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A woman with dark hair and bangs is smiling broadly, looking upwards and to the right. She is wearing a light blue scarf and a brown button-down shirt over a white t-shirt with a graphic. She is standing in a workshop or factory setting, with a workbench in front of her. On the workbench, there are some tools, including a pair of scissors and a small box. The background shows industrial structures and a bright light source, possibly a skylight. The overall atmosphere is one of hope and achievement.

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It's time for a
futures market
in health care—
an innovation
that will provide
stability and
lower prices
for patients.

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WHAT OUR EDITORS ARE UP TO THIS MONTH

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PIECE IN THE EAST

Look out for Eastworld, our coming newsletter about business in China, penned by our crew in Hong Kong.

DESTINY'S CHILD

The future of design is on the agenda at our Brainstorm Design conference, March 25–26 in Singapore.

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Mission Possible



▶ A DAY BEFORE THIS ISSUE of the magazine went to press in mid-January, I went to a hipster workspace in Manhattan to hear Microsoft CEO Satya Nadella talk about the future. Naturally, he began by talking about the past. When Nadella joined the company as a 25-year-old computer scientist in 1992, Microsoft's stated purpose as a corporation was to put "a computer on every desk and in every home," as founders Bill Gates and Paul Allen famously enshrined it.

Under Gates' successor as CEO, Steve Ballmer, the mission statement went through a wordy rewrite—one that seemed to lose both its clarity and its real-world ambition. And not long after Nadella took the reins in 2014, the statement got another revise, one that has stuck until now: Microsoft's mission is "to empower every person and organization on the planet to achieve more."

"The sense of purpose and mission needs to be something you keep front and center," Nadella said in his January remarks to a smattering of tech and business reporters. "Of course, you have to reinterpret this for what is a changing world"—an imperative that, it seems, is driving the CEO to rethink what Microsoft's core aim is today, at the dawn of a new decade.

Indeed, it's a worthwhile issue for every company and organization to ponder, and *Fortune* has been doing the same—a self-reflection timed to the start of our 10th decade. Yes, our sprightly magazine has just turned a youthful 90 years old.

Fortune, as you'll see with this issue

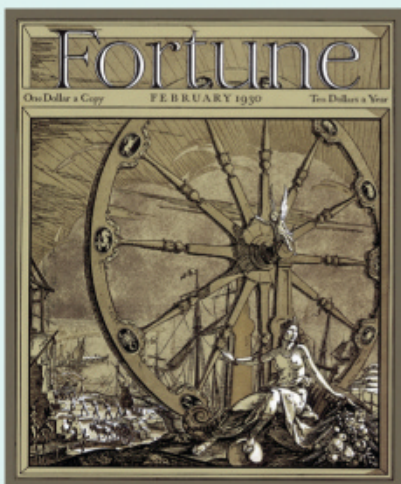
and with our stories on Fortune.com, will continue to lead the business conversation. With the guiding wisdom of history and an unflinching eye to the future, we'll report and reveal the stories that matter today—and that will matter even more tomorrow. That is the purpose that drives us. With the trusted power to convene and challenge those who are shaping industry and society around the world, *Fortune* will seek to light the path for global leaders—and give them the tools to make business better. (*Fortune* CEO Alan Murray, a seasoned editor himself, likes to shorten this to "making business better.")

It sounds awfully highbrow, I know—and maybe just a bit precious. (Such is the risk when you put things down on paper: Just look back on the sweet sentiments you wrote in your high school yearbook.) But we mean it through and through. And, I'm thrilled to say, we're investing like crazy in it.

In mid-January, we launched a new (and very fast) Fortune.com and an immersive video hub—which I hope you'll spend hours exploring. *Fortune* chief technology officer Jonathan Rivers and his remarkable tech team—in partnership with digital edit leaders Andrew Nusca and Rachel Schallom, and video czar Mason Cohn—spent months building them. (Coming soon: a new mobile app for iOS and Android.)

All of this, of course, comes with a quid pro quo. We're asking our web readers to let us know who they are. For a while, we'll continue to make our digital content free to everyone, but a paywall for nonsubscribers is coming soon. And the easiest way around that is to sub-


OUR INAUGURAL ISSUE
February 1930





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A WORK IN PROGRESS. *Fortune's* layout board for the February 2020 issue.



scribe—which I hope you will do.

To that end, my colleagues and I present this reimagined print magazine as well—the most ambitious redesign in our history. We’ve upgraded the paper stock to showcase the striking design that creative director Peter Herbert has laid out so masterfully with art director Josue Evilla—and offers, in our view, a more generous template to the images that director of photography Mia Diehl and her colleagues have so carefully curated.

Our cover this month, illustrated by Craig & Karl, whose work has been exhibited at museums in Athens, New York, Paris, and Shanghai, is both a look back to *Fortune's* many decades of bold cover design and a leap forward. (I can’t tell you how many hours the entire editorial team spent debating which of Craig & Karl’s compelling cover creations to run, so we ultimately opted for two. We hope you’ll

mix and match at the newsstand.)

My editorial colleagues—led by deputy editor Brian O’Keefe, senior features editor Matt Heimer, features editor Kristen Bellstrom, the tireless and unflappable senior editors Daniel Bentley and Lee Clifford, and a host of others—have invested an unfathomable amount of time getting each story, large and small, to sing.

At the heart of each new issue you’ll find a deep exploration of a topic that every businessperson ought to care about. For February, we’ve chosen one of the more ineluctable aspects of technology today: artificial intelligence. Careful readers will get a glimpse of where Nadella seems to be leading Microsoft, whether by mission or by manifestation: figuring out new ways to use A.I. to empower customers and his company too.

In all, I might humbly suggest that our 90th anniversary issue embodies not only our new mission statement,

but also our original one in 1930.

“*Fortune's* purpose is to reflect Industrial Life in ink and paper and word and picture as the finest skyscraper reflects it in stone and steel and architecture,” wrote founder Henry Luce. But above all, he said, we’ll make the discoveries of business clear, coherent, and vivid, “so that the reading of it may be one of the keenest pleasures in the life of every subscriber.”

Perhaps “one of the keenest pleasures in life” is too high a bar to hit. But we’ll keep aiming for it.

As always, please let us know what you think.

CLIFTON LEAF
Editor-in-Chief, *Fortune*
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**We have
a long list
of people
to thank.**



We're truly honored to be named one of the World's Most Admired Companies by Fortune. But who we really want to thank are our 125,000 employees. They bring their passion and expertise to work every day while helping to positively impact the communities we serve.





Blazing a Trail Toward Wellness Without Barriers

WellCare's holistic approach is a refreshing antidote to the compartmentalized health care status quo.

ACCORDING TO THE CENTERS FOR DISEASE

Control and Prevention, how we live, eat, work, and play wield a tangible impact on our health. For more than 25 years, one company has been leading the way in holistic care. Tampa-based WellCare Health Plans provides managed-care plans—through Medicaid, Medicare Advantage, and Medicare Prescription Drug Plans—for more than 6.4 million Americans, with a focus on going beyond doctors' offices and lab tests to treat the whole individual.

Through its visionary Community Connections program, WellCare leverages more than 500,000 social services organizations in its members' local communities to help remove social barriers such as transportation limitations and housing complications that might deter consistent preventative care.

“Our growth is made possible because our associates never lose sight of what's most important—our mission to serve our members, providers, and partners.”

KEN BURDICK
CEO, WellCare



Since 2011, Community Connections has provided nearly half a million referrals to those in need.

“We use a boots-on-the-ground approach to help our members access care and services to address their health needs,” says WellCare CEO Ken Burdick. “Our community engagement teams identify social service needs in our local communities, and our toll-free, nationwide Community Connections Help Line is available to both WellCare members and the general public.”

WellCare's 14,000-plus employees benefit from the company's core ethos as well, enjoying competitive benefits designed with work-life balance in mind, from flexible schedules and casual work environments to company-sponsored volunteer opportunities and financial assistance for emergency economic hardships.

For its groundbreaking commitment to redefining health care and broad-reaching spirit of inclusivity, the organization has garnered an impressive roster of awards. In 2019, WellCare received scores of 100% on the Disability Equality Index and on the Human Rights Campaign's Corporate Equality Index, which measures companies based on their corporate policies and practices related to LGBTQ+ workplace equality. And for the third year in a row, WellCare was named to Points of Light's The Civic 50, distinguishing it as one of the most community-minded companies in the country.

From 2014 to 2018, the organization increased revenue by 58%, and between 2014 and September 2019, grew its membership base by 70%. And with that growth comes a deep commitment to philanthropy: In 2019 alone, WellCare committed nearly \$2 million to the communities it serves and clocked its corporate volunteer rate at 75% (double the national average). Burdick says, “Our growth is made possible because our associates never lose sight of what's most important—our mission to serve our members, providers, and partners.” ■



We Are One Team

At WellCare, we believe only when we come together can we truly affect meaningful change.

We support inclusiveness; diversity of backgrounds and perspectives; and an environment where all associates are encouraged to bring their true selves to work.

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FORTUNE



The Conversation

SUNDAR PICHAJ

He's been running Google's advertising juggernaut for four years. Now he's taking over from Google's founders at the helm of holding company Alphabet and all its multibillion-dollar "other bet" science projects. His biggest challenge: leading a corporate giant through the changes of adulthood. **INTERVIEW BY ADAM LASHINSKY**

“There are a lot of advantages of scale. It allows us to take a long-term view and be very user-focused.”

WHAT TO EXPECT FROM THE NEW BOSS

When did Larry Page and Sergey Brin tell you about the change?

PICHAJ It was a series of conversations over time. As Google turned 20 last year [in 2018], that was the first time I think they probably started having longer-term conversations. Particularly when Google hit 21 in September, that was a kind of a milestone. They did actually speak about it with me in the context of the company turning 21, like a child ready to be independent. And they did want to play a different role as advisers and founders.

Alphabet was formed, and you became CEO of Google, in 2015. Now that you're running both, does the rationale hold today? Do you still need Alphabet at all?

I definitely think so. It has allowed us to not have a single management team try to scale and deal with many different separate areas. And how we need to approach each of these areas sometimes can be very, very different. They are different businesses with different time horizons. Alphabet allows us to pursue some of the other areas with maybe different structures we need. So, for example, we have a very successful venture and growth investment portfolio, **i** which allows us to partner literally with hundreds of companies.

And we can manage them with

SUNDAR PICHAJ, the 47-year-old CEO of search-ad giant Google, also became head of its parent, Alphabet, on Dec. 3, when the company's cofounders, Larry Page and Sergey Brin, announced their intention to step away from day-to-day business. In his first interview since his promotion, Pichai sat down with *Fortune* at Google's Mountain View, Calif., headquarters for a wide-ranging conversation that covered Pichai's path to power, the heavy management load he carries, and the benefits and burdens of running a massive, no-longer-youthful company. This edited version has been condensed for space and clarity.

the discipline and the rigor of an investment company. Also I think with the “other bets” **2** we are definitely at a phase where, while we take a long-term view, we also want to marry that with the discipline of making sure they are doing well. The Alphabet structure allows us to set up some of these things as independent companies and to raise money from outside investors. So if you take Verily, **3** for example, we have world-class investors like Silver Lake and Temasek, and we have a board. It’s a proper functioning company.

A TECHNOLOGIST-MANAGER LEADS

You mention investment discipline. The non-Google part of Alphabet loses a lot of money. **4 Now that you’re in charge, should we expect to see more investment discipline?** The question is, how do you assess the value of the entity you’re creating

Your claim to fame at Google was overseeing the development of the Chrome browser. Why was that so important?

In 2004, Flickr and Google Maps and Gmail were part of this exciting development where the web was shifting from just being about content to actually running applications. This was the moment when we realized the browser was actually a platform, a modern operating system for the Internet. We started working on Chrome around 2005. Chrome really found its footing in 2011 or 2012. These things take time, and that’s what innovation looks like.

BETWEEN THE LINES

(1) How Alphabet invests: Capital G is an in-house private equity fund that invests in growing companies. GV, formerly Google Ventures, takes smaller stakes.

(2) Outside the core: When Google created Alphabet, it categorized noncore entities like Waymo self-driving cars and Google Fiber broadband as “other bets.”

(3) Talk about healthy R&D: Verily Life Sciences is Google’s health-related research arm, one of several health initiatives. It has worked on projects as diverse as glucose-detecting contact lenses and robotic surgical equipment.

(4) Is the sky really the limit? Wall Street expects the non-Google part of Alphabet to lose as much as \$4 billion in 2019. The head of Waymo, for example, recently said the company has invested “billions” in that project alone.

(5) Is the new CEO less invested? Alphabet’s stock has jumped in 2020 on the assumption Pichai would be less beholden than Page and Brin to the “other bets.” This comment will fuel that fire.

and how do your other partners and other stakeholders? It’s a direction we had already gotten underway. But you will see me focused on that more and emphasize that more. **5**

Will you seek outside investors for additional Alphabet entities?

We expect most of the “other bet” companies to follow a process like that over time. **6**

I was interested to learn that while you’re an engineer, you’re not a computer scientist. You studied materials science. Why did you pursue a career as a manager rather than a technologist?

I worked in engineering for a long time. I was a semiconductor engineer. Some of my early work was on building a 1GB DRAM [chip] in ’95. **7** But with the advent of the Internet I realized it would have a profound impact on everything we do. I saw that shift and wanted to play more directly in the development of the Internet.

MANAGING AT SCALE

Google is so much bigger than when you started. As a manager, how do you confront bigness?

First of all, there are a lot of advantages of scale. It allows us to take a long-term view, be very user-focused, and pursue projects, even where the immediate value is not clear. For example, we started investing in A.I. very early on. One of the big shifts I made when I took over as the CEO was to really embrace an A.I.-first shift in terms of how we were building our products. Many years ago we had to invest tens of millions of dollars to build special A.I.-purposed chips. That was before it was clear what we would use all this for, but scale is what allows you as a company to kind of bet on those trends. But with scale comes definitely challenges. It’s tougher to

execute at scale.

But you constantly find when companies are smaller, they make more decisions that are more like betting the company. Then they tend to get more conservative at scale. So how do you make sure as a company, you're ambitious, you're willing to take risks, you're willing to be wrong, you tolerate failures as you embrace success?

Other than in "other bets," what's an example of how you're doing that in core Google?

Quantum [computing] has been a 13-year effort for us. Many years ago we saw the opportunity to provide other companies with our cloud technology, but we realized it's a deep commitment to drive that shift to be an enterprise-first company in our cloud area.

That's the kind of commitment you take and the journey you take. So we place big bets all the time. But you have to work harder at making sure you're effective.

It must be a personal challenge for a CEO too. How many direct reports do you have?

It's about 16.

That's a lot of people.

It's a lot of people. It's a big company.

8

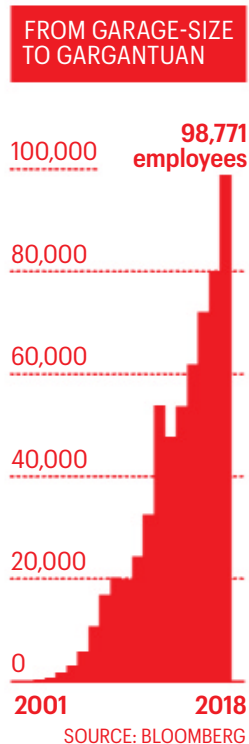
Do you intend to have a No. 2, a chief operating officer?

We have extraordinary leaders, people who are really empowered to run their businesses. And we have world-class functional leaders. I do think it's a team sport. If you think, for example, about building the great "assistant" experience in the context of Google Pixel, **9** we need different teams to come together to make that possible. And we have very capable leaders. Take Thomas Kurian running Cloud. **10** He can make decisions for Cloud. And I partner with him closely.

(6) Help could be on the way: Only Verily and Loon, a balloon-based Internet project, have drawn outside investors. Alphabet has a total of eight other noninvestment entities that could be candidates for new capital.

(7) Life before Google: Pichai worked at chip equipment maker Applied Materials after getting a master's at Stanford. He did a stint at McKinsey and earned an MBA from Wharton before joining Google in 2004.

(8) Headcount



(9) Hey, Google! Google Assistant is its answer to Amazon's Alexa. The service is built into its Pixel phones and other devices. The company says it has 500 million users.

“Transparency without context is not easy. When you have 1,000 people, everybody has shared context for what the decisions are. To try to do this at 100,000 people doesn't always work.”

So I'm hearing you say putting someone between you and your 16 direct reports is not currently a priority.

We have a structure that works well.

Let's talk about Google's famous culture. Last year you dramatically changed the company's TGIF all-hands tradition. **11 Why?**

We are going to continue having TGIF, and we will always make changes to TGIF. Most employees, when they come into Google from the outside, regardless of the level they come in, they get blown away by the level of transparency within the company. Those are all cherished traditions of the company. It is just that when the company is over 100,000 people, at what unit levels do you kind of do those things?

But you were clear at the time that there had been a problem with information leaking from the TGIFs. That implies some employees could no longer be trusted.

At their scale TGIF had definitely gotten harder. Transparency without context is also not easy. When you

have 1,000 people, everybody has shared context for what the decisions are. To try to do this at 100,000 people doesn't always work in that centralized form. So those are the nuances of it. And so it's something we are going to play with and evolve and continue. But we'll work through it as a company. We always have.

Do you think Google employees are too entitled? **12**

Oh, no. I feel fortunate to have a company where employees deeply care about the work they do and the impact the work has.

Who do you see as your biggest competitors?

I've always worried as a company at scale your biggest competition is from within, that you stop executing well, you focus on the wrong things, you get distracted. I think when you focus on competitors you start chasing and playing by the rules of what other people are good at rather than what makes you good as a company.

Do you have a scenario you plan for in which regulators break up Alphabet on antitrust grounds?

At our scale we realize there will be scrutiny. We always engage constructively, and we take feedback to the extent there are areas where sometimes we may not agree with it. But obviously we understand the role of regulators.

How can you convince skeptics that Google can be trusted with users' data?

Today, we provide some of the most important services out there for users. Every day users come to Google

CULTURE

(10) Empowered deputy: An ex-Oracle executive, Kurian joined Google last year and has been given broad authority and resources to compete against Microsoft and Amazon.

(11) Not in the garage anymore: For years Page and Brin hosted all-company meetings every Friday afternoon at which an ask-anything culture ruled. Pichai has scaled back the frequency and free-wheeling nature of the meetings.

(12) 17 types of tofu: Google is famous for its perks, from free rides to work to ubiquitous free meals and snacks to back massages and dry cleaning. Another prized perk: the ability to comment to management on anything employees like.

to ask us profound queries. Privacy is something we are constantly evolving and trying to do better. We think we can use A.I. over time to give more benefits to users with less data. That's the direction we are working on.

Your emphasis on cloud computing seems to be a clear acknowledgment that Amazon has a business worth competing against.

We are a cloud-native company. As a company we operate many services with a billion users each, and we've been doing cloud as long as anybody else. It's a big opportunity, but we are doing it because we genuinely think when we look at our technology we see that we can offer something different-shaded and we are world-class in our ability to do so. We obviously have competitors. But why you do something is about user focus. You want to originate there, for that to be a true north.

Before we run out of time, I have my Fitbit on my wrist. I don't see anything on yours.

I'm careful about [what I wear] because we're constantly testing stuff, and I never know what's released or not. We are obviously excited by the potential for using technology to help improve fitness and health outcomes for millions of people.

Last thing. You got a big raise last month. Do you and your wife have a plan for what you're going to do with your wealth?

