, while slightly improving the quality of the crops: a staggering result, albeit on a very small scale. This year, CAP expanded the pilot to about 200 acres of sorghum and cotton across Arizona, and, if all goes well, hopes to deploy the system regionally by 2023, continuing to cover the cost of the equipment for farmers who install it.

N-Drip is the brainchild of Uri Shani, a professor of soil physics at the Hebrew University of Jerusalem and a former chairman of Israel's water authority. He set out seven years ago to devise a microdrip irrigation system cheap enough to make sense not just for lettuces and berries but also commodity crops such as soy and corn, which make up the bulk of the world's agricultural output.

Shani is 72 years old, with short salt-and-pepper hair, wire-rimmed glasses, and an avuncular manner. He was born in 1950, on a kibbutz suffused with an angst peculiar to life in an arid country committed to agricultural self-sufficiency. "My father was an engineer who worked primarily on water. I grew up thinking about water and water solutions all my life," Shani says, speaking by Zoom from N-Drip's office in Tel Aviv.

After completing his military service with an elite commando unit, Shani went on to Hebrew University, Israel's preeminent research institution, and got a master's degree in soil physics. For his Ph.D. work, he moved to Kibbutz Yotvata, in the desert in Israel's far south. The area gets less than an inch of rain each year and has only brackish groundwater for irrigation purposes: the outer limits of agriculture. He began there as a grad student and ended up managing the kibbutz.

Shani later became a professor, and in 2006 was tapped to become the first head of the newly created Israel water authority. The role was complex, spanning engineering, management, politics, and economics, and he took it on with the country experiencing its worst-ever drought. Shani turbocharged investment in water recycling and desalination. To pay for it, he significantly—and controversially—raised the price of water.

"Around the world, the reason why there are so many water problems is very few countries are prepared to charge consumers the real price," says Seth Siegel, N-Drip's chief sustainability officer and the author of a 2015 New York Times bestseller, *Let There Be Water*, that recounts Israel's rise as a leader in water conservation and technology. In 2012, Shani left office with Israel in a freshwater surplus. "It was extraordinary what he pulled off."

A private citizen once again, Shani began ruminating on the growing threat of water shortages worldwide. More than a quarter of the world's population lives in water-stressed countries, and the United Nations estimates that water scarcity could displace 700 million people by the end of the decade. The most significant contribution he could make, he decided, would be to help drip irrigation go mainstream. That meant inventing a system that ran without filters and pumps.

To understand Shani's challenge, you first must understand what's happening inside those humble black plastic dripper lines. Along each one is a series of holes, and fastened inside every hole is a plastic widget about the size of a Tic Tac, called an emitter. Water moves through an exceedingly narrow, maze-like channel inside the emitter, regulated so it comes out in measured droplets. The resistance produced by those emitters is the reason so much pressure is required to move water from one end of a field to the other in a traditional system.

Shani conceived a new kind of emitter, one that offered so little resistance that the water ▶

◀ pressure provided by gravity alone—accrued during the 1- to 2-foot descent from the irrigation canal to the field below—would be enough to propel the water all the way down hundreds of feet of tubing and out into the ground. First, he experimented with weaving plastic and metal fibers into various three-dimensional lattice structures. But it was on a hike one day, he says, that the breakthrough came: Instead of a zigzag channel, his emitter would consist of a rod suspended inside a cylinder, with water flowing through the tube shape formed between them. Unlike with a traditional emitter, now, no single particle of debris could block the water's flow. "Boom," Shani says. "I was absolutely convinced it would work. Then we developed all the mathematics."

Once he fine-tuned the concept, Shani needed to commercialize it. He contacted Eran Pollak, a former finance ministry official with whom he'd worked closely as water chairman, and told Pollak he'd invented drip irrigation that used only gravity. Pollak was skeptical. He'd grown up on a kibbutz, too, and he knew about irrigation; there was no such thing as zero-pressure drip.

"My first reaction was, of course this would change the world, but it will never work," Pollak recounts. He met Shani at N-Drip's headquarters, which at the time was a small office in a strip mall in a Tel Aviv suburb. Shani led him to a shed out back. "It was 20 meters of pipe, manually glued together, dripping water on the ground from a small plastic garbage can," Pollak says. "It was in the most elementary stage imaginable, but this was the minute in which I understood it could work." Pollak signed on as chief executive officer.