I've always viewed society having played a big role in helping me to reach where I am today, and our intent is to give back. I've always viewed my life as a phase in which I'm working hard and trying to achieve impact in the context of the work I do through the products we build. But there's a phase of my life when I want to step back, and that will involve giving back to society. **■**



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²Expense ratio data as of 3/29/2019. Based on a comparison of total expense ratios for U.S. communication services sector-level ETFs with similar holdings and investment objectives, within the universe of 12 U.S. ETFs in the Morningstar Communications category.

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As of 11/30/2018, this fund changed its name from Fidelity Select Telecommunication Services Portfolio.

³Source: Standard & Poor's, FactSet, as of June 30, 2018.

Because of their narrow focus, sector investments tend to be more volatile than investments that diversify across many sectors and companies.

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POLITICS

Understanding the Election as Brand Marketing

Voters aren't just casting votes for people, they're choosing brands on a shelf. One thing a "brand" analysis shows? How far Democrats have to go. BY GEOFF COLVIN



▶ **WHY DID VIRTUALLY** every top pollster and pundit get the 2016 election screamingly wrong? On election eve, the *New York Times* analytical unit and the PredictWise prediction market aggregator showed Hillary Clinton winning by wide margins. FiveThirtyEight gave her a 71% chance of winning. The Princeton Election Consortium's Sam Wang put the probability at 93% and said he'd "eat a bug" if Donald Trump won; Wang later ate a cricket on CNN. Even Trump's staff didn't think he could capture the White House. A senior campaign staffer told CNN on election night, "It will take a miracle for us to win."

Yet a radically different kind of analysis, entirely overlooked at the time, got it right. This assessment considered the candidates not as politicians or even as people but rather as brands to be marketed, like cars or toothpaste. It showed that Trump was a far stronger candidate than Clinton, especially in key swing states. This analysis promises to be a powerful tool again in this election, explaining what propelled Pete Buttigieg into the top tier of Democrats, why Joe Biden looks worryingly Clintonesque, and why Trump remains by far the dominant candidate.

The framework was developed almost 30 years ago at the Young & Rubicam ad

Amateurs think brand stature is most important. But it counts for little without brand strength.

agency (now Y&R and BAV Group within the advertising giant WPP) and is still used widely. It gauges brands on two dimensions: brand stature, determined by how well-known and well-liked a brand is, and brand strength, based on a brand's differentiation and relevance. Brand marketing amateurs might reasonably assume that brand stature is most important. But it isn't. It counts for little without brand strength, which must be achieved first and is far more elusive. Achieving it, says a Y&R document, is "the central challenge of every brand."

Now think back to 2015, when 17 Republican candidates were standing on a stage. Who was the most differentiated? And who was the most relevant to the lives of consumers? It was Trump by a mile on both measures.

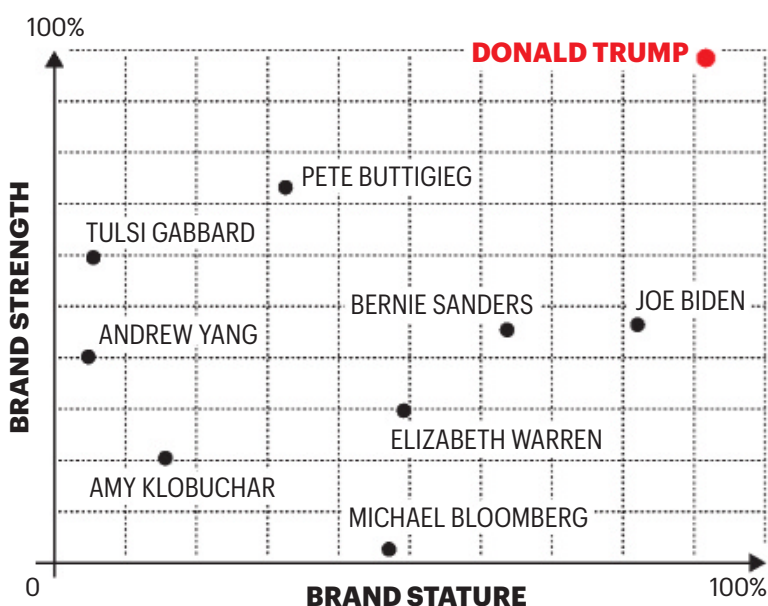
In the general election, Y&R polling showed that Trump and Clinton were about equal in brand stature (high) but that Trump's brand strength was extremely high, while Clinton's was low. She wasn't clearly differentiated; "Clinton was very similar to all other politicians," a Y&R analysis concluded. As for relevance: Everyone remembers Trump's

slogan, but can you remember Clinton's? (It was the bland "Stronger Together.") Michael Sussman, CEO of BAV Group, says high-stature, low-strength brands like hers are in a category called "commodity or eroded." By contrast, Trump's brand strength is practically off the chart, and his brand stature remains high. He's in Y&R's "leadership" category, filled with outperforming brands such as Apple and Disney.

It's true that in 2016 brand Hillary got more votes than brand Trump. But both campaigns knew the rules of the electoral system. Clinton's brand stature seemingly gave her a lock on the big industrial states that Obama had won in 2008 and 2012: Pennsylvania, Ohio, Michigan, and Wisconsin. But Trump won all of them in 2016. Brand strength—the fact that he was perceived as differentiated and relevant—carried the day. Trump's high brand stature may seem a mystery in light of his low approval ratings. But while they're low by historical standards, says FiveThirtyEight, his favorable percentages are about the same as Barack Obama's were at the same point in his first term, in the low to mid-40s. They're also about the same as the current

BRAND WARS

A plot of the major presidential candidates on their brand strength (how differentiated and relevant they are) and stature (how well-known they are). The results may frighten Democrats.



SOURCE: BAV GROUP



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ratings of the dominant Democratic challenger, Joe Biden, according to the RealClearPolitics average of polls. In addition, since brand stature depends not just on esteem for the brand but also on knowledge of it, Trump's TV-based fame is a powerful advantage over all other candidates. In mid-2015, barely a month after declaring his candidacy, his name recognition was 92%, a Gallup poll found, the same as Joe Biden's is today, says the Morning Consult survey research firm. Now, with the added fame of being President, Trump's overall brand stature is slightly greater than Biden's.

In the brand-based analysis, Buttigieg is the big story of 2020 so far. Among the general population, Buttigieg notches the highest brand strength of all Democrats by wide margins—Biden is in Hillary territory—but is still well short of Trump. Buttigieg's brand stature is lower than Sanders's or Biden's, but that's okay at this stage. Brand strength is the platform on which brand stature is built, so he's positioned to migrate further than others into Trump's realm.

Anything can happen in politics, and surprises surely await. But prognosticators (and the rest of us) must remember: Candidates aren't just people. They're brands on display, and Americans are deciding which one they'll reach for. ■

ASIA

A Race for the Elusive Chinese Coffee Drinker

Homegrown Luckin Coffee is taking on the might of Starbucks in a country where a regular coffee habit is still a novelty. **BY GRADY MCGREGOR**



Zero to 3,600: Luckin outlets are opening at a rate of eight per day.

▶ **THE CHINESE CHAIN** Luckin Coffee is staking its future on two bold ideas. First, that a tech-driven retail model can satisfy customers, and second, and more important, that Chinese consumers will actually drink coffee.

Last summer, the company listed on Nasdaq, raising over \$500 million at a valuation north of \$4 billion. With this funding, the company has ramped up its dizzying growth strategy. Founded in 2017, Luckin has already opened more than 3,600 locations in China at a pace that will soon enable it to surpass Starbucks' 4,100. The strategy has divided analysts: Luckin bulls point toward profits the company has posted on a store level, but pessimists remain wary of the company's heavy spending on expansion and marketing.

STIHL

A man with a beard, wearing a grey long-sleeved shirt and blue jeans, sits on a weathered wooden bench in a lush green yard. On the bench next to him are several STIHL battery-powered tools, including a leaf blower, a trimmer, and a chainsaw. In the background, there are large trees and a white house with a blue roof. The scene is bathed in warm, golden light, suggesting late afternoon or early morning.

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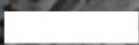
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REAL EASY

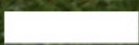
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REAL PRIDE



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A woman with curly hair, wearing sunglasses, a grey t-shirt, blue jeans, and brown boots, is using a STIHL trimmer to trim grass along a metal fence. The fence is in front of a house with a large window and a white lattice skirt. The sky is overcast with grey clouds. The STIHL logo is in the top left corner.

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TRIMMERS



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STIHL

*A majority of STIHL gasoline-powered units sold in the United States are built in the United States from domestic and foreign parts and components. ©2019 STIHL STN16FP3-12-142769-1

“If [their aggressive-ness] works out, you’ve hit one over the fence, but if it doesn’t work out, you crash and burn pretty fast,” says Jeffrey Towson, investment professor at Peking University.

Luckin’s founders are veterans of China’s car-rental industry, and many of its stores have more in common with a Hertz lot than a traditional coffee-house. In small and less prominent locations, they serve mostly as hubs for pickup and delivery orders.

This—plus the company’s mobile-ordering technology—is why it has been able to grow both quickly and efficiently.

Yet two decades after Starbucks opened its first store in mainland China, consumers still drink only five cups of coffee per year, according to the International Coffee Organization.

“The big question for Luckin has always been, do Chinese consumers really like coffee or not?” says Towson. “We’ll see.” ■

BY THE NUMBERS

EVERY 3.5 HOURS

A new Luckin Coffee location opens (on average). Starbucks is opening a new outlet in China every 15 hours.

13 YEARS

From the time Howard Schultz bought Starbucks to its opening of 3,500 stores. It took Luckin just two.

ECONOMY

The Optimism Divide

Investors have shown boundless enthusiasm, while CEOs have grown increasingly pessimistic. Somebody’s wrong.

BY GEOFF COLVIN



▶ **TROUBLE IS BREWING** when the owners of a business and the managers who run that business see the world in fundamentally different ways. That’s the uncomfortable situation right now at America’s publicly traded corporations. The owners—investors—see a brilliant future for U.S. companies, bidding their stocks up to record highs. But the managers—CEOs—see a far darker future, as revealed in surveys of CEO sentiment. The contrast is starker than it has been in years, perhaps decades. “Somebody’s wrong,” says investment strategist Rob Arnott of Research Affiliates, “and is going to have to change their plans.”

Investors’ ebullience is obvious in the stock market, where dollars do the talking. But the deep pessimism of CEOs is less visible and has gone largely unnoticed. They’re invariably upbeat when speaking to investors, but when CEOs respond anonymously to surveys, their mood shifts dramatically. The economic outlook of CEOs surveyed by the Business Roundtable recently worsened for the seventh consecutive quarter. Most of the bosses don’t expect a recession, but the possibility of one is now their No. 1 worry, up from No. 3 a year ago, says a survey

by the Conference Board. The Roundtable CEOs say their plans for capital investment and for hiring have decreased significantly. When America's biggest companies are cutting back on the two main factors of production—capital and labor—the outlook would not seem bright.

Yet stocks keep surging. What gives? Are CEOs and investors looking at the same world? The answer, which helps explain this bizarre conflict, is that in many ways they are not.

“CEOs have been in a desperate struggle to generate earnings growth,” says Savita Subramanian, chief of U.S. equity research at Bank of America. That has been hard because “sales growth has been relatively tepid” over the past 12 months, she says. “CEOs realize a lot of the levers they’ve used to generate growth in earnings per share—cost cutting, share buybacks—are running out of steam. You can’t do those things forever.” Add a slowing economy and rising labor costs to the picture, and

Investors don't see the CEOs' worries in large part because they aren't looking for them.

CEO gloom makes sense.

Yet investors, looking outside companies rather than inside them, see a different world. The consumer is healthy and the Fed is friendly. What's not to like? “The narra-

tive of low rates is driving sentiment,” says Arnott.

“People are starting to really rely on the ‘Fed put’—the expectation that the Fed will rescue the economy from any impending recession. “That’s dangerous. The Fed isn’t as powerful as some people think.”

Investors don't see the CEOs' worries in large part because they aren't looking for them. Remember that investors aren't individuals, for the most part. They're overwhelmingly institutions such as mutual funds and pension funds, which in the past decade have largely forsaken value investing, with its fuddy-duddy focus on a company's ability to deliver long-term profits with little debt. Instead, they've pursued growth and yield, strategies that have worked well. But experience says they don't work well indefinitely.

Separating investors even further from CEOs is the widespread use of so-called quant funds, largely driven by algorithms. “Most of them are

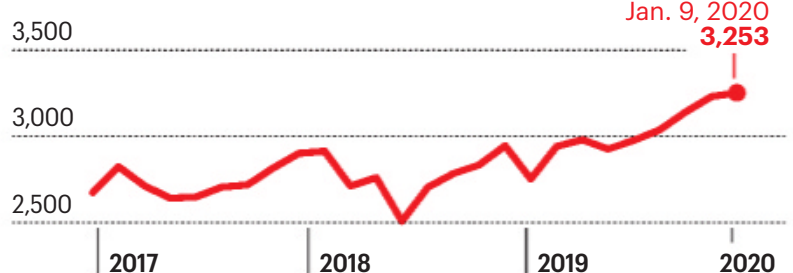
momentum-based,” says Subramanian. You simply buy what's going up. “So you're super bullish right now.” To a momentum algo, all those CEO worries are irrelevant.

Wall Street analysts may

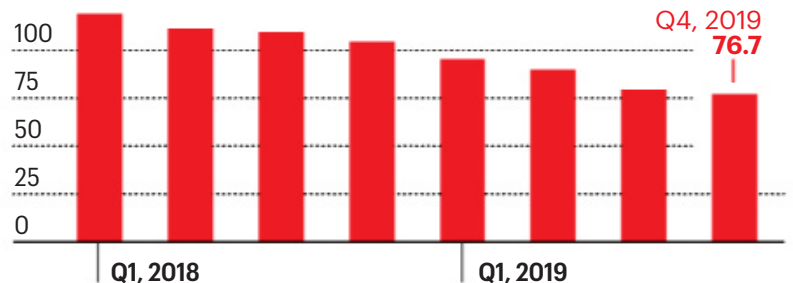
MIXED SENTIMENT

There's a growing gulf between how investors and corporate leaders view the economic picture.

S&P 500 INDEX



CEO ECONOMIC OUTLOOK INDEX



READINGS OF 50 OR ABOVE INDICATE AN ECONOMIC EXPANSION. SOURCES: S&P GLOBAL; BUSINESS ROUNDTABLE

be encouraging investors to ignore mounting risks even more than usual. Research shows that analysts are habitually overoptimistic in predicting profit growth for individual companies. The further out the forecast, the more extravagant it is; then, as the actual earnings report draws closer, analysts scale back their estimates toward reality. They've done it for decades, and are doing it now. For example, they predicted a year in advance that profits for the S&P 500 would grow 12.1% in last year's third quarter, says data from Refinitiv. Actual profit growth: -0.3%.

You'd think investors would learn to discount analysts' long-term esti-

mates. But the too-bullish problem gets worse in a slowing economy like the one we're in. “When economic growth slows, [the size of the forecast error] increases,” say McKinsey researchers. Analysts are still reassuring investors that they needn't worry. The aggregate forecast for profit growth in 2020's fourth quarter is a knockout 14.5%.

None of which is to say that the despondent CEOs are right and the Champagne-popping investors are wrong, at least not in the short run. “This market looks to us like a bubble,” says Arnott. “But bubbles can go on much further than most people realize. It will end, but we don't know when.” ■



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TECH

Getting 5G Up to Speed

This year marks the coming-out party for the zippy successor to today's wireless networks. **BY AARON PRESSMAN**

AFTER YEARS OF HYPE, most Americans will finally be able to use new, superfast 5G mobile networks in 2020—at least if they buy a new phone.

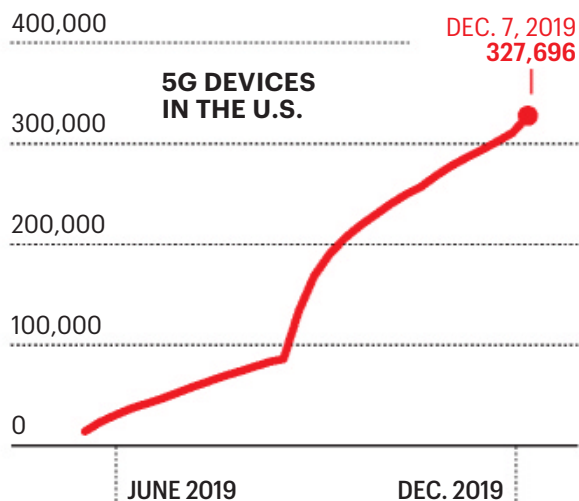
Last year, the four major wireless carriers—AT&T, Verizon, T-Mobile, and Sprint—started

introducing 5G, but most of them added service only in parts of a few dozen cities. And even then, some of those connections were barely faster than existing 4G LTE networks.

This year, the push for 5G will accelerate. AT&T and Verizon plan to

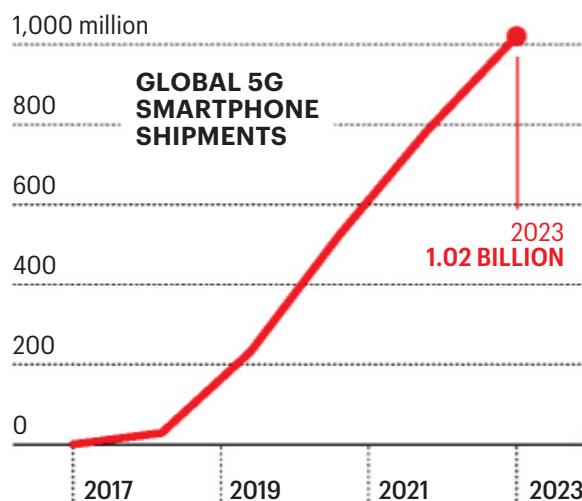
U.S. GETS STARTED

U.S. adoption of 5G has grown rapidly in the short amount of time service has been available.



GOING GLOBAL

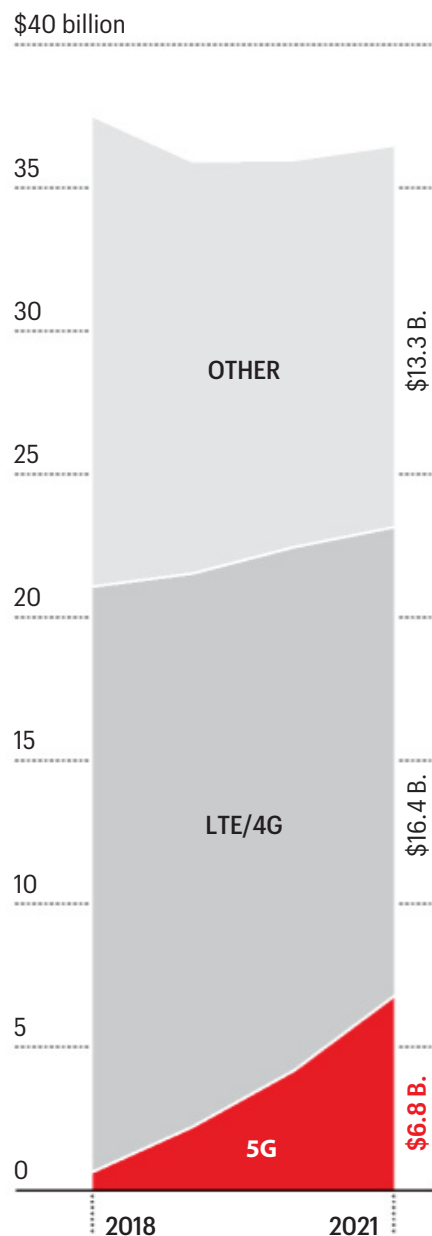
The number of people worldwide using 5G is expected to soar.



BIG UPFRONT COSTS

Spending by mobile carriers on 5G equipment and installation is climbing steadily.

GLOBAL WIRELESS INFRASTRUCTURE REVENUE FORECAST



RAMPING UP SERVICE

Of the three biggest wireless carriers, AT&T currently has the fewest U.S. cities wired for 5G. But like its competitors, it's ramping up: It plans to expand across the country this year. Below are the 19 cities where AT&T presently offers coverage.

CITIES WHERE AT&T OFFERS 5G

As of Dec. 27, 2019



extend their 5G service nearly nationwide. T-Mobile, which already has broad coverage but with limited speeds, hopes to add faster connections. Meanwhile, Sprint's fate is tied up in the legal fight over its proposed merger with T-Mobile. If the deal

is blocked, Sprint may lack the money to expand its limited 5G footprint.

In general, the upgrades by the carriers should, for example, allow for downloading an entire 4K movie in less than a minute. They'll also open the door to improved

technology, such as virtual reality goggles that rely on wireless networks for their whizbang imagery instead of goggles that require users to strap on bulky portable computers. Additionally, businesses hope to benefit by tapping 5G to connect more sensors

that measure everything from moisture on crops to traffic on roads. And 5G could help autonomous vehicles and factory robots send data back and forth so they can operate.

However, this wireless nirvana is still a few years away. Mobile carriers must add hundreds of thousands of new cellular sites. AT&T, for example, built more cell sites in 2019 than in the previous five years combined.

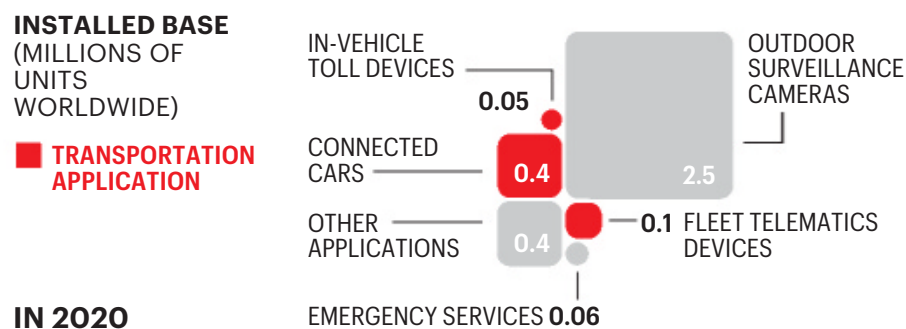
It plans to install even more this year. "Carriers are going to make or break their reputations based on how robust their networks are," says Chris Sambar, executive vice president of AT&T's technology operations.

Then there's the problem of 5G-compatible phones. So far, consumers have been able to buy only a few very expensive models, like Samsung's \$1,300 Galaxy S10 5G. More phones should be coming later this year. Still, the wireless industry's hope that millions of people will buy new devices so they can get 5G may be too optimistic.

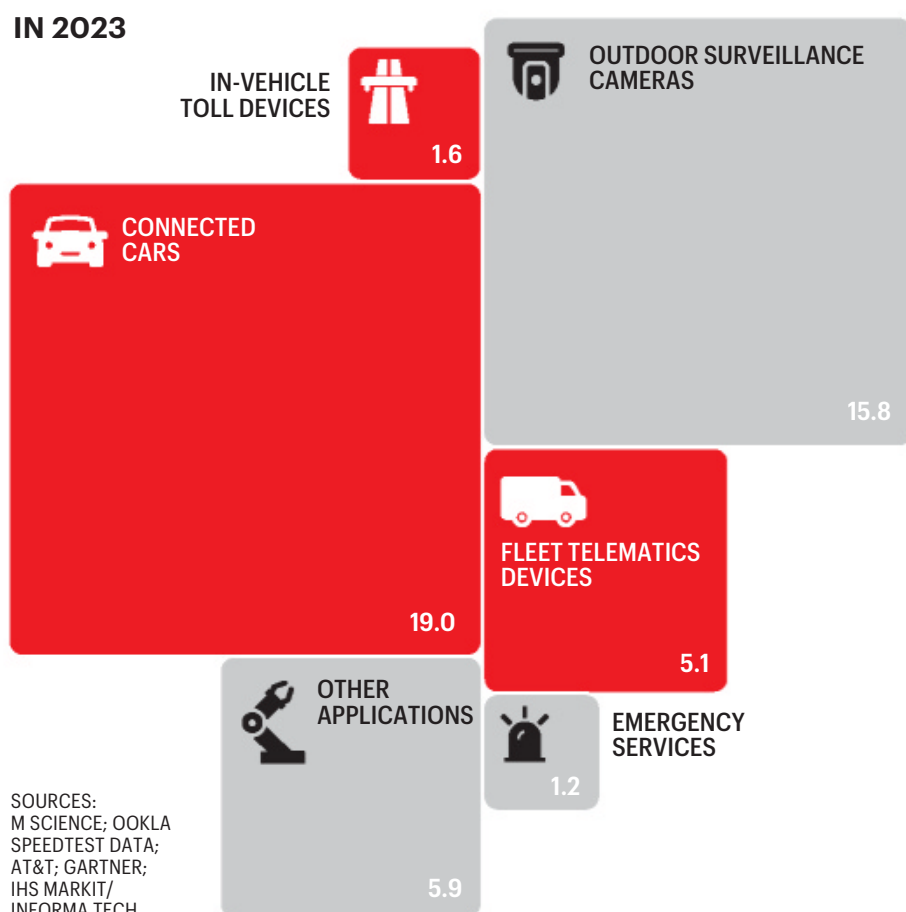
For one thing, many new technologies that are supposed to make 5G indispensable, including those wireless virtual reality goggles, aren't available yet. Without a killer app, mobile carriers will have a hard time convincing consumers that 5G is worthwhile. Says IDC analyst Jason Leigh, "The simple fact of the matter is, for many, 4G LTE works perfectly fine." ■

IT'S NOT JUST PHONES

In addition to smartphones, 5G is expected to be harnessed for a wide range of so-called Internet-of-things products. Here are those top uses.



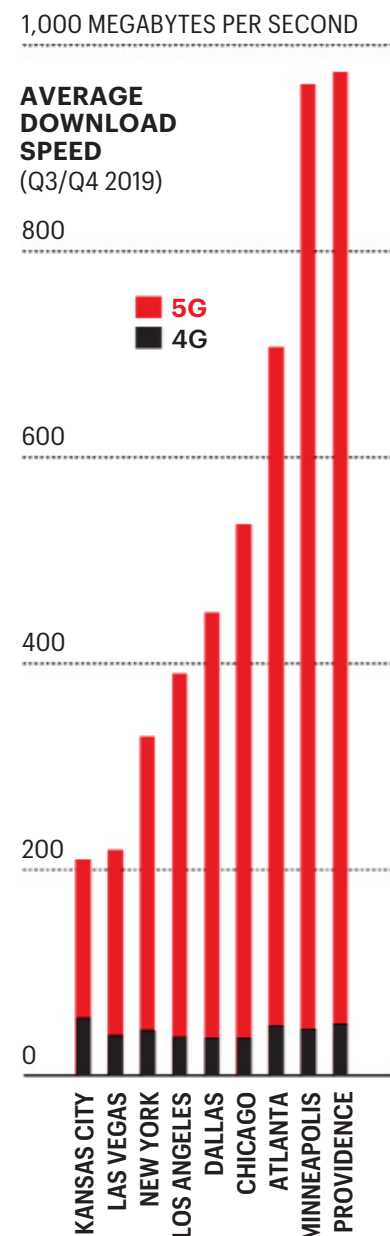
IN 2020



SOURCES: M SCIENCE; OOKLA SPEEDTEST DATA; AT&T; GARTNER; IHS MARKIT/INFORMA TECH

A MAJOR SPEED IMPROVEMENT

Consumers using 5G will notice speedier uploading and downloading compared with 4G LTE. However, those 5G speeds vary widely by city.



CULTURE OF COFFEE INNOVATION

Q&A with Khaled Almadi and Ahmed Alkharji,
co-founders, Elixir Bunn

Dissatisfied with the corporate world soon after leaving college, Khaled Almadi and Ahmed Alkharji took a step that would have been unthinkable in Saudi Arabia just a generation ago: They left their jobs and started an independent specialty coffee chain, which is transforming Saudi café culture.

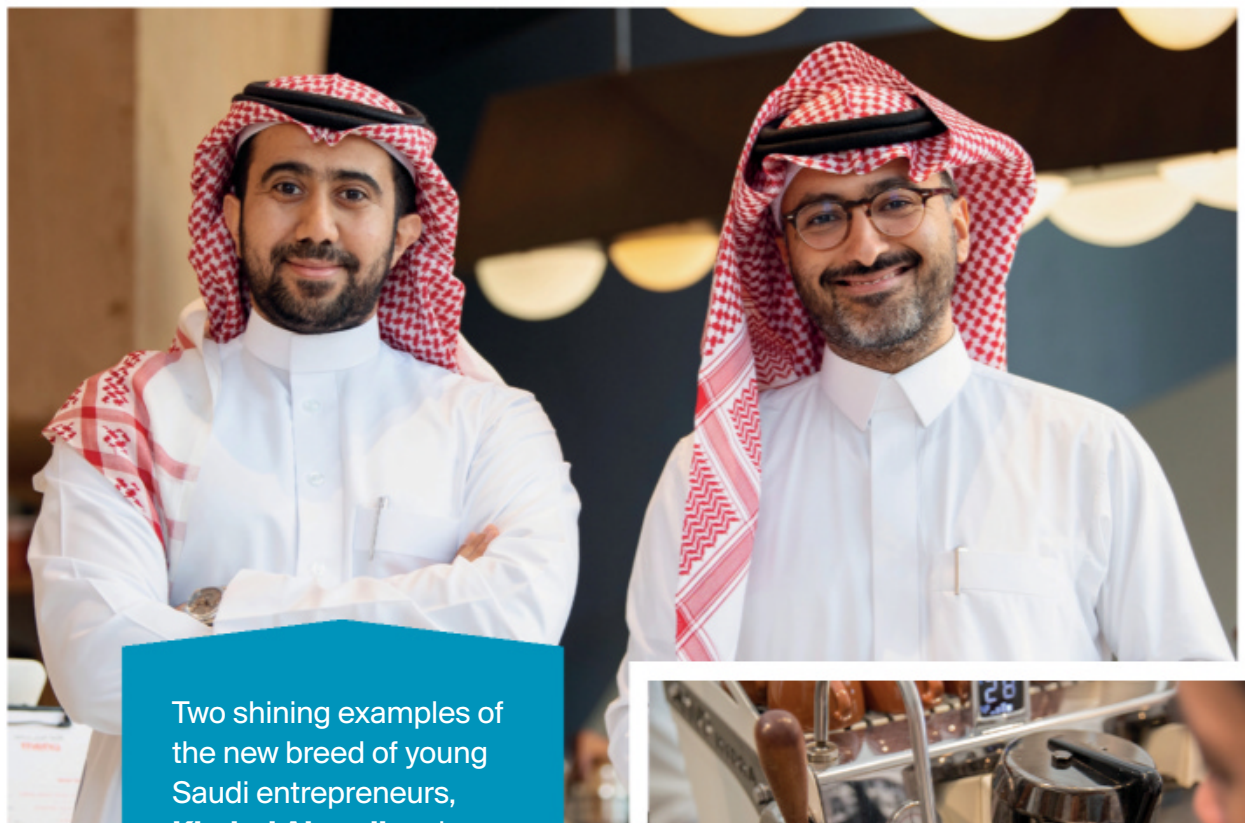
For hundreds of years, coffee has played an important part in Saudi life, and it is often mixed with spices such as cardamom as part of an elaborate ritual in homes, at events, and even in Bedouin tents. However, the contemporary third-wave coffee movement had largely passed the Kingdom by—until Khaled and Ahmed began experiencing the coffee revolution for themselves.

On a trip to Japan with Khaled in 2013, “I drank an espresso in Tokyo that was a real game changer,” Ahmed recalls. “I could not understand how such a place could produce such a fantastic and memorable cup of coffee. From that moment on, we resolved to introduce the extraordinary tastes and flavors of specialty coffee into Saudi Arabia.” Inspired by their experiences overseas, the business partners launched Elixir Bunn, a chain of cafés that is now transforming coffee culture in Saudi Arabia.

The company’s first store, in Riyadh, opened the doors its early 2015, before expanding into two more locations in 2019. Elixir Bunn now employs nearly 50 people and has ambitious plans for nationwide expansion.

To win over a market that had no experience of high-end coffee, Elixir Bunn made savvy investments in social

media and in creating a memorable customer experience. Attention-grabbing campaigns with Instagram influencers helped raise the interest of the Saudi public, and the company’s friendly customer service and competitive prices were soon winning new converts to its specialty coffees. With the Saudi government slashing red tape and making it easier for private



Two shining examples of the new breed of young Saudi entrepreneurs, **Khaled Almadi** and **Ahmed Alkharji** turned their backs on office life and the corporate world to launch one of the most successful coffee brands in the country: **Elixir Bunn Coffee Roasters.**



Specialty coffee being brewed for consumers in Saudi Arabia



CULTURE OF INNOVATION

►► businesses such as Elixir Bunn to flourish, the country's coffee scene and café culture are now expanding at a rapid rate. From 180 cafés per million people in 2018, by 2022 there are expected to be 260 per million and by 2030 no fewer than 1,000 cafés per million citizens. Khaled and Ahmed are now extending this boom to Saudi Arabia's growing number of coffee producers by actively supporting coffee cultivation in the Kingdom. "We have already sourced some extraordinary coffees from Jazan, in the south of the country," Khaled says. "We want all parts of the value chain to benefit from the coffee revolution."

How is the role of coffee changing in Saudi Arabia in the 21st century?

Khaled: Coffee is an essential element in our heritage. It is a symbol of the hospitality and generosity of the Arabian Peninsula. When Saudis began traveling overseas, they brought the taste for specialty coffee home and incorporated it into their daily life and rituals.

Why is the Saudi café market growing so rapidly?

Ahmed: There are three things that you will not find in any other country at the moment: Firstly, we are a coffee nation; secondly, young people have high purchasing power; and thirdly, there is no other business that competes with cafés and coffee drinks in the market.

What can customers find in Elixir Bunn that they cannot find in Starbucks?

Khaled: We do not just sell a customer a cup of coffee; we sell an enjoyable and rich experience from the moment a customer walks in,

“

WE WORK HARD TO DEVELOP LOCAL CRAFTSMANSHIP TO ENSURE THAT ALL PARTS OF THE VALUE CHAIN BENEFIT FROM THE COFFEE REVOLUTION.

—

KHALED ALMADI AND AHMED ALKHARJI, CO-FOUNDERS, ELIXIR BUNN

”



Faisal Alraithy, a coffee producer in Al-Raith brews Moka Pot in Wadi Lajab valley

up until the time they finish their cup and leave the café. We serve specialty-grade coffees and we focus heavily on customer service. We train our baristas carefully about how they should serve coffee to customers. We want to make third-wave coffees approachable and enjoyable for our customers.

What are your plans for working with coffee producers in Saudi Arabia?

Khaled: The quality of the coffee produced in the Jazan region is spectacular. We have been making social investments there since early 2017 and will be bringing new coffees from Al Dayer and Al-Raith mountains to our stores next year. We are also planning to organize more trips for our customers to the coffee plantations of this incredible region.

How easy is it to be a young entrepreneur in contemporary Saudi Arabia?

Ahmed: The new generation is embracing entrepreneurship. Young people are more interested than ever in setting up their own businesses. There is also a great deal of financial support from venture capitalists and private equity firms. We have the most important VCs in the Middle East. If an entrepreneur has a good idea that adds value locally or globally, then the finance will come.



VENTURE

Hollywood's Community Action Hero

Too many entertainment executives are still just talking about diversity. Dan Lin has been walking the walk for years. **BY DINAH ENG**

▶ **WHEN DAN LIN** started as a creative executive at Warner Bros. in the late '90s, diversity was not a priority at most studios.

Back then, Lin was one of three minorities in the film production group at the junior executive level, developing movies that WB top brass would consider for green-lighting. He noticed that any time Jet Li, Ang Lee, or Jackie Chan came in for a meeting, his bosses encouraged Lin to join them.

PHOTOGRAPH BY
MAGGIE SHANNON

The young executive, who is fluent in Mandarin and English, grabbed the opportunity to witness the decision-making process with studio execs and prominent filmmakers, and he used his language skills to help translate conversations.

Today, Lin is the most prolific and successful Asian-American producer in Hollywood, and diversity is front and center at his production company, Rideback.

Lin's producing credits include the *Lego Movie*

Dan Lin at his Rideback Ranch campus in L.A.'s Historic Filipinotown.

and *It* franchises, and his films have grossed more than \$5 billion in worldwide box office. Lin recently helmed hits such as Disney's live-action *Aladdin* and Oscar-nominated *The Two Popes* for Netflix. And he's not slowing down. Current projects include *Lethal Weapon 5* and a sequel to *Aladdin*.

Last year, Lin teamed up with MRC, the studio behind *House of Cards*

Selected Works



The Lego Movie (2014)

Budget: \$60 M.
Global gross: \$468 M.

and films such as *Ted* and *Baby Driver*, to create the Rideback TV Incubator, a paid residency program for mid-career TV writers from underrepresented backgrounds. Participants are paired with volunteer mentors and develop shows to pitch at cable networks and streaming services.

“This is not a charity,” Lin says. “Hollywood is a business.” He adds that the incubator will create eight shows that will be produced by Rideback and receive financial and studio support from MRC.

“We want to prove this is a new way to do business. Diversity is a good driver for profit and brings fresh perspectives to the Golden Age of Television,” he says.

Albert Cheng, COO and cohead of television at Amazon Studios, praised Lin’s approach: “Dan has broken a lot of barriers because he works hard, is focused, and has genuine humility, openness, and a desire to build and lead.”

The desire to succeed while helping others along the way was ingrained in Lin from childhood. The producer, who was born in Taiwan, immigrated to the U.S. with his parents when he was a year old.

“My way of learning about American culture was through watching movies and TV,” Lin says.

“Our family and I came as immigrants, and many people helped us along the way. So when we were blessed with opportunities, we wanted to circle back to bring others along.”

After getting a BS in economics from the Wharton School in 1994, Lin worked as a management consultant before joining Universal Studios. Returning to school, he got his MBA from Harvard and eventually became senior vice president of production for Warner Bros. Pictures.

“Asians are taught to respect authority and to defer to others,” says Lin, 46. “I had to push myself to speak up in meetings and adjust to corporate America, because if I waited to speak, I would never be heard. I watched those who were successful and emulated them.”

In 2007 he left to form his own production company with an exclusive feature deal at Warner Bros. A few years later, the married father of two took his young family to a dude ranch in Montana, where he heard stories about the Old West. He was struck by conversations about how powerful community and commitment to others can be.

“The ethos of Rideback Ranch, the creative campus we’ve built here, comes from that,” Lin explains.