N-Drip installed its first official field trial at the end of 2017, on five acres of sugarcane in Eswatini (formerly Swaziland), drawing water directly from a river. They found that the system not only worked and used less water but also increased crop yields by 30%. With encouraging results in hand, N-Drip moved on to larger trials in Australia and the U.S., and has since expanded to 17 countries, from Vietnam to Nigeria. If Shani's vision bears out, N-Drip stands a chance at modernizing millions more farms, and transforming freshwater consumption globally.

To date, N-Drip has raised $25 million in funding, and its system is being used by hundreds of farmers for 4,000 acres' worth of crops, ranging from cotton to potatoes to soybeans. But Shani has a long way to go if he intends to convert the Earth's 600 million flood-irrigated acres, and the road from garden shed to global irrigation solution will have plenty of obstacles.

Because N-Drip doesn't use filtration, most of the hiccups thus far have had to do with all the unexpected things one might find in water on a farm. Early in one trial, a California grower contacted N-Drip in a panic to say that his system had stopped functioning. When Shani arrived, he found a fish the size of his index finger clogging one of the pipes. A clump of green algae did something similar on a farm in Kazakhstan. Now, N-Drip's water tanks are outfitted with mesh netting to capture all manner of plant and animal life.

In the baking sun of Arizona, in a region with particularly mineral-rich water, the dripper lines got so hot that calcium carbonate precipitated out, coating the emitters in limescale like the inside of a British teakettle. That led N-Drip to develop protocols for burying its lines in a thin coating of soil to keep them cool and for using softeners on hard water.

"MY FIRST REACTION WAS, OF COURSE THIS WOULD CHANGE THE WORLD, BUT IT WILL NEVER WORK"

David Midmore, a professor emeritus of plant sciences at Australia's Central Queensland University and an expert on microdrip irrigation, says that if N-Drip truly plans to reach the world's 500 million small-scale farmers, and not just large, sophisticated growers, success depends not only on designing the right technology but also on investing substantially in education and support. "It's very important that the growers be taught the correct ways to drip-irrigate, to have simple measures of water in the soil, and how not to over- or under-irrigate," he says. "It's not only training, but follow-up."

N-Drip insists that small farms are a crucial part of its mission. "If a rich farmer in Australia increases yield by 47%, that's great, pop open the Champagne, take a fancier vacation that year," says Siegel, the company's chief sustainability officer. "But if a subsistence farmer increases yield, and they have more food to eat and more food to sell, it transforms that

▲ PROFESSOR URI SHANI, INVENTOR OF N-DRIP, IN MANHATTAN

family and that community."

To that end, as the Covid-19 pandemic unfolded in 2020, putting lucrative projects in the U.S. and Australia on hold, N-Drip pivoted to manufacturing a 1-acre kit designed for these users. This DIY system arrives with a link to a YouTube video and simple, Ikea-esque line drawings to guide the farmer through installation.

N-Drip has also developed a proprietary soil sensor, called N-Drip Connect, that monitors plant and soil conditions and sends farmers real-time guidance via a smartphone app on when to irrigate and fertilize. The sensor feeds back to the company's agronomic team, too, so that it can keep tabs on the field conditions.

Another challenge for N-Drip will continue to be economic. The system can be installed for a fraction of the cost of a conventional pressurized drip system, with none of the ongoing energy costs, but water is free or heavily subsidized for most farmers globally. Although some, such as Australian cotton growers, might be willing to invest to urgently protect a fast-dwindling resource, many of the world's small farmers would be unable to cover even a modest additional expense.

"The smallhold market is a huge market, and one that can benefit most from our system, but it's very difficult to do business with if you don't have a large and well-positioned partner," Pollak concedes. N-Drip envisions providing its system to these farmers primarily via nonprofits, government agencies, and large corporations making good on sustainability pledges. Its executives say the opportunity, in the near term, can be measured in hundreds of thousands of acres of agricultural land.