DAN LIN’S BEST ADVICE

Move your company offices to a diverse neighborhood. We moved our offices from Hollywood to Historic Filipinotown because we wanted to work in an area that was more ethnically diverse, representing a richer array of cultures and backgrounds. We employ neighborhood residents and look for people who have different life experiences than we do.

“When a cowboy falls off his horse, you ride back to help him up. Studios emphasize quarterly earnings. Here we’re a community for artists. We collaborate and celebrate people’s wins, and we support them when they fail.”

Rideback Ranch, located in L.A.’s Historic Filipinotown, houses Lin’s production company, the Warner Animation Group, David Ayer’s Cedar Park Entertainment, Margot Robbie’s Lucky Chap Entertainment, and others. They also volunteer for community projects in the neighborhood with Rideback.

Lin’s diversity initiatives are numerous: Rideback employees work with fifth-graders at Union Avenue Elementary, which serves a mostly immigrant student population in Historic Filipinotown, teaching them how to write screenplays as part of a citywide Young Story-

tellers program.

Along with filmmaker Ava DuVernay and Los Angeles Mayor Eric Garcetti, Lin launched the Evolve Entertainment Fund to open doors into the entertainment industry for underrepresented college students through paid internships and mentoring.

And this year, Lin plans to expand the Rideback Collective, a collaborative screenwriter program, by providing financing for up to 10 writers to develop their projects, which Rideback would then produce.

The future of successful storytelling, he says, is a world in which Hollywood power brokers no longer say that diversity should be a priority for business reasons. Instead, success will mean routinely hiring filmmakers and TV show creators who are diverse.

As for Lin, “I’m not waiting for the future. I’m doing it.” ■

It (2017)

Budget: \$35 M.
Global gross: \$702 M.



Aladdin (2019)

Budget: \$183 M.
Global gross: \$1.05 B.



The Two Popes (2019, Netflix)

Three Oscar and four Golden Globe noms.



INVESTING

Placing the Right Bet on Sports Gambling

Casinos, media companies, and team owners are competing to cash in on legalization. Here's why investors should pick the underdogs. **BY RYAN DEROUSSEAU**



▶ A SUPREME COURT decision that wins bipartisan praise is about as rare as a backdoor cover on a seven-team parlay. And if you know what a backdoor cover on a seven-team parlay is, you may know which decision we're referring to. In *Murphy v. NCAA*, in May 2018, the court struck down a federal law that had effectively banned commercial sports betting in most states—a move that earned praise from gamblers of every political stripe.

In the wake of the ruling, 14 states have passed laws allowing some form of sports betting. On Feb. 2, Super Bowl LIV will serve as the latest example of the shift's financial impact. Last year, gamblers placed an estimated \$6 billion in legal bets on the Super Bowl, up 26% from 2018. And in the past 12 months, the number of legal-wagering states has nearly doubled, meaning this year's pot is virtually certain to be bigger.

This favorable legal climate has opened up broad new gambling markets. Major League Baseball, the National Basketball Association, and the National Hockey League have inked partnerships with gaming companies in pursuit of new revenue. Media companies that broadcast sports have added gambling programming to entice advertisers. Online betting sites have vastly expanded their businesses.

But investors who believed this wagering

PHOTO ILLUSTRATION
BY **EDMON DE HARO**

wave would lift the stocks of big casinos and gaming companies have wound up on the wrong side of the spread. Since the *Murphy* decision, the VanEck Vectors Gaming ETF, which tracks the global gaming industry, is down almost 10%, while the S&P 500 has returned 22.5%.

Sports gambling is “a low-margin business,” explains Matt Carey, who covers the subject for data provider GamblingCompliance. Commissions on sports wagers range between 5% and 10%. Even if you assume that Americans bet \$150 billion illegally on sports each year (an estimate at the high end of the range), and that all of that money will eventually flow into legal venues, the resulting revenue would top out at \$15 billion—penny-ante stuff in the \$300-billion-a-year U.S. gaming industry. And the odds in sports betting don’t tilt dramatically in favor of the house the way they do in casino

To profit, investors need to focus on the stocks of smaller companies that can get a bigger revenue boost from sports wagering.

games like craps or slots.

The upshot is that the sports surge isn’t financially meaningful for casino giants like MGM Resorts International or Las Vegas Sands. To profit from the legalization boom, investors need to focus on smaller companies that can

get a proportionally bigger revenue boost from sports wagering—including companies that aren’t chiefly known for gaming today.

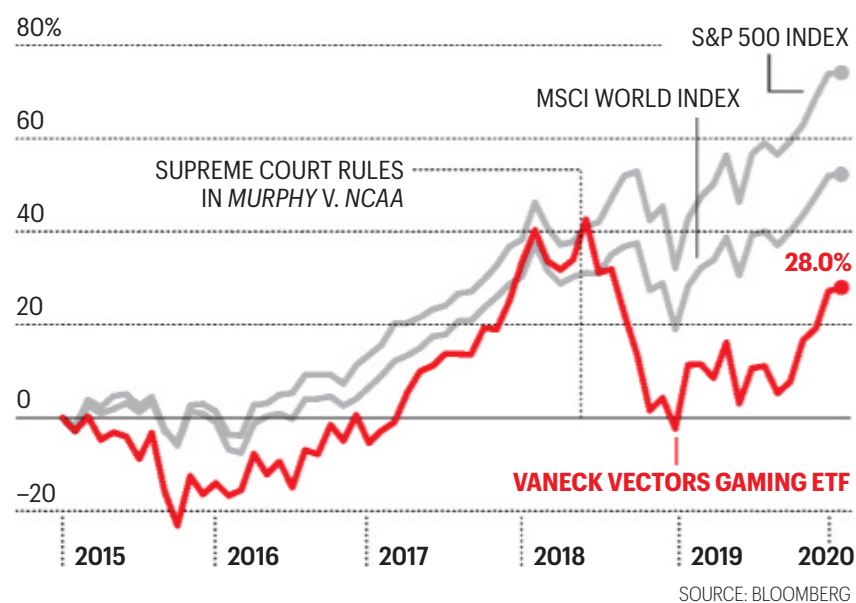
To circumvent the headache of obtaining licenses in legal-betting states, the most popular online betting platforms partner with casinos. That has created a big opportunity for **Boyd Gaming (BYD, \$30)**, a small casino operator that has teamed with betting site FanDuel. FanDuel now runs some of its sports books under Boyd’s banner. In return, Boyd can market to FanDuel’s database of over 10 million customers—bettors whom it can woo to play blackjack or roulette in its casinos, or on its rapidly expanding online platform. The company has thrived—revenue jumped 25% in 2019, to \$3.3 billion—but its stock still trades at reasonable valuations.

Eldorado Resorts (ERI, \$59) owns a 20% stake in the U.S. subsidiary of London bookmaker William Hill, “one of the best retail sports

books,” according to David Katz, an analyst at Jefferies. Hill now runs Eldorado’s sports-wagering business, giving it an edge in capturing new customers. And in June the company agreed to acquire the much-larger Caesars Entertainment, which has three times El-

A “SURE THING” THAT HASN’T PAID OFF

The legalization of sports wagering didn’t do much to bolster the stocks of most casino and gaming companies.

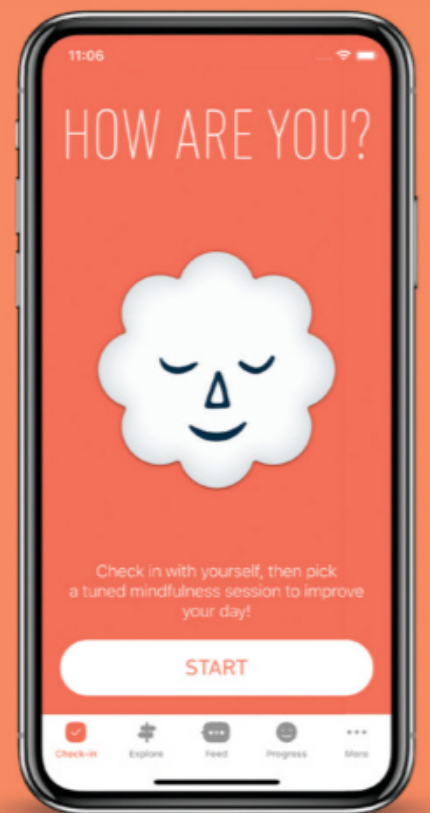


dorado’s revenue. In early 2019, Caesars signed a deal that lets it use National Football League branding in its casinos; that deal could give the company an inside track to win more business if the NFL eventually decides to more directly embrace betting.

Last September, **Fox Corp. (FOX, \$36)**, owner of Fox Broadcasting and Fox Sports, teamed with gaming company the Stars Group to launch online platform Fox Bet—one of the most direct efforts by a media company to profit from sports gambling. The hope is that Fox Bet will drive traffic to Fox’s extensive football, soccer, and college sports programming, and vice versa. Evercore ISI analyst Vijay Jayant believes Fox Bet alone could generate \$1 billion in annual revenue by 2025.

Many analysts anticipate that jurisdictions that have legalized sports betting will also allow franchise owners to host gambling in their teams’ arenas. One of the only publicly traded companies with exposure to both teams and arenas is the **Madison Square Garden Co. (MSG, \$299)**, which owns New York’s famed Garden as well as the NBA’s Knicks and the NHL’s Rangers. As a play on gambling, the stock is a long-term bet: It’s not clear when or even if New York State will expand legalization. But Robert Routh of FBN Securities says MSG’s stock is significantly underpriced compared with the value of its business. That means any substantial surge in revenue, whatever its cause, could boost the stock. Think of it as an intriguing long shot—just like a seven-team parlay. ■

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STOP, BREATHE & THINK



BUSINESS OF FOOD

How Idaho Became Caviar Country

Geopolitical and conservation concerns have opened up a high-end market for American fish farmers. **BY JEFF JOHN ROBERTS**

▶ **IN DECEMBER, CHEF** Eric Wuppermann decided to offer caviar as part of a seafood night at his restaurant in Leadville, Colo. He considered procuring the naturally salty sturgeon eggs from up-and-coming suppliers in Italy and Belgium, before opting for an even newer source: Idaho.

Such a move would have been inconceivable 25 years ago, when the delicacy was synonymous with white-tie snobbery and imported from Russia and Iran. In recent years, however, the caviar market has been

disrupted by a combination of environmental and geopolitical shifts. Those factors, along with millennials' more adventurous palates, have helped create an opportunity for American fish farmers.

"I used to have Russian people coming to my back door with suitcases full of caviar, but that doesn't happen anymore," says Rod Mitchell, who owns Maine-based caviar purveyor Browne Trading. Mitchell says famed caviar from wild beluga sturgeon in the Caspian Sea has all but disappeared from the U.S. as a result of environmental degradation and tightened enforcement

Forget Russia. Caviar now hails from locales like Idaho and Kentucky.

of a 1973 endangered-goods treaty.

Sturgeon farmers in California's Sacramento Valley began producing the first high-end American fare in the 1990s, and those in states like North Carolina and Florida followed. Today, purveyors point to Idaho's Snake River white sturgeon, which produces limited but highly sought-after eggs, as top of the line.

"Idaho is far and away the best," opines Dale Sherrow of Seattle Caviar Co. Meanwhile, at the lower end of the market, Kentucky fishermen have been hauling paddlefish out of the Ohio River to produce so-called spoon-bill caviar.

While 25% tariffs on Chinese caviar have given a boost to U.S. producers, the real shift has been among millennials, who have grown accustomed to seeing caviar on sushi rolls and brunch dishes, and even in meal kits or arriving via home delivery, which Mitchell says is his fastest-growing market. Turns out they like caviar for its taste—not just for its status-symbol reputation. ■

BY THE NUMBERS

\$71/oz.

Wholesale price of Snake River white sturgeon caviar

BY GREG SIMON AND JEFF FELDMAN

It Is Time for a Futures Market in Health Care



F

FINANCIAL FUTURES were created in the 1970s at a time of very high interest rates and inflation. Those economic ills were cured by the mid-1980s. Oil futures were created in the early 1980s at a time of shortages and volatile prices. The oil market stabilized a few years later. Stabilization of prices and supply happened because industry participants could transfer risk and achieve predictable pricing while speculators could find trading opportunities.

Today, it is health care costs that are out of control and that have risen to unsustainable levels. Insurance premiums and co-pays are at record highs, and some insurance companies are refusing to pay for some of the most expensive treatments. Capital market tools can do for health care what they did for interest rates and energy—provide stability and reduce prices—all of which is in the interest of patients. But so far, those tools don't exist for health care.

Creating a Health Care Marketplace

A futures or forward contract is a legal agreement to buy or sell a commodity or financial instrument at a predetermined price at a specific future time. It is a classic two-way market between willing buyers and sellers.

Conversely, health care is a one-sided marketplace. Patients receive

The U.S. spends as much on diabetes care each year as we do on oil—but there are no financial products to keep prices stable and predictable.

a service and pay the bill without knowing the price beforehand and without any way to use financial tools (think about home mortgages and car loans) to spread the costs over time—which is one reason that medical bills are the biggest cause of personal bankruptcies.

This one-sided marketplace affects employers as well. A review of large- and medium-size self-insured companies reveals that many have hedging strategies to deal with interest rate, energy, and currency risk (even the weather!), yet their health care risk is not hedged at all. Insurance companies, in particular, know little about the health issues for the next year's insured population, so they are subject to price shocks for sicker patients.

One of the primary reasons a financial market has not developed for health care is the inability to represent the component costs in an accurate way. In the case of energy, for example, there are financial instruments that represent the cost of various grades of oil, gasoline, natural gas, and coal. Similarly, there are tradable contracts for many agricultural commodities (wheat, corn, soybeans, etc.). To likewise create a financial market for health care, we must be able to represent the costs of specific drugs, procedures, and so on.

Until recently, this has not been possible for lack of data. With the advent of electronic health records (EHRs), we can now receive a current anonymized data feed of paid claims on behalf of patients and know the cost of treating particular conditions in various places and populations. We can define the “unit” as the cost of

treating one patient for one disease for one year—or as the cost of a knee replacement or an open-heart surgery. An insurance company could then transfer the risk of any specific cost increases to the financial markets.

To put the problem in perspective, the United States spends roughly \$350 billion a year on oil. The value of structured financial products to hedge or speculate on the price of oil, based on that expenditure, totals hundreds of billions of dollars. We spend a similar amount annually just on diabetes care, but there are no financial products to provide predictable and stable prices for vital components of diabetes treatment, such as insulin.


The U.S. health care system is at long last edging closer to value-based pricing—in which fees are determined by patient outcomes rather than by each service performed. But here, drugmakers will assume new risk, for

example, if their drugs don't work in certain patients. For this approach to scale, pharma companies will need a way to hedge or “lay off” this risk to speculators. Otherwise, they'll do what they've always done: raise prices.

It's now possible using health data to create indexes that represent the cost of treating specific diseases, taking specific medications, and the cost of many medical procedures. Based upon these indexes, we can create financial tools (futures, forwards, options) that can allow for price discovery and risk transference.

Turning Health Care Costs Into Assets

This allows us to turn health care costs into assets, as was done for oil or for carbon credits on the Chicago Climate Exchange. A hospital would be able to sell surgical procedures (knee replacement, for example) in bulk to insurance companies in a competitive marketplace that can provide for true price discovery—and allow for more efficient pricing. Further, if an instrument that represents a procedure, treatment, or drug is available on an exchange, even a prospective patient can purchase it.

A health care futures market will lead to stable and lower prices for consumers and more predictability for drug companies, providers, and payers as they learn to do what farmers have done for decades—hedge the future. 

ABOUT THE WRITERS

Greg Simon was the president of the Biden Cancer Initiative and the executive director of the White House Cancer Moonshot Task Force. Wall Street veteran Jeff Feldman has specialized in health care and biotech investment for the past 20 years.

AVIATION

BOEING'S LONG DESCENT

A shareholder-first culture fueled the 737 Max crisis. Now it may keep the aerospace giant from recovering.

BY DAN CATCHPOLE

FOR NEARLY A YEAR, the world's largest aerospace company has been engulfed by a scandal of its own making. The 737 Max crisis, which unfolded after 346 people died in two crashes linked to software malfunctions in Boeing's newest jetliner, has put the company under an unforgiving lens. Scrutiny from journalists, crash investigators, regulators, Congress, and the Department of Justice has exposed profound flaws in Boeing's corporate culture—shaking its workforce, forcing supplier layoffs, and shattering fliers' trust.

What's more, the Max scandal isn't the only dire threat to Boeing's trajectory. Well before the crashes, Boeing had struggled to plug a gaping hole in its product lineup between its single-aisle 737 and larger twin-aisle 787 planes. Now, plans to launch an entirely new, "clean sheet" jetliner for this midsize market have been shelved, as the company scrambles to get the Max back in the air.

These twin crises, industry insiders say, spring from a culture that consistently put short-term rewards to shareholders ahead of engineering-driven decisions and long-term strategy. For all of Boeing's business coups and innovation, one



EARTHBOUND
The 737 Max crisis has forced Boeing to suspend the deliveries of hundreds of commercial planes, while hamstringing its efforts to design new products.

stark statistic has come to symbolize the company's priorities: Over the past six years, Boeing spent \$43.4 billion on stock buybacks, compared with \$15.7 billion on research and development for commercial airplanes. The board even approved an additional \$20 billion buyback in December 2018, less than two months after the first 737 Max crash, though it subsequently shelved that plan.

Down payments on orders for the Max—the fastest-selling jet in Boeing's history—helped pay for the rounds of buybacks. Share repurchases, in turn, have helped the company's stock price more than triple

LINDSEY WASSON—REUTERS

“If you cut R&D, cost-cut, give cash to shareholders—then you're



REAL MONEY

204%INCREASE IN
BOEING'S STOCK
PRICE SINCE
FEB. 11, 2016**\$43.4
BILLION**AMOUNT SPENT BY
BOEING ON SHARE-
HOLDER BUYBACKS
SINCE 2013SOURCE: COMPANY
FILINGS**\$9
BILLION**CURRENT ESTIMATED
COST TO BOEING OF
THE 737 MAX CRISIS,
IN LOST ORDERS,
COST OVERRUNS,
AND PRODUCTION
SHUTDOWNSSOURCE: COMPANY AND
ANALYST ESTIMATES

since 2016, even after a recent sharp drop. Boeing's defense-and-space and global services divisions, which together account for about 40% of revenue, have kept it afloat even as commercial-jet sales fall. But the Max scandal has put an end to Boeing's run as a Wall Street bull. Each new revelation suggests that the company's shareholder-centric mentality has contributed to—and perhaps is partly to blame for—both the Max crisis and its potholed product road map. “Wall Street does not want to hear about new clean-sheet planes,” says Ken Herbert, an aerospace analyst at Canaccord Genuity. And so far,

he adds, the board of directors hasn't “provided the leadership or oversight the company's needed.”

Boeing declined to comment for this story. But the question facing new CEO David Calhoun is whether he can break Boeing's addiction to shareholder payouts and plot the company's long-term recovery.

BOEING'S CULTURE problems aren't two or even 10 years in the making. Aerospace experts trace them to 1997, when Boeing acquired rival McDonnell Douglas, absorbing many of that company's executives along with its

finances-first ethos.

In the years prior to the merger, Boeing had largely avoided share repurchases; McDonnell's board, led by its CEO Harry Stonecipher, had pursued them enthusiastically. Within a year of the merger, buybacks became a cornerstone of Boeing's strategy. As a Boeing executive and later CEO, Stonecipher also advocated aggressive cost-cutting, pushing the company to deliver an after-tax profit margin of 7%—a mark Boeing had not hit since the 1970s. His successor, Jim McNerney, continued to put profit margins first. “When people say I changed the culture of Boeing, that was the intent, so that it's run like a business rather than a great engineering firm,” Stonecipher told the *Chicago Tribune* in 2004. “It is a great engineering firm, but people invest in a company because they want to make money.”

The downsides of cost-cutting soon appeared in Boeing's 787 Dreamliner program, which began in 2003. Management pushed the company to save money by outsourcing development of critical components to suppliers, many of which proved not up to the task, leading to repeated breakdowns and delays. When the jet finally flew in 2011, it was three years late and \$25 billion over budget. In 2013, after the plane was in service, electrical fires in batteries on two 787s prompted regulators to ground the airplane for nearly a month.

The 787's painful legacy continues today, notes Scott Hamilton, head of aerospace consulting firm Leeham Co. Its problems prompted Boeing leadership in 2011 to decide to put new engines on the 737, dubbing it the 737 Max, rather than build an entirely new airplane. “Their hand was forced,” Hamilton says. “The issue was how badly they screwed up the 787 program, which destroyed their product strategy for the next several decades.”

Boeing suspended buybacks during the 787 debacle. Resuming in 2013, they have since averaged \$6.2 billion annually. Meanwhile, the company

playing with Boeing's future.”

has spent an average of \$2.47 billion annually on commercial-plane R&D. By 2016, the 787 program was cash positive, and that year Boeing leadership committed to returning 100% of free cash flow to shareholders. “Let’s say you only return 50%,” Hamilton says. “You could have funded an entire airplane program.”

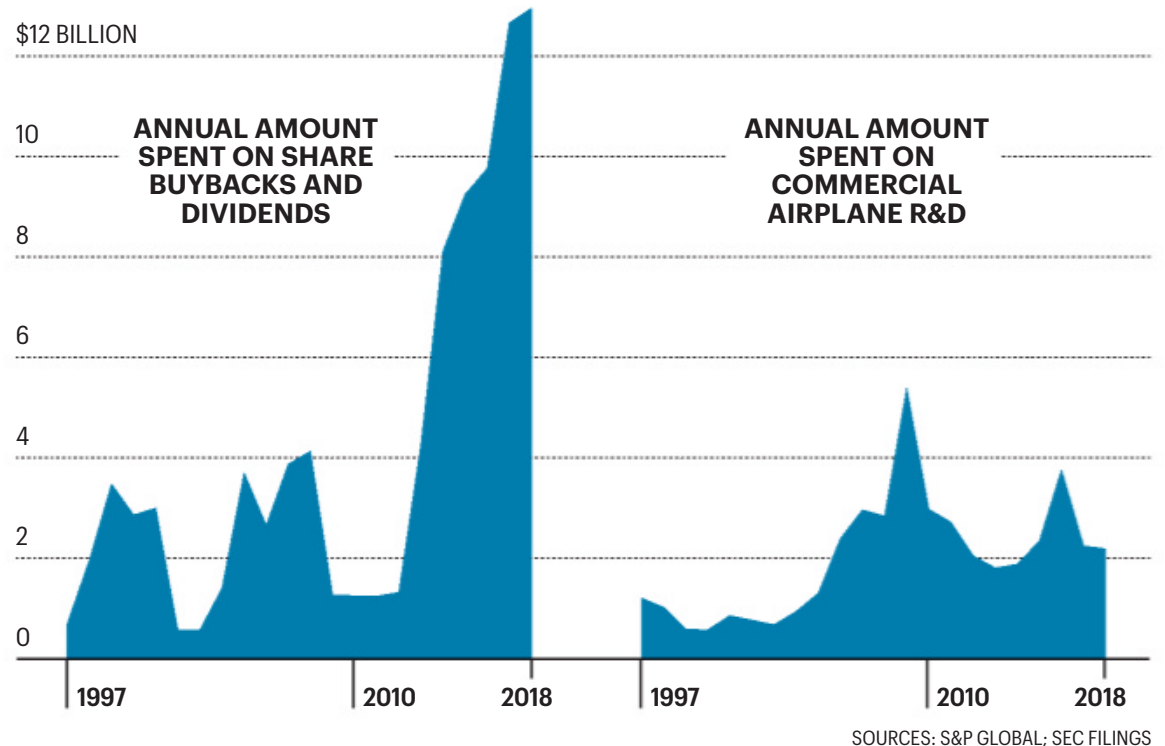
THE COMPANY desperately needs that program now. By the middle of the past decade, Boeing was confronting its lack of a new mid-market airplane (known in-house as the NMA). This category of jetliner carries around 250 passengers over distances of 4,000 to 5,000 miles. Mid-market is the only segment of the commercial-jet business expected to see strong demand in the near future, making the category critical to Boeing and rival Airbus. “Boeing likely needs two clean-sheet airplanes this decade,” says Richard Aboulafia of consulting firm Teal Group.

In 2016, however, then-CEO Dennis Muilenburg pledged to double Boeing’s profit margins to the mid-teens, a goal that made plane development that much more challenging. Punting on the decision to begin designing an NMA became an annual tradition for Boeing leadership.

Boeing’s indecision has given Airbus room to dominate the market. Given its problems with the Max, analysts and consultants agree that the earliest Boeing can start an NMA project is 2021. Even on that timetable, Boeing “will have lost market

OUT OF BALANCE

Boeing’s recent spending on share buybacks and dividends has substantially outweighed its spending on commercial-jet R&D. Analysts say that imbalance is indicative of a shareholder-first culture that has worsened the company’s predicament.



share to the A321XLR and maybe the A330neo,” two new Airbus models, says Ron Epstein, an aerospace analyst for Bank of America Merrill Lynch. “Some of it is *fait accompli*,” he adds. “The XLR is here—that’s [lost] market share” for Boeing.

“The decisions Boeing makes in the next five years will define the business for the next 25 years,” says Herbert, the Canaccord analyst.

“They need to embrace an engineering culture; they need to embrace what worked for the company’s first 85 years.” Herbert points to Boeing’s unprecedented run of creativity in the late 1950s and ’60s, when it launched the 707, 727, 737, and 747.

But the fallout from the Max crisis may well push Boeing in the opposite direction. Costs related to the Max have topped \$9 billion and could easily double. To shore up its balance sheet Boeing is reportedly considering borrowing money to pay shareholder dividends—and cutting R&D spending. Those are steps in the wrong direction, says Epstein. The only way forward is to put investors’ short-term interests on hold, he argues: “If you don’t do that—if you cut R&D, cost-cut, give cash to shareholders—then you’re playing with Boeing’s future.” ■

“Let’s say you only return 50%” of cash flow to shareholders, says one analyst. “You could have funded an entire airplane program.”

A STRAIGHTFORWARD INCOME?

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1. Potential Safety of Principal

When investing in municipal bonds, investors are paid back the full face value of their investment at maturity or earlier if called, unless the bond defaults. This is important because many investors, particularly those nearing retirement or in retirement, are concerned about protecting their principal. In June of 2017, Moody's published research that showed that rated investment grade municipal bonds had an average cumulative 10-year default rate of just 0.09% between 1970 and 2016.* That means while there is some risk of principal loss, investing in rated investment-grade municipal bonds can be an important part of your portfolio.

2. Potential Tax-Free Income

Income from municipal bonds is not subject to federal income tax and,

depending on where you live, may also be exempt from state and local taxes. Tax-free income can be a big attraction for many investors.

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ARTIFICIAL
INTELLIGENCE

The hype about artificial intelligence is unavoidable. From Beijing to Seattle, companies are investing vast sums into these data-hungry systems in the belief that they will profoundly transform the business landscape. To better gauge its true impact, we studied A.I.'s use in hiring and drug discovery, examined its rapid rise in China, and went deep on Big Tech's quest to build true thinking machines. You can't escape the A.I. hype. But the stories in the pages ahead will deepen your understanding of a technology that may reshape our world.

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THE QUEST FOR HUMAN-LEVEL A.I.

From Alphabet to Microsoft, the biggest companies in tech are investing heavily to develop technology that could radically reshape the business world. When it arrives is anyone's guess. BY JEREMY KAHN



LAST JULY, SATYA NADELLA, THE CEO of Microsoft, one of the world's most valuable companies, with a market capitalization hovering above \$1 trillion, filmed a short video with Sam Altman, the 34-year-old entrepreneur best known for his stint running Silicon Valley's preeminent startup accelerator, Y Combinator.

The setup for the three-minute segment, which Nadella posted to his LinkedIn profile, bore an uncanny resemblance to an episode of the online video series *Between Two Ferns*, which features comedian Zach Galifianakis conducting intentionally awkward interviews with A-list guests like Barack Obama and actress Charlize Theron. In this version, Nadella and Altman were positioned in modest-size chairs against a black background. Between them was a small coffee table with two

glasses of water and a tiny plant perched on top. The 52-year-old Nadella played the role of host, posing questions to Altman while holding a notecard in his hands.

But Nadella wasn't going for laughs. Rather, the purpose of the video was to discuss a major milestone for both executives: Microsoft's \$1 billion investment in the San Francisco-based startup Altman currently runs, OpenAI.

"So, our mission is to develop artificial general intelligence, broad A.I. systems that can do a lot of tasks at superhuman level," Altman explained to Nadella. "I think that this will be the most important technological development in human history. When we have computers that can really think and learn, that's going to be transformative."

With Microsoft's headline-grabbing investment in OpenAI, Nadella signaled his company's commitment to that mission. And from a strategic point of view, he officially entered Microsoft in a technological arms race against Alphabet, Google's parent company, and a handful of others competing to develop technology that could radically reshape the business world. The outcome of the race could well determine whether Microsoft, Alphabet, or someone else is the world's most valuable company in 20 years' time.



ARTIFICIAL
INTELLIGENCE

Nadella's decision to invest in OpenAI was also a subtle acknowledgment that his company's own internal efforts to stay at the bleeding edge of A.I. technology were falling short. Microsoft needed to catch up.

"This is about capturing the next great pool of wealth in technology," says Craig Le Clair, an analyst at Forrester Research, the tech analytics firm. He compares A.I. to electricity in its potential impact. Sundar Pichai, Nadella's rival CEO at Alphabet, has gone further, calling A.I. the most important project humanity would ever work on, "more profound than fire."

Imagine being able to monetize the invention of fire. Now imagine missing out on the chance to monetize fire.

● **OPENAI WAS FOUNDED** in 2015 by, among others, Altman and Elon Musk, the billionaire founder of Tesla. While OpenAI's goal is to develop artificial general intelligence (AGI), the company says it is dedicated to ensuring the technology is developed in a way that "benefits all of humanity." For that reason, OpenAI was initially set up as a nonprofit corporation. Last year, however, the company established a for-profit arm, the entity in which Microsoft invested. The terms of the deal make Microsoft the preferred partner for OpenAI to commercialize any technology it develops and chooses to license on the path to AGI.

The term "general" in the name artificial general intelligence is meant to differentiate it from more prosaic "narrow" artificial intelligence. It is narrow A.I. that in recent years has brought us breakthrough tech such as Alexa and Siri; the ability to unlock your iPhone with your face; and Facebook's auto-tagging of your friends in the photos you upload. Narrow A.I. systems also route Amazon orders to your home and decide which agent handles your customer service call to your bank.

The same underlying breakthroughs in algorithms, data science, and computing are responsible for much of the current excitement about both types of A.I. But the two are distinct in their capabilities, and at the moment only narrow A.I. actually exists. AGI is a purely theoretical technology.

Narrow A.I. is often compared to an idiot savant—it's good only at a specific

skill, like recognizing speech or identifying faces, and today it requires many thousands or millions of examples to learn that skill well. Even so, these systems are incredibly valuable—and are only getting more so. The McKinsey Global Institute estimates that the application of narrow A.I. will add some \$13 trillion to the global economy by 2030, an amount that it says would make the technology more impactful than the steam engine was in the 1800s.

But AGI would be many times more valuable still. AGI is the A.I. of Hollywood and sci-fi paperbacks. If it ever happens, it would make all the technological wonders of today's narrow A.I. look as quaint as Stone Age ax heads. AGI promises a single piece of software capable of learning almost any task at human or superhuman level—a system that can master new skills quickly, perhaps by watching a single demonstration or just by reading, with no training at all, and maybe entirely at its own initiative.

"Within Silicon Valley, AGI is a kind of religious argument. You're either a believer or you're not."

CHRIS NICHOLSON, COFOUNDER & CEO OF PATHMIND

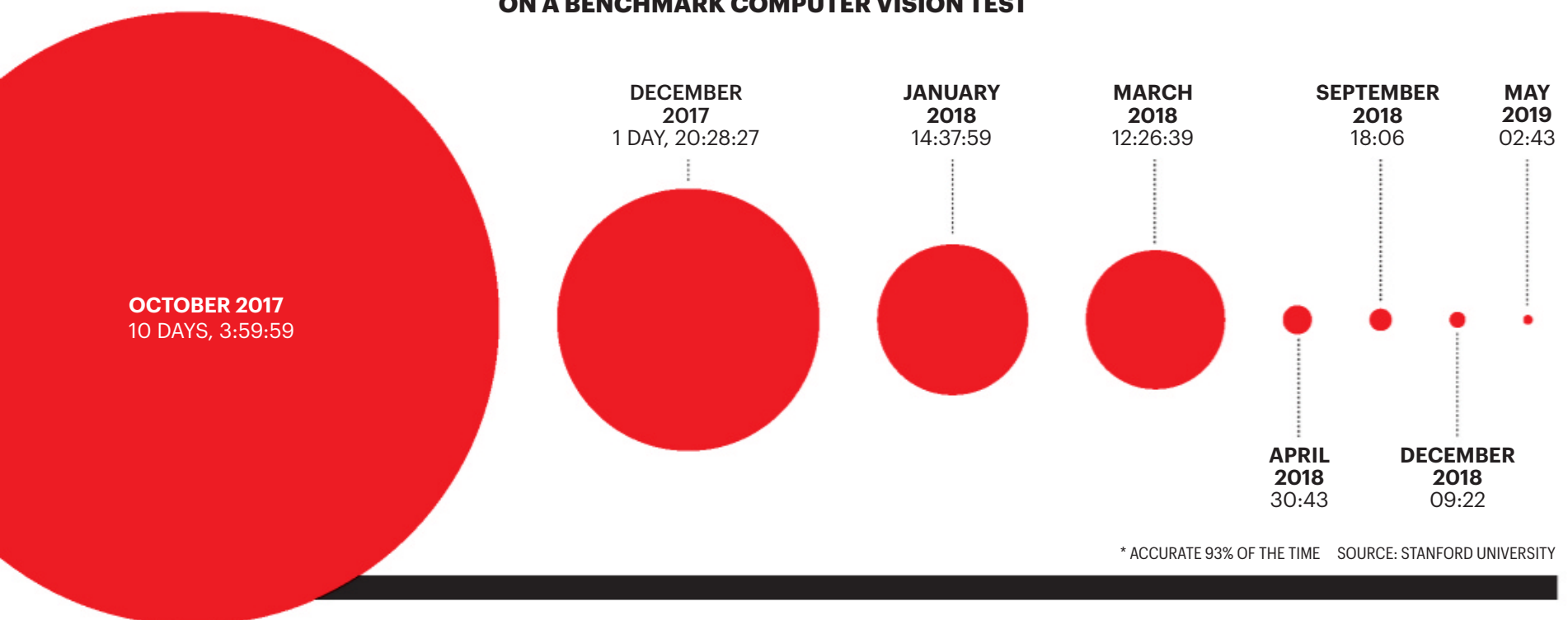
Imagine that rather than assign a 15-person task force to decide where your company should build a new factory, you simply ask your company's AGI. The system would immediately begin researching decision factors: proximity to suppliers and customers, transportation links, land-acquisition costs, local labor markets, tax incentives, etc. It would make a recommendation and produce a report explaining its reasoning. And it would do all this in minutes, not the weeks or months it would take the human task force. Then, if management agreed, it would instantly generate all the relevant work orders to start the process.

It is impossible to overestimate how valuable such a system would be to Microsoft or any other company that developed it. (It might also pose an existential threat to highly paid advisers, such as the McKinseys of the world.) OpenAI has capped the return

THE BREAKDOWN

A.I. IS LEARNING (WAY, WAY) FASTER

NEW ALGORITHMS AND COMPUTING HARDWARE have led to dramatic gains in the speed of A.I. systems in the past two years. The bubbles below represent the amount of time it took to train an A.I. model to be as accurate as a person in identifying images of 1,000 different kinds of objects. But whether advances in such narrow systems will equate to progress toward AGI remains to be seen.

**COMPUTATION TIME REQUIRED TO ACHIEVE A STATE-OF-THE-ART ACCURACY LEVEL*
ON A BENCHMARK COMPUTER VISION TEST**


its initial financial backers can earn at 100 times their investment, with the rest of the money flowing to the organization's non-profit. (Microsoft and OpenAI won't disclose the exact cap Microsoft has agreed to.) Of course, as with nuclear power, such superintelligence might also be dangerous, as Musk himself has famously warned.

AGI has long been fodder for novelists, filmmakers, philosophers, and futurists. It has been the implicit, and at times explicit, goal of an entire branch of computer science, at least since the 1950s. But AGI was always a research project. It was never a business plan—until now.

Big Tech has begun spending big bucks in its quest for AGI. Microsoft and Alphabet each sponsor not one but two separate R&D entities largely dedicated to developing advanced A.I. Facebook has invested in a blue-sky A.I. lab. Chinese search giant Baidu has one too. And smaller labs exist at Uber, Salesforce, and others. Investment in

AGI is forecast to reach \$50 billion by 2023, according to a report from Seattle-based research firm Mind Commerce.

This investment has come despite the view of many computer scientists that AGI is still, at best, decades away. But for the world's biggest technology companies, AGI is a race they can't afford to lose—even if it turns out no one ever wins. "It's about enhancing the perception of being a technology leader and innovator and being at the forefront," says David Smith, an analyst for emerging technologies at research firm Gartner. That perception helps sell cloud-computing services and recruit engineering talent. But AGI isn't merely about playing defense—research toward AGI feeds progress in narrow A.I. "The thing about A.I. is when you work to push forward the research, the downstream applications are incredible," says Mark Cuban, the billionaire tech entrepreneur and owner of the Dallas Mavericks, who has invested in a handful of A.I. startups.

GRAPHIC BY
NICOLAS RAPP



ARTIFICIAL INTELLIGENCE

● **ON A SUMMER'S EVENING** in 2015, Altman, who was running Y Combinator at the time, invited Musk to dinner at the Rosewood Sand Hill hotel, in the heart of Silicon Valley. The hotel, a luxurious stone ranch offering views of the foothills of the Santa Cruz Mountains, was a comfortable enough spot from which to contemplate Armageddon—and how to potentially stop it.

Musk's views about the dangers of AGI had been informed by his involvement as an early investor in an unusual London-based startup called DeepMind. Founded in 2010, the company is led by Demis Hassabis, a former chess prodigy turned video game entrepreneur, who has an undergraduate degree in computer science and a Ph.D. in cognitive neuroscience. His intuition is that by drawing inspiration from the way the human brain works, DeepMind can achieve AGI. DeepMind's mission statement is so audacious it borders on the ridiculous: "to solve intelligence, and then use that to solve everything else."