An early example of this sort of partnership is with PepsiCo Inc., which contracts directly with 40,000 farmers for ingredients such as corn, oats, and potatoes, and has set a goal of improving agricultural water-use efficiency by 15% by 2025. PepsiCo piloted N-Drip's technology with a handful of farmers in India, Vietnam, and the U.S., and saw improved crop yields with less fertilizer input and 50% less water consumed versus flood irrigation.

Peter Gleick, the president-emeritus and co-founder of the Pacific Institute, a nonprofit research institute focused on freshwater issues, stresses that when it comes to the future of irrigation, it's critical that we not lose sight of the big picture. Converting cotton or alfalfa fields to drip irrigation is a step in the right direction, but a larger question looms: Should we really be growing those crops in arid climates to begin with? "We need to have a real conversation about what it makes sense to grow in the water-scarce West, as well as a conversation about growing what we choose to grow more efficiently and more carefully," he says. "This technology might help with the second question, but it's not going to help with the first, more political one."

Gleick notes that it's one thing to object in principle to using precious drinking water to grow crops for animal feed, and another to tell farmers they should stop cultivating. Back at CRIT Farms, Moore says he's happy to be contributing to research he sees as vital to agriculture's future in the region. Next year he plans to use N-Drip's system on additional acreage. Although the tribes' reservation hasn't had its water quota reduced, Moore knows that shortages will come for everyone one day. "We need to start living like we're affected by those cutoffs to buy us some time," he says. "To survive as a people, and as a business, we need to be looking at technologies like this." Ⓑ

AI THAT WORKS FOR EVERYONE

Timnit Gebru, Google's former co-head of ethical AI research, on how to rethink and reform her field

By Dina Bass
Photograph by Donavon Smallwood

Timnit Gebru is one of the leading voices working on ethics in artificial intelligence. Her research has explored ways to combat biases, such as racism and sexism, that creep into AI through flawed data and creators. At Google, she and colleague Margaret Mitchell ran a team focused on the subject—until they tried to publish a paper critical of Google products and were dismissed. (Gebru says Google fired her; the company says she resigned.) Now Gebru, a founder of the affinity group Black in AI, is lining up backers for an independent AI research group. Calls to hold Big Tech accountable for its products and practices, she says, can't all be made from inside the house.

What can we do right now to make AI more fair—less likely to disadvantage Black Americans and other groups in everything from mortgage lending to criminal sentencing?

The baseline is labor protection and whistleblower protection and anti-discrimination laws. Anything we do without that kind of protection is fundamentally going to be superficial, because the moment you push a little bit, the company's going to come down hard. Those who push the most are always going to be people in specific communities who have experienced some of these issues.

What are the big, systemic ways that AI needs to be reconceived in the long term?

We have to reimagine, what are the goals? If the goal is to make maximum money for Google or Amazon, no matter what we do it's going to be just a Band-Aid. There's this assumption in the industry that hey, we're doing things at scale, everything is automated, we obviously can't guarantee safety. How can we moderate every single thing that people write on social media? We can randomly flag your content as unsafe or we can have all sorts of misinformation—how do you expect us to handle that?

That's how they're acting, like they can just make as much money as they want from products that are extremely unsafe. They need to be forced not to do that.

What, specifically, should government do?

Products have to be regulated. Government agencies' jobs should be expanded to investigate and audit these companies, and there should be standards that have to be followed if you're going to use AI in high-stakes scenarios. Right now, government agencies themselves are using highly unregulated products when they shouldn't. They're using Google Translate when vetting refugees.

As an immigrant [Gebru is Eritrean and fled Ethiopia in her teens, during a war between the two countries], how do you feel about U.S. tech companies vying to sell AI to the Pentagon or Immigration and Customs Enforcement?

People have to speak up and say no. We can decide that what we should be spending our energy and money on is how not to have California burning because of climate change and how to have safety nets for people, improve our health, food security. For me, migration is a human right. You're leaving an unsafe place. If I wasn't able to migrate, I don't know where I would be.

Does anything give you hope about increasing diversity in your field? The labor organizing at Google and Apple?

All of the affinity groups—Queer in AI, Black in AI, Latinx in AI, Indigenous AI—they have created networks among themselves and among each other. I think that's promising and the labor organizing, in my view, is extremely promising. But companies will have to be forced to change. They would rather fire people like me than have any minuscule amount of change. B

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