It began to look less ridiculous though, in January 2013, when DeepMind stunned computer scientists by debuting an algorithm that had taught itself to play seven different classic Atari video games, such as *Pong*, *Space Invaders*, and *Breakout*, achieving superhuman performance in three of them. The breakthrough resounded through Silicon Valley like the crack of a starter's pistol: The race for AGI was on, and the Valley's digital giants were desperate to get in on it.

In 2014, Google, which already had its own advanced A.I. research lab called Google Brain, acquired DeepMind for a reported \$650 million, a massive sum for a company that didn't have a single product or a dollar of revenue. Meanwhile, Facebook, which had also been in the hunt to buy DeepMind, established its own advanced artificial intelligence research lab headed by Yann LeCun, one of the field's top researchers.

DeepMind's acquisition alarmed Musk, even though he made money from it. Shortly after the deal was announced, he wrote a blog post warning, "The pace of progress in artificial intelligence (I'm not referring to narrow A.I.) is incredibly fast. Unless you have direct exposure to groups like DeepMind, you have no idea how fast—it is growing at a pace close to exponential. The risk of

something seriously dangerous happening is in the five year timeframe. 10 years at most... This is not a case of crying wolf."

Musk is friends with Google cofounder Larry Page. But he told journalists he feared Page's company might succeed in creating superhuman intelligence, and then lose control of it. Even if that didn't happen, Musk said he worried about a single corporation controlling such a powerful technology.

At dinner, Altman introduced Musk to a 29-year-old computer scientist named Ilya Sutskever, who was at the time working at Google Brain. Despite his age, Sutskever was already a legend among A.I. researchers: In 2012, A.I. software he helped create achieved an unprecedented score on ImageNet, a test that assesses an A.I.'s ability to identify pictures of 1,000 different types of objects. Also at the dinner was Greg Brockman, a 26-year-old coding whiz who had recently left his job as the chief technology officer at the payments processing unicorn Stripe. Together, they were hoping to secure Musk's backing for a new kind of A.I. organization, one dedicated to open research and free from control by any single corporation.

The dinner led to the formation later that year of OpenAI. Musk joined its board and was listed as a cofounder. A set of initial donors—including, among others, Musk, Altman, Brockman, and Musk's fellow PayPal alums billionaire Peter Thiel and LinkedIn cofounder Reid Hoffman—pledged \$1 billion to support the research group. Sutskever came on board as OpenAI's chief scientist.

● **SHORTLY AFTER HE** was appointed CEO of Microsoft in 2014, Nadella moved to reposition his company around artificial intelligence. Nadella declared that all of Microsoft's products and services would be "infused with A.I." and called A.I. one of three fundamental technologies that will shape the future (the other two being "mixed reality" and quantum computing). The CEO saw

"The thing about A.I. is when you work to push forward the research, the downstream applications are incredible."

MARK CUBAN, BILLIONAIRE TECH ENTREPRENEUR AND INVESTOR IN A.I. STARTUPS, ON THE VALUE OF WORKING TO DEVELOP AGI

enormous potential for A.I. across Microsoft, including in the office productivity software and cloud-computing services that, together, made up two-thirds of Microsoft's revenues. It was not ground Nadella wanted to cede to Google or other tech rivals.

Microsoft had a long-standing research organization, with labs around the world, dedicated to state-of-the-art technologies, from virtual reality to cybersecurity, and yes, to A.I. But, as a company, Microsoft had mostly been interested in “augmenting human intelligence”—in other words, narrow A.I. Microsoft's labs hadn't produced the kind of flashy breakthroughs that DeepMind and Google Brain had. The company sometimes gave the impression AGI was a quixotic quest not worth pursuing.

But sitting out the AGI race presented Microsoft with a problem. The buzz around a series of breakthroughs at DeepMind and Google Brain created a perception that Alphabet was also leading the pack in narrow A.I. applications—giving Alphabet an edge in hiring the best researchers out of academia and potentially in selling cloud services too. This perception was further cemented in 2016 when DeepMind's A.I. algorithm AlphaGo defeated the world's best player in the ancient strategy game Go. Most A.I. researchers had thought it would be at least another decade before a system could conceivably equal humans at the game, which has exponentially more possible move combinations than chess. (Or *Pong*.) “The acquisition of DeepMind was the best marketing spend Google ever made,” says Chris Nicholson, the cofounder and CEO of Pathmind, a San Francisco company that helps businesses implement A.I.

Nadella had to do something to boost Microsoft's A.I. bona fides. In 2016 he restructured the company's research efforts, establishing a separate organization focused solely on A.I. research and applications of A.I. in Microsoft products like its Bing search engine and Cortana digital assistant. The CEO also began convening a weekly meeting of his top executives to discuss progress on the company's A.I.-related projects. But those were incremental changes. Microsoft still lacked an A.I. moonshot.

● **OPERATING OUT** of a three-story, gray-sided, pre-earthquake building with loft-like



SHALL WE PLAY A GAME?

Games have long been used as mile markers in the evolution of A.I. because they present intellectual challenges in a simplified setting. Here are a few notable wins for the computers:

● 2015: ATARI

Expanding on its previous work with the game system, DeepMind demonstrates an A.I. capable of mastering 49 Atari games—from *Pong* to *Space Invaders*—many to superhuman ability with just a few hours of training.

● 2017: POKER

Libratus, a poker-playing A.I. created by researchers at Carnegie Mellon University, defeated four pros in no-limit Texas Hold'em.

▲ 2019: STARCRAFT 2

DeepMind's AlphaStar A.I. ranks in the top 99.8% of the world's players in the complex, real-time strategy video game *Starcraft 2*, showing a mastery of both long-term strategy and arcade-style tactical battles.

interiors in San Francisco's Mission District, OpenAI now employs 120 researchers. In the past year, the group has made a series of announcements around “grand challenges,” designed to showcase its own progress toward AGI—and raise its public profile.

It created a team of five A.I. software bots capable of playing together in the video game *Dota 2*, which is frequently used in professional e-sports tournaments. OpenAI's five bots defeated the reigning champion human team in a best-of-three demo match in San Francisco in April.

Separately, OpenAI revealed a language algorithm capable of taking a few human-written sentences and then riffing on them, generating several paragraphs of coherent prose—a significant leap forward in the field of natural-language processing.

Finally, in October, the company debuted a human-like robotic hand that could unscramble a Rubik's cube. Roboticists have struggled for years to mimic the dexterity of a human hand. OpenAI's hand learned the task well enough that, more often than not, it could unscramble the cube without dropping it.

The three announcements show a lot about how OpenAI thinks it can get to AGI—and also why the organization has become a lightning rod for criticism.

But first, some background: The current push for AGI, along with the rest of the current A.I. boom, is built on neural networks—a kind of software loosely based on the human brain. Arrayed in multiple layers, these artificial neurons convert some raw input, such as the pixels in an image, to some output, such as the label “cat.” Because of the many intermediate layers of artificial neurons these networks rely on, they are said to be “deep,” and using them to perform a task is called deep learning.

Current research into AGI largely divides into two camps: those who believe deep learning alone will be sufficient to achieve AGI vs. those who think it will have to be combined with something else, such as logical rules. Within the deep learning camp, there are further divisions: one tribe emphasizes algorithmic innovation. The other puts more focus on the sheer size of the neural networks they are building and the amount of data they are fed. OpenAI is firmly in the “size matters” society.

OpenAI's signature achievements have all



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involved huge models, consuming massive amounts of computing power. Each of its five *Dota2* bots, for example, was controlled by an algorithm that took in 159 million different parameters, or data variables. Over their 10 months of training, the bots racked up the equivalent of 45,000 human-years' worth of *Dota2*-playing experience.

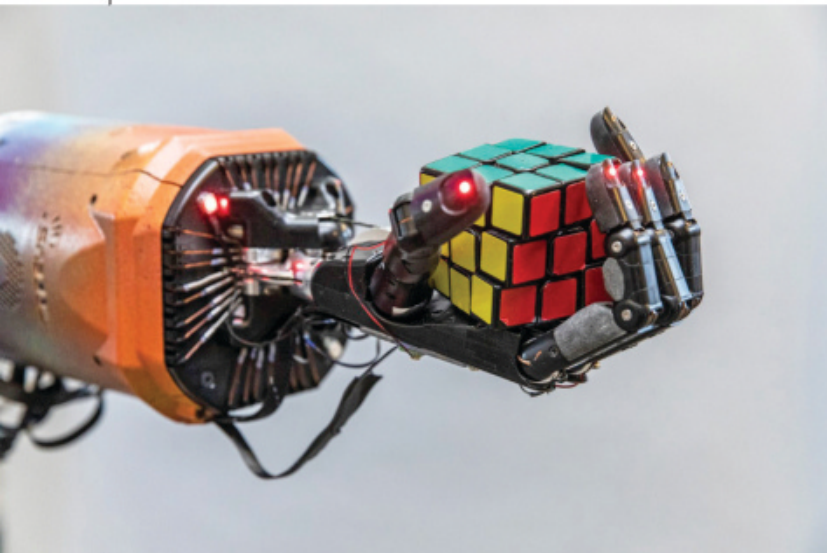
Altman told Nadella during their video chat in July that "increasing the size of the largest models we can train, keeps letting us solve seemingly impossible tasks." Altman, Brockman, and Sutskever have all said building ever-larger neural networks is an

important avenue to explore for making progress toward AGI.

Few researchers outside the company agree with OpenAI's thesis, however. Gary Marcus, an emeritus professor of psychology and neuroscience at New York University who is now CEO of startup Robust AI, says there is no evidence larger neural networks will suddenly begin to exhibit human-like skills, such as commonsense reasoning or conceptual thinking. "This is to ascribe to deep learning the quality of magic," he says. He says OpenAI has failed to show its systems can build representations of the world.

FOUR COMPANIES ON THE LEADING EDGE OF A.I.

Big Tech is engaged in a high-stakes race to create so-called artificial general intelligence (AGI). IBM and China's Baidu are among the companies driving the technology forward. But here are four contenders leading the way in the competition to conquer true artificial intelligence. —J.K.



▲ OPENAI

The San Francisco-based A.I. research lab was founded as a nonprofit in 2015 by a group that included Tesla founder Elon Musk with a mission to create AGI that "benefits all of humanity." Last year, it created a for-profit arm, into which Microsoft invested \$1 billion in July. Musk left the board in 2018.

BEST KNOWN FOR: Open AI Five, a team of five A.I. bots that beat the world's top human team in the video game *Dota2* in April 2019, and its Rubik's cube-solving robotic hand (above).

APPROACH TO AGI: A belief that larger and larger neural-network models are a promising pathway toward superintelligence.

● DEEPMIND

Founded in 2010 by chess prodigy turned video game entrepreneur Demis Hassabis, it wants to "solve intelligence, then use that to solve everything else." Google bought the London-based company in 2014 for about \$650 million. Its algorithms have improved a range of Google products.

BEST KNOWN FOR: AlphaGo, the A.I. software that beat the world's best human player of the ancient strategy game Go in 2016—considered a major milestone in computer science.

APPROACH TO AGI: Hassabis, who has a Ph.D. in neuroscience, has pushed the company to look to the human brain for inspiration to create nimble, sophisticated algorithms.

● GOOGLE BRAIN

Google's in-house, blue-sky A.I. research lab was set up in 2011 by Stanford University machine-learning expert Andrew Ng and Jeff Dean, one of Google's top software engineers. The original goal was to create A.I. with the intelligence of a human child.

BEST KNOWN FOR: Transformers, a kind of neural-network design that has led to big breakthroughs in natural-language processing, and Tensorflow, a major A.I. programming language.

APPROACH TO AGI: Originally focused on supervised learning, in which algorithms learn from large numbers of labeled examples, Brain has branched out into other kinds of neural-network-based approaches.

● FACEBOOK A.I. RESEARCH

Mark Zuckerberg recruited deep learning pioneer Yann LeCun in 2013 to establish Facebook A.I. Research (FAIR) with a goal of creating human-like A.I.

BEST KNOWN FOR: The A.I. programming language Pytorch and Mask R-CNN, a computer vision algorithm that can detect objects, draw boundaries around them, and identify them.

APPROACH TO AGI: Much of its work involves unsupervised and self-supervised learning, in which algorithms do not require labeled data sets. FAIR's research is more closely tied to its parent company's needs than some other labs—for instance, detecting A.I.-generated "deepfake" videos.


**ARTIFICIAL
INTELLIGENCE**

the demands of running Tesla and SpaceX and conflicts of interest as Tesla increasingly moved into A.I. and sought to recruit the same researchers as OpenAI.

In need of more cash, OpenAI's board decided to radically transform its structure: In March, Altman announced the creation of OpenAI's for-profit arm. The new structure allows OpenAI to take on venture investment. Crucially, it also gives the group the ability to issue stock options to attract and retain top computer scientists. Reid Hoffman's charitable foundation and Khosla Ventures, a prominent Silicon Valley venture capital firm, became the for-profit's first investors, injecting unspecified amounts. Then, in July, Microsoft put in its \$1 billion.

Some of that cash will come back to Microsoft as OpenAI buys data center time from the company's cloud-computing arm, Azure, which it has agreed to use exclusively. What the investment *does not* do is give Microsoft ownership rights to AGI—if OpenAI is successful in developing it. That will remain the property of the nonprofit part of OpenAI, which has also retained voting control of its for-profit wing. (If that makes you wonder if Microsoft's investment is really about AGI after all, you aren't alone.)

Both Microsoft and OpenAI declined to allow their executives to be interviewed about their partnership for this story. But a look at how Google has benefited so far from Google Brain and DeepMind provides a glimpse of what Microsoft stands to gain, even if it never gets its hands on AGI.

Algorithms that Brain has developed have helped improve Google's search engine, Google Translate, Google Maps, and its cloud-computing infrastructure. "Those kinds of things are really valuable for the company," says Jeff Dean, the senior software engineer who helped found Google Brain and now heads all A.I. research at Google.

DeepMind, meanwhile, has an entire group called DeepMind for Google (or DMG for short), responsible for collaborating with its sister company and other parts of Alphabet. "We don't choose product problems and then work out how to fix them," says Koray Kavukcuoglu, DeepMind vice president of research. But if DeepMind's research happens to be useful to a problem another Alphabet company is working on,

DMG will often collaborate on a solution. In 2016, DeepMind said it had helped Google figure out a better way to manage the cooling systems in the company's data centers, reducing its cooling bill by 40%. It later used a version of this algorithm to help extend the battery life of Android phones. In 2017, a DeepMind algorithm became the engine behind the computer-generated voice of Google's digital assistant.

● **THE BIGGEST QUESTION** about the corporate race for AGI is whether the large technology companies funding it actually believe—or even care—if creating human-like or superhuman intelligence is possible. "Within Silicon Valley, AGI is a kind of religious argument," says Pathmind's Nicholson. "You're either a believer, or you're not."

Josh Tenenbaum, a professor of computational cognitive science at MIT, is a believer: He runs a lab focused on reverse-engineering human intelligence and building more human-like A.I. But, like many in the field, Tenenbaum thinks AGI is "very far away." And he is among those who think the big corporations competing in the race for AGI are not being fully transparent about their motivations.

While there are certainly researchers at DeepMind, Google Brain, and OpenAI who genuinely want to achieve AGI, companies such as Alphabet or Microsoft, in Tenenbaum's view, care mostly about advances in narrow A.I. They're focused on getting better tools for building a range of narrow systems—such as algorithms to spot credit card fraud or recognize faces or parse legal documents. These narrow systems can be used internally as well as sold to cloud-computing customers.

Microsoft's partnership with OpenAI certainly has the potential to yield such innovations. The two companies have committed to helping Azure build better supercomputing capabilities, including the development of new chips designed to make the training and running of A.I. systems more efficient.

Whatever Nadella's true goals may be for the OpenAI deal, by making a 10-figure investment the CEO has put down a marker in the world of A.I. research. His company has joined the race for AGI. Even if Microsoft doesn't win, it may be the best \$1 billion investment he ever made. ■

\$50 billion

Projected global investment in artificial general intelligence by 2023

SOURCE: MIND
COMMERCE

\$13 trillion

Estimated amount that narrow A.I. applications will add to world economic output by 2030

SOURCE: MCKINSEY
GLOBAL INSTITUTE

Without A, B and O, we can't save anybody.

Only 3 out of 100 Americans donate blood—and that's not enough to help patients in need.

Without more donors, patients will not have the type A, B, O or AB blood they need.
You can help fill the **#MissingTypes** this summer. Make a blood donation appointment today.

RedCrossBlood.org/MissingTypes



merican
Red Cross



Haier's smart kitchen display at the 2019 IFA Berlin.

HAIER'S SMART HOME STRATEGY

How the IoT ecosystem company has transformed itself—and the way we live.

HAIER SMART HOME, A SUBSIDIARY OF HAIER

Group, is included on *Fortune's* World's Most Admired Companies list once again this year, a recognition of the globalization of its smart home ecosystems brand strategy. It is the only Chinese appliances company that made the cut.

POWERING INNOVATION

But Haier should no longer be defined as merely an appliances company. With artificial intelligence [A.I.] and Internet of things [IoT] technology as twin engines powering innovation—with the user at the center—Haier has transformed itself into an IoT ecosystems company with offerings that reach far beyond the simple functions of traditional home appliances.

Its suite of products now offers users the ability to do things they've never before been able to do, such as track the farm-to-table process of food from the comfort of their homes or customize and purchase clothing using only a smart mirror—capabilities that Haier believes will spearhead the burgeoning Internet of food and Internet of clothing movements.

Thanks to its successful transition into the smart home field, Haier was the only IoT ecosystems company to be recognized in the BrandZ Top 100 Most Valuable Global Brands for 2019.

To fuel its continued innovation, Haier has set up 10 research and development centers around the world, in places like Japan, New Zealand, and the United States, creating leading patents and setting industry standards in various geographic markets and product categories. Some of the company's first-of-its-kind technologies include self-cleaning washing machines and air conditioners, as well as its all-space smart refrigerator, which can recommend dinner recipes based on the ingredients inside. And if you need additional ingredients, it can order them and have them delivered to your home within an hour.

Because Haier Smart Home understands that different consumers have different preferences and needs, the company offers holistic customized solutions for every user that Haier calls "the 5+7+N total

solution.” The “5” represents the main spaces in a home: the kitchen, living room, bedrooms, bathroom, and outdoor space; “7” represents the core IoT categories: food, clothing, security, air, water, health, and education; and “N” stands for the infinitely customizable design-and-functionality options that can be chosen by the user via COSMOPlat, Haier’s proprietary cloud-based mass-customization solutions platform.

FAR-REACHING IMPACT

As the world’s largest platform of its kind, COSMOPlat allows Haier’s smart home solutions to extend outside of the home as well. Its 15 subplatforms stretch across key industries such as clothing, food, housing, travel, health, and education, integrating consumers, brands, and manufacturers into one ecosystem—and powering product customization.

In addition to the transformative technological innovations at the company’s core, Haier is also transforming the structure of business management itself. Haier’s RenDanHeYi model is expected to become the third global management model, after the Ford and Toyota models. Its meaning lies in its name: “Ren” refers to each employee, “Dan” refers to the needs of each user, and “HeYi” refers to the connection between each employee and the needs of each user. Within this model, companies are divided into microenterprises on an open platform, and the traditional “empire” system of management is dismantled, creating “zero distance” between the employee and the needs of the customer.

This management model has been implemented and verified in the United States, Australia, Japan, and elsewhere. An example of its success is GE Appliances, a Haier company, which has achieved double-digit growth for 14 consecutive quarters.

But the greater the company, the greater the responsibility. As Haier becomes more global, it not only serves global users with its products but also empowers global communities with its citizenship initiatives. Haier’s Project Hope, for instance, began back in 1995 with the opening of the first Hope Primary School, and the initiative has since built hundreds of elementary schools throughout China, acting on its mission to nurture future generations by supporting education in underdeveloped regions. And through its digital “Haier & Me” photo-sharing campaign last year, Haier initiated many citizenship projects in Thailand, Indonesia, and the Philippines.

In the U.S., GE Appliances is spearheading efforts to build communities and develop a pipeline of skilled manufacturing talent.

From Qingdao Haier to Haier Smart Home, Haier has changed more than just its name. Its position within the competitive high-tech landscape has shifted as well. Haier believes that to be competitive, today’s top smart home companies must go beyond what a single product can do and join the race to build ecosystems.

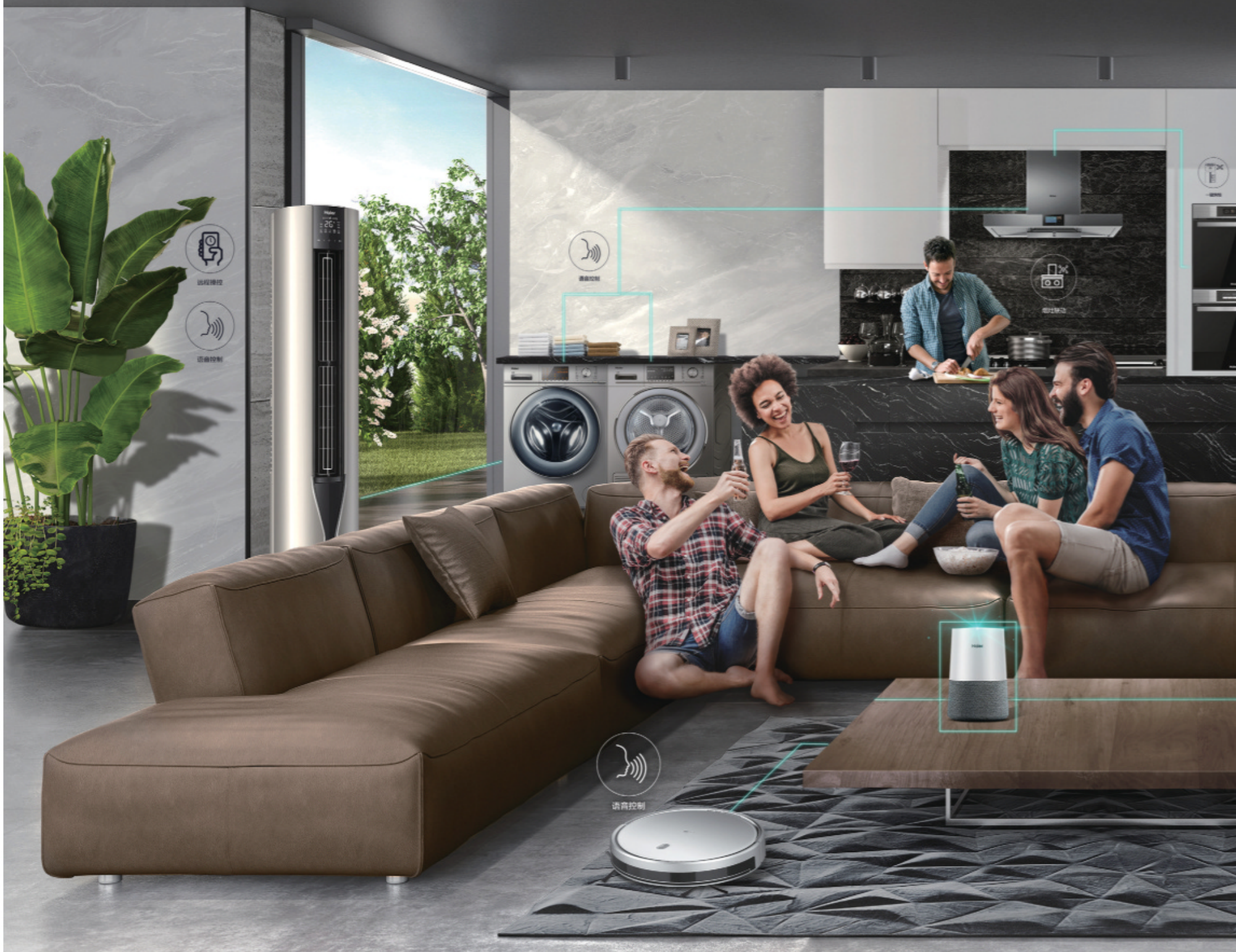
As Haier becomes more global, it not only serves global users with its products but also empowers global communities with its citizenship initiatives.



And that’s just what it has done. According to Euromonitor International, a market research institute, Haier has been ranked among the top five global appliances brands since 2009. Now, as Haier transforms itself into an IoT ecosystems brand, consumers throughout the world are poised to benefit from the existing and upcoming innovations and new technologies Haier brings into their lives. ■

Haier

Haier



Haier Smart Home Customized for a better life

DESIGN A HOME

BUILD A HOME

SERVICE A HOME



5 Smart Home Spaces, 7 Professional Solutions, Unlimited Personalized Scenarios
 Completely meet every family's living need in clothes, food, air, water, entertainment and more



Smart Kitchen

Smart Bathroom

Smart Living room

Smart Bedroom

Smart Balcony

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TikTok:

CHINA STARTS THE CLOCK

With its addictive video app, ByteDance is the first A.I.-powered Chinese company to hit it big in the West. Beijing is betting one of these companies will be next. **BY EAMON BARRETT**

ANDY WARHOL WAS WRONG. The pop artist famously asserted that in the future everyone would be famous for 15 minutes. But what Warhol failed to imagine back in the 1960s was TikTok, the dangerously addictive video-sharing app that today doles out global renown in 15-second increments.

With some 1.5 billion downloads worldwide—including 124 million in the U.S. as of November—TikTok is racing ahead in the battle for eyeballs, where its short clips compete with the likes of Facebook, Instagram, Twitter, and YouTube. In the world of TikTok, a group of tweens doing a choreographed dance routine can go viral overnight; a dancing ferret can garner millions of likes; or a clip of a man shaking his groove thing in a plushy rabbit costume might turn into a meme. (There's a lot of dancing on TikTok.)

While the content that powers TikTok is created by the app's obsessive user base, the company's A.I.-powered recommendation algorithms—which customize picks for users with increasingly uncanny insight—are what makes the platform so truly enthralling. That secret sauce is provided by TikTok's parent company, Beijing ByteDance. And thanks to TikTok's runaway success, ByteDance has emerged as a somewhat unlikely player in another global contest: the A.I. Arms Race.

The privately held ByteDance was founded in 2012 by former Microsoft engineer Zhang Yiming. Six years later, a \$3 billion fundraising round led by SoftBank valued ByteDance at \$75 billion, ranking it among the world's most valuable startups. That was before TikTok crossed the billion-user threshold.

Given its prowess in a hot technology like artificial intelligence and its wild popularity outside China, ByteDance should, in theory, be a darling of policymakers at home.



CLOCKWISE FROM TOP LEFT: SHIHO FUKADA—BLOOMBERG VIA GETTY IMAGES; APP VIA GETTY IMAGES; MICHELLE GROSSKOPF—THE NEW YORK TIMES/REDUX; JOE SCARNICI—GETTY IMAGES

Instead, it often appears to be out of favor with the government. The company has been made to apologize several times in recent years owing to content shared over its various apps. (In addition to TikTok, ByteDance owns other video-sharing platforms and a news-aggregating app called Toutiao that utilizes A.I. in a way similar to TikTok.)

There are other reasons that ByteDance might not have been Beijing's first choice to carry the banner for Chinese A.I. The central government intends for artificial intelligence to become a long-term driver of economic supremacy, a means for social governance, and a key tool in developing greater military strength. In short, Beijing has a plan for what A.I. development should look like in China—and frivolous videos are not a core part of it.

But if ByteDance is in some ways an outlier in the fast-growing Chinese A.I. ecosystem, in other ways it is a model for the sort

of unpredictable success that's likely to be replicated given the vast sums of public and private capital flowing into both primary A.I. research and A.I.-based startups in China.

"The industry is definitely hot right now, and I don't think it will abate," says Henrik Bork, managing partner of Beijing-based consultancy Asia Waypoint. "We are only just beginning to see A.I. getting started in China."

● **IT WAS A BOARD GAME** that helped kick off the current A.I. boom in China. In 2016, Lee Sedol, a South Korean master in the ancient Chinese game of Go, played a best-of-five-game competition against an A.I. system developed by DeepMind, an A.I. startup owned by Google parent company Alphabet. The object of Go is to surround more territory than your opponent on a board of 324 squares by laying down pebble-like pieces, and it's considered to be exponentially more complex

SOCIAL MANIA

TikTok has proved to be a global phenomenon, minting video stars and spawning new business ideas. Clockwise from top left: People in costume posing at a TikTok Creator's Lab event in Tokyo; a user showing off the TikTok app in Paris; a bevy of young TikTok influencers, who have banded together to collaborate on content, in December at the "Hype House" in L.A.; revelers at a TikTok party at NeueHouse Hollywood.



ARTIFICIAL INTELLIGENCE

A.I. IN CHINA

than chess. Some 280 million people in China tuned in to watch Lee's televised showdown with the algorithm, called AlphaGo. Lee was confident he would beat the algorithm. He lost all but one game.

For policymakers in Beijing, witnessing an A.I.-powered Western computer defeat a human in the ultimate Chinese game was a wake-up call—described by many as a “Sputnik moment” for A.I. in China. According to Luciano Floridi, the director of the Digital Ethics Lab at Oxford University, before 2017 A.I. was treated by Beijing as just one among many technologies in which China should improve its expertise. That soon changed.

The following year Beijing released the Next Generation Artificial Intelligence Development Plan (AIDP). The pivotal policy document singled A.I. out as a strategic technology and set a target for China to become the world leader in A.I. by 2030, with A.I. contributing \$150 billion to Chinese GDP.

Then Beijing did what it typically does when it wants to kick-start a given industry: It engaged in a bit of central planning.

In 2017, the central government selected five leading tech companies as “national champions” in A.I., instructing each to pursue a specific avenue of A.I. research. In return for picking up the mantle, the champions receive government support, such as access to finance, preferential contract bidding, and sometimes even market share protection. China's leading search engine provider, Baidu, was tasked with developing autonomous driving, for example. E-commerce giant Alibaba, meanwhile, has been charged with advancing technology needed to build smart cities. In the past few years, the number of A.I. champions has risen to at least 15. (See box.)

The pairings between champion and designated area of expertise aren't always as random as they might seem. Even before the AIDP was released, Baidu was investing heavily in autonomous vehicles (AVs). The year before that, Alibaba launched its smart-city software service, City Brain, which uses big-data analysis to assist with urban planning and management.

Despite the big policy push from Beijing, China's approach to A.I. is only semi-centrally planned. Plenty of the heavy lifting is being left to local governments. Some \$15 billion of new funding for A.I. has been

pledged by Shanghai. Tianjin, another coastal metropolis, is raising \$16 billion in funds for A.I. And the city of Beijing is currently building a \$2.2 billion industrial park for A.I. research.

“There's a lot of bottom-up,” says Jeffrey Towson, a private equity investor and former professor at Peking University. “There are a lot of entrepreneurs, lots of venture capital, and half the time the government is trying to figure out what's going on.”

Just as AlphaGo's victory caught the attention of Chinese officials, the dollar amounts being invested by the Chinese to pursue their A.I. goals have set off alarm bells in the U.S. amid concern that Washington isn't investing enough in the technology. In November, for instance, Congress's National Security Commission on Artificial Intelligence, chaired by former Google CEO Eric Schmidt, published an interim report in which it warned that China is outpacing the U.S. in A.I. spending. That was followed by a report from the Center for a New American Security urging the U.S. government to fund \$25 billion of R&D in A.I. At a debate in December, Democratic presidential candidate Andrew Yang warned that China is “leapfrogging us in A.I. because they have more data than we do and their government is subsidizing it to the tune of tens of billions of dollars.”

The Trump administration, meanwhile, has imposed export controls on several categories of A.I. technology in an attempt to curb the flow of key A.I. intellectual property to China. But the Chinese are making gains in the research arena as well. Judging by the number of A.I. patent filings and published academic papers on A.I., China is now neck and neck with the U.S. (See graphic on page 80.)

● **CHINA'S RAPID PROGRESS** in A.I. has done much to even the playing field with the West. But in many fundamental ways China still has ground to make up. Jeffrey Ding, a researcher at Oxford's Future of Humanity Institute who studies China's A.I. strategy, recently conducted a systematic comparison of the U.S. and China A.I. ecosystems. “My conclusion was that the U.S. is still far ahead,” says Ding.

One area in which the U.S. has a clear lead is in hardware. China currently consumes 58% of the world's semiconductor supply. But according to the Center for Strategic

55%

Compound annual growth rate of China's A.I. industry from 2014 through 2018

SOURCE: QIANZHAN INDUSTRY RESEARCH INSTITUTE; CAICT

and International Studies (CSIS), only 16% of chips used in China are produced within the country, and only half of those are made by Chinese companies. Beijing has a plan to meet 70% of its domestic demand by 2025 and has pledged more than \$100 billion to that end. However, China's leading chipmaker, Semiconductor Manufacturing Industry Corp., still lags far behind its Western rivals. SMIC began producing 14-nanometer chips only last year; industry leaders have all moved on to 7-nanometer chipsets. (In chips, smaller is better.) "China still depends heavily on Western technology," says Lian Jye Su, principal analyst at ABI Research in Singapore. "That explains the sense of urgency from Beijing to accelerate China's R&D into these sectors."

One area in which the U.S. and China have begun to square off: the war for talent. In November, a Senate Committee on Homeland Security and Governmental Affairs labeled China's talent acquisition strategies—the committee counts some 200 plans—a threat to national security, claiming that "China unfairly uses the American research and expertise it obtains for its own economic and military gain." The report notes that the U.S. lacks a "comprehensive strategy to combat this threat" of brain drain.

● **ONE OF THE FACTORS** most often cited when discussing China's advantages in developing artificial intelligence is its massive treasure trove of data. A.I. algorithms feed on data in order to learn. And it's certainly true that, for the right company, data is available in abundance in China. That's not only because of the country's roughly 1.4 billion people, generating multitudes of data points, but also because of a, shall we say, cooperative regulatory environment. And China has a massive video surveillance system with millions of A.I.-enabled cameras.

In this setting, the development of facial recognition technology has thrived. China is home to two of the world's most valuable computer-vision companies—Hong Kong-based startup SenseTime, which is valued at more than \$7 billion, and Beijing's Megvii, which is valued at just over \$4 billion and plans a Hong Kong IPO this year. Megvii operates the world's largest open source database for training other facial recognition algorithms, Face++, which has over 300,000



NATIONAL CHAMPIONS OF A.I.

When China proposes a national policy for industrial advancement, it doesn't leave success to chance. Instead, the government selects leading enterprises—state-owned or otherwise—and designates them "national champions." Those selected are expected to work toward the government's goals and are often rewarded with preferential policy treatment and easier access to financing. In 2017, Beijing selected five companies to spearhead its A.I. program. That number has grown to at least 15. Here are five of the most important:

1

CHAMPION: **BAIDU**

ARENA: **AUTONOMOUS DRIVING**

STATS: "China's Google" launched an open source platform for autonomous driving software, called Apollo, in 2017. Baidu stylizes Apollo as the equivalent to Google's Android operating system, but for autonomous vehicles (AVs).

2

CHAMPION: **TENCENT**

ARENA: **COMPUTER VISION FOR MEDICAL DIAGNOSES**

STATS: The operator of the WeChat super-app has been an active investor in digital health care since at least 2014. Its Medical A.I. Lab is currently working on a computer vision system designed to diagnose Parkinson's disease.

3

CHAMPION: **HUAWEI TECHNOLOGIES**

ARENA: **A.I. INFRASTRUCTURE AND SOFTWARE**

STATS: Huawei, the global telecom equipment giant that has been embroiled in the U.S. vs. China trade battle, was added to China's roster of A.I. national champions last September. It is tasked with boosting "device, edge, and cloud" capacity.

4

CHAMPION: **ALIBABA GROUP**

ARENA: **SMART CITY INITIATIVES**

STATS: China's largest e-commerce conglomerate has pursued its designated mission by developing the City Brain initiative, which uses cloud computing and big data to improve urban planning and is deployed in 23 cities including Kuala Lumpur.

5

CHAMPION: **SENSETIME**

ARENA: **COMPUTER VISION**

STATS: SenseTime began as an academic project at the Chinese University of Hong Kong in 2014 and is now a leader in the field of computer vision with a valuation of over \$7 billion. Its technology is used in some government surveillance projects.

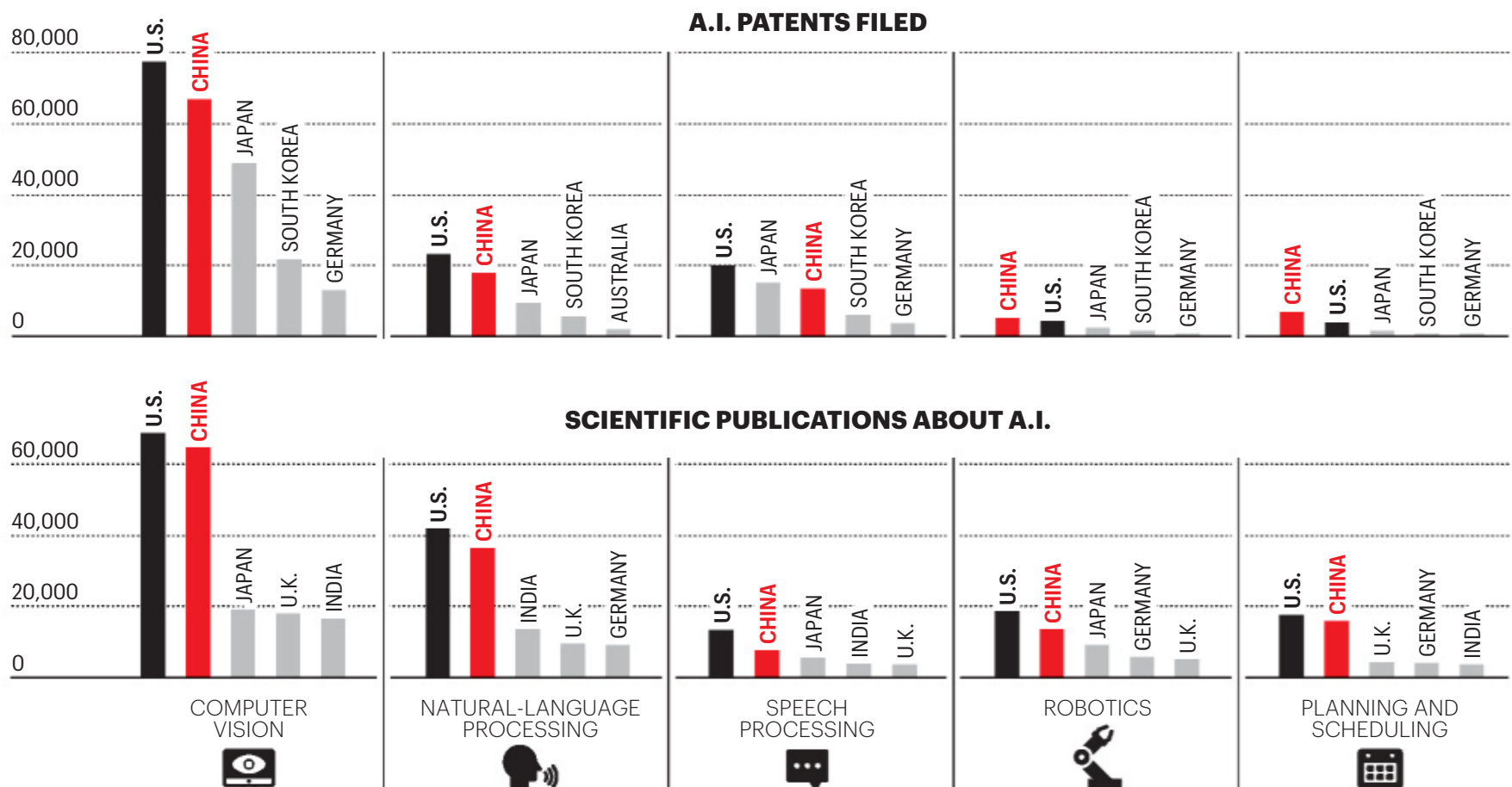


ARTIFICIAL INTELLIGENCE

THE BREAKDOWN

A NEW ARMS RACE IN A.I. RESEARCH

In major areas of artificial intelligence, China is challenging the U.S. in key measures of intellectual property success.



NOTE: A SCIENTIFIC PUBLICATION OR PATENT MAY BELONG TO MORE THAN ONE CATEGORY. SOURCE: WORLD INTELLECTUAL PROPERTY ORGANIZATION

users. It has reportedly used government data banks to help compile its training program.

China has faced criticism for its use of facial recognition to track citizens—particularly the Muslim Uighur population—and its experiments with a “social credit system” that would incorporate facial recognition to monitor behavior. As of December, anyone purchasing a new SIM card in China is required by law to submit to a facial recognition scan in order to confirm their identity.

But a massive library of its citizens’ faces alone doesn’t assure China of a long-term advantage in A.I. more broadly. “I think a lot of the arguments about how China’s data advantage means it’s going to be ahead on deploying A.I. applications are overstated,” says Oxford’s Ding. “More facial recognition

data, for instance, doesn’t benefit other verticals, like smart manufacturing, precision medicine, or autonomous vehicles.”

Given all the anxiety in the West about China’s A.I. ambition, even TikTok has come under scrutiny. In November, the Committee on Foreign Investment in the United States (CFIUS) opened an investigation into whether TikTok posed a national security threat, prompted by reports alleging that TikTok shares user data with the Chinese government. Bytedance, which declined to be interviewed for this article, has denied the accusations and says its U.S. data is stored on servers in either the U.S. or Singapore.

But for most of TikTok’s billion-plus users, such concerns aren’t on their radar. They are focused on chasing fame, 15 seconds at a time. ■

CHARLES TYRWHITT

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A photograph of three Old Dominion Freight Line employees standing in a warehouse. On the left, a man in a dark green polo shirt and dark pants. In the center, a woman in a light green polo shirt and khaki pants. On the right, a man in a dark green polo shirt and dark pants. They are all looking towards the camera. The background shows warehouse doors and a white trailer with the Old Dominion Freight Line logo and the number 604640.

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*Source: 2019 Mastio & Co. National LTL Carrier Report

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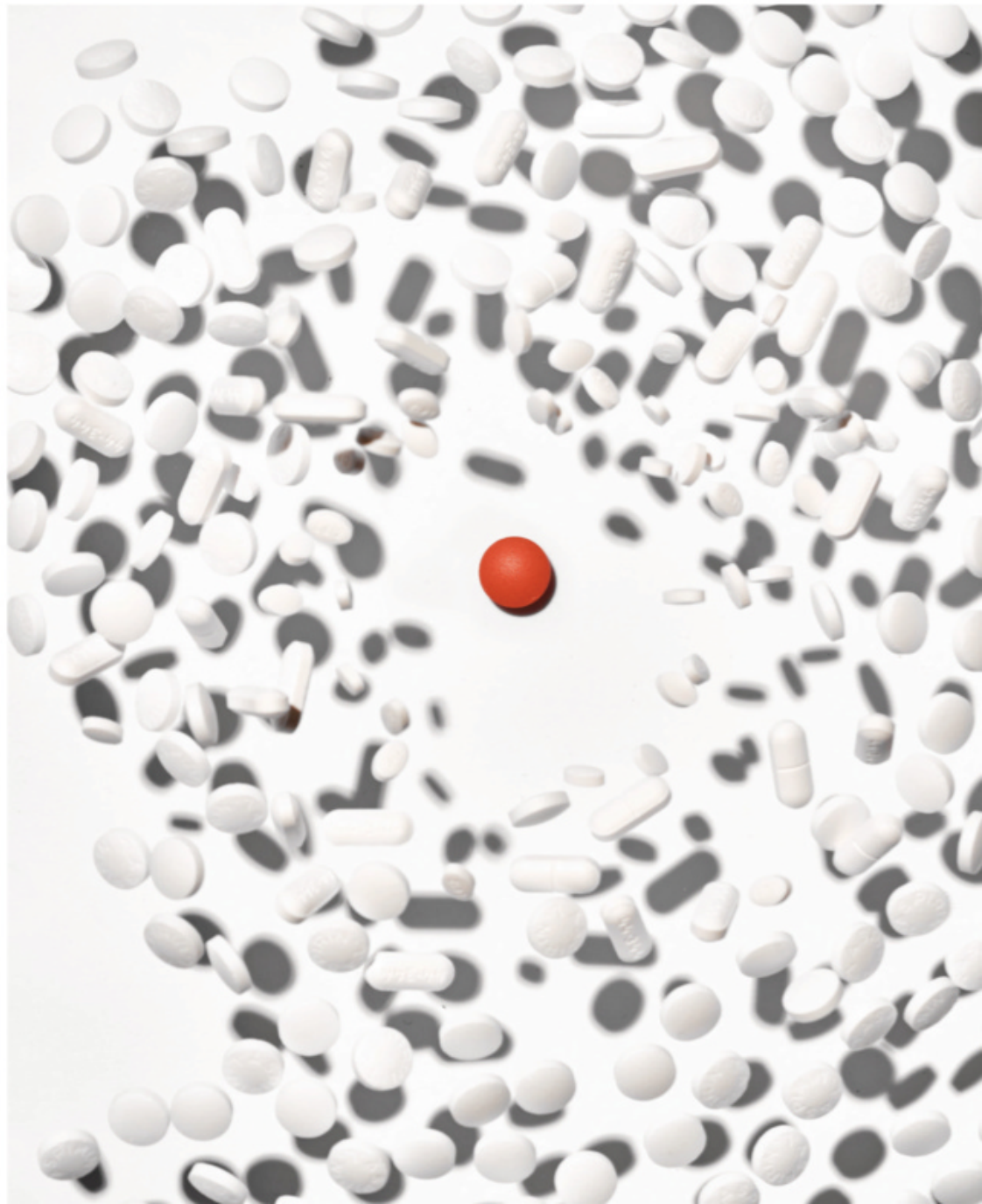
MEDICINE BY MACHINE

Computer algorithms are sifting through an endless archive of biological data—and quickly finding patterns that it would take a human a lifetime to discover. Is A.I. the missing cure for the world's ailing drug industry?

BY JENNIFER ALSEVER



WHEN A CANADIAN company called Deep Genomics announced in September that it had used artificial intelligence to solve a long-standing mystery about a genetic disorder called Wilson's disease—and, what's more, had used another deep-learning platform to identify a potential treatment—there was a flurry of excitement in the drug development world. The apparent milestone, which the company hailed as the “first-ever A.I.-discovered therapeutic candidate,” got echoing headlines from dozens of news outlets, and in January, the five-year-old startup re-



ceived a \$40 million endorsement in the form of a fresh round of venture capital funding.

But the discovery itself is far more nuanced than most of the press reports have made it seem—and illustrates both the remarkable potential of A.I. in drug development and its inevitable limitations, at least in the near term.

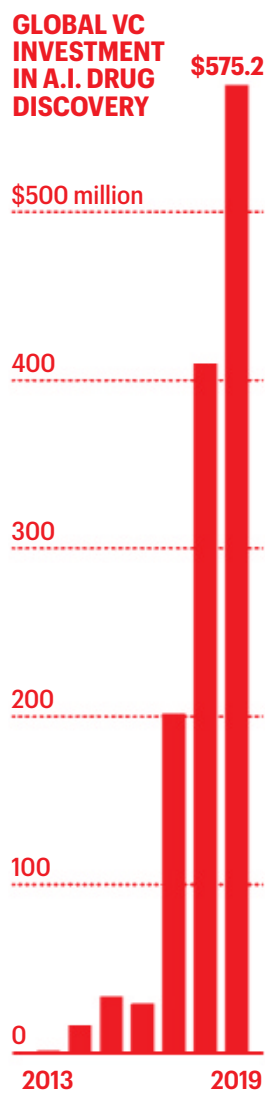
The team at Deep Genomics began by feeding massive amounts of data related to more than 200,000 gene mutations into so-called training algorithms—teaching their computers to find connections between those misspelled snippets of human DNA and the faulty proteins they encode, which in turn seem to drive certain human diseases. “The A.I. learned to understand the molecular biology,” says Deep Genomics CEO Brendan Frey, who did his doctoral studies at the University of Toronto under A.I. pioneer Geoffrey Hinton and later became a leading researcher in neural networks himself.

In the case of Wilson’s disease, a rare disorder that prevents sufferers from metabolizing trace amounts of copper found in food (and which can lead to liver disease and a host of neurological and other problems), the company’s A.I. found just such a connection with blistering speed. It has deciphered precisely how a mutation known as Met645Arg leads to a crucial defect in an essential copper-metabolizing protein.

Next, the company used another set of A.I. tools to sort through billions of molecules and rapidly identify nontoxic compounds that could correct the error made by the genetic glitch and enable a functional protein to be produced. The algorithms came up with no fewer than 12 drug candidates, each of which appeared to work in both cell models and mice. Deep Genomics hopes to put one of them, known as DG12P1, into human clinical trials as soon as next year.

From a scientific perspective, “it’s a big leap forward,” says Dr. Fred Askari, who directs the Wilson’s Disease Program at the University of Michigan School of Medicine. And when seen through the traditional lens of the drug industry, it may seem to be an even grander achievement: The entire process took just 18 months, Frey says, compared with a more typical preclinical development timeline of three to six years. If this can be repeated again and again, as Deep Genomics

RUSHING IN



NOTE: INCLUDES GRANT & CORPORATE FUNDING
SOURCE: PITCHBOOK

98%

The share of investigational compounds that never get commercialized.

claims it can, then the effect could be revolutionary. Shrinking the time to discovery, after all, means quicker help for patients—and, in theory, less cost to drugmakers.

No wonder much of Big Pharma is racing into the field. Novartis is now collaborating with Microsoft on A.I.-driven drug discovery; Pfizer is using IBM’s Watson; and others (including Johnson & Johnson, Merck, AstraZeneca, and GlaxoSmithKline) have inked drug development partnerships with smaller A.I. companies. All told, investors have put \$2.4 billion into hundreds of such startups since 2013, according to data from PitchBook.

Yet as promising as all this sounds, there are caveats to consider before you grab those A.I. pitchforks and storm the barricades. First is that Deep Genomics’ drug candidate has yet to be tested in a single patient, so—as the company itself acknowledges—we don’t yet know that it works.

Dr. Eric Topol, a prominent cardiologist and geneticist at Scripps Research and author of the 2019 book *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*, has been carefully reviewing the A.I. hope and hype for years. “We’re long on promise and short on proof,” he says.

“A.I. is a term that conflates ideas that we’re pretty sure will work in the future with ideas that are really just proof of concept,” agrees the University of Toronto’s David Duvenaud, whose celebrated research was crowned “Best Paper” at last year’s largest academic A.I. conference, the NeurIPS. At the gathering, Duvenaud surprised many by giving a blunt critique of the shortcomings of his own theoretical paper—a commentary that data scientist Mostapha Benhenda says reflects the more sober view of the field that many of his colleagues now share. “Such open self-criticism was unthinkable a couple years ago,” marvels Benhenda, whose Paris-based crowdsourcing startup, Melwy, fact-checks and fixes drug development algorithms.

One critical limitation, say experts, is simply the lack of good data on which to train the machine-learning systems. There are academic sources on genetic and molecular interactions to plumb, but comprehensive information about many chemical compounds—and more important, patient data from many clinical trials—is often proprietary to drug-



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makers and is rarely shared. Much of the data that is available, moreover, is poorly characterized or poorly structured, says Dr. David Agus, professor of medicine and engineering at the University of Southern California and the founding CEO of USC's Lawrence J. Ellison Institute for Transformative Medicine. "It's garbage in, garbage out," he says.

That said, if A.I. can truly slash the discovery time for new medicines by half, it might finally offer an antidote to ever-soaring drug prices. That's because a big area of promise for the technology is in tackling the mysteries of genetic disorders, like Wilson's disease, in which the patient population is relatively small and where Big Pharma isn't likely to bother with investing in new medicines. (Wilson's disease affects an estimated one out of every 30,000 people worldwide, and Met645Arg, the gene variant that Deep Genomics' A.I. programs helped decipher, is just one of more than 500 mutations that may

play a role in causing it—making the potential market for the company's experimental drug likely even tinier.)

In the past two decades or so, drugs for such "orphan diseases" (those for which the U.S. patient population is fewer than 200,000) have represented an increasing share of newly approved medicines in the U.S., rising from 10% of the total in 1998 to 44% in 2017, according to a study this past fall by America's Health Insurance Plans. At the same time, their prices have skyrocketed, leaping from an average per person annual cost of \$7,136 in 1998 to \$186,758 in 2017—a 26-fold increase over 20 years. Today, nine of every 10 orphan drugs cost more than \$10,000 annually per patient.

If A.I. can reverse that frightening trend—and shrink both the time and cost of discovering new targeted treatments for these uncommon maladies—it will be worth all of the hype, and then some. ■

A.I.'S PHARM TEAM

Entrepreneurs are employing machine learning for every phase of drug development—from identifying better biological targets and experimental compounds to designing smarter clinical trials. Here, a few pioneers.

● DEEP GENOMICS DISCOVERING MEDICINES

In September, the Toronto startup claimed to have developed the first-ever A.I.-discovered therapeutic candidate, when it announced a new investigational compound for Wilson's disease, a genetic disorder that limits a person's ability to metabolize copper. CEO Brendan Frey says human trials on the compound will start next year. By then, he predicts, the company will have up to five new drug candidates in the works as well.

● ATOMWISE VIRTUAL DRUGMAKING

The San Francisco company is employing "convolutional neural networks," the same technology used in facial recognition and self-driving

cars, to find new treatment indications for existing medicines. Its computers create a 3D grid of a disease protein's biochemistry and then run it through various combinations of 11 billion different molecules—many of which are drawn from public sources, such as the National Institutes of Health PubChem library. The algorithms then identify combinations of molecules that would match that protein's biochemistry. Atomwise buys the promising compounds and sends them to academic and pharma researchers to test in cell lines and animal models; the company now has 550 projects with 250 research hospitals underway. "It's just like testing a prototype of an airplane before making it, says Atomwise founder and CEO Abraham Heifets. "You run simulations to ensure

the planes will fly, be quiet, and fuel-efficient. You'll test a thousand wings in the computer for every one you build."

● LANTERN PHARMA REVITALIZING DISCARDED COMPOUNDS

The Dallas company combs through data from hundreds of drugs in "failed" clinical trials to identify ones that might work for certain genetic subsets of patients. Such drug rescue isn't new, but Lantern hopes its algorithms will dramatically speed things up. It recently acquired four compounds that were previously shelved by Big Pharma companies—including an abandoned chemotherapy agent that Lantern's A.I. platforms suggest might be effective in a particular subset of patients

with lung cancer. After digesting reams of clinical and other data, including some from the drug's initial owner that was a decade old, Lantern's A.I. engines identified a six-gene "signature" in a specific group of patients—females with adenocarcinoma who had never smoked in their lives—who were most likely to respond to the drug. (The company hopes to work with the FDA to design a new clinical trial to test the therapy specifically in this cohort of patients.) Lantern's investment so far: less than \$2 million, a fraction of the typical outlay by drugmakers for a compound in late-stage testing. "Drugs shouldn't cost \$300,000 per dose," says CEO Panna Sharma. "If we can do this faster, cheaper, and make drugs more personalized, then that changes everything."

SIRI, DID I ACE THE INTERVIEW?

Some of the world's biggest companies are relying on A.I. to build a better workforce. But be warned: The tech can create new problems even as it solves old ones. Here's how HR is learning to love the robots. **BY MARIA ASPAN**



IN HIS AMSTERDAM OFFICES, about an hour's drive from his company's largest non-American ketchup factory, Pieter Schalkwijk spends his days crunching data about his colleagues. And trying to recruit more: As head of Kraft Heinz's talent acquisition for Europe, the Middle East, and Africa, Schalkwijk is responsible for finding the right additions to his region's 5,600-person team.

It's a high-volume task. Recently, for an entry-level trainee program, Schalkwijk received 12,000 applications—for 40 to 50 openings. Which is why, starting in the fall of 2018, thousands of recent university graduates each spent half an hour playing video games. "I think the younger generation is a bit more open to this way of recruiting," Schalkwijk says.

The games were cognitive and behavioral tests developed by startup

Pymetrics, which uses artificial intelligence to assess the personality traits of job candidates. One game asked players to inflate balloons by tapping their keyboard space bar, collecting (fake) money for each hit until they chose to cash in—or until the balloon burst, destroying the payoff. (Traits evaluated: appetite for and approach to risk.) Another measured memory and concentration, asking players to remember and repeat increasingly long sequences of numbers. Other games registered how generous and trusting (or skeptical) applicants might be, giving them more fake money and asking whether they wanted to share any with virtual partners.

Their results, measured against those of games played by 250 top-performing Kraft Heinz staffers, told Schalkwijk which candidates Pymetrics thought were most likely to succeed—because their traits, as represented by their gaming skills, most closely matched those of the risk-seeking, emotionally intelligent employees the company prizes. That data in turn helped decide job offers, creating a machine-assisted recruiting class.

Schalkwijk is one of a fast-growing cohort of human resources executives relying on artificial intelligence to recruit, assess, hire, and manage their staff. In a 2018 Deloitte survey,



32% of business and technology executives said they were deploying A.I. for “workforce management.” That share is almost certainly higher today—and it’s spreading to encompass some of the world’s largest companies.

As a job seeker, you might have your application vetted by a Mya Systems chatbot at L’Oréal or PepsiCo. You could respond to an A.I.-crafted job posting vetted by Textio, perhaps at Expedia Group or ViacomCBS. You could be asked to play Pymetrics games not only at Kraft Heinz but also at Unilever or JPMorgan Chase. You could record one of the automated HireVue video interviews used by Hilton and Delta Air Lines.

Your relationship with A.I. may extend past the job offer too. Once hired, you might find yourself filling out employee-engagement sur-



veys designed by Microsoft’s LinkedIn, where your answers could help set your manager’s performance targets. Your employer could tap you for promotion opportunities identified by Workday’s A.I. If you work at an Amazon warehouse and miss your productivity goals, in-house systems could recommend that you be fired. On the other hand, if you work at IBM and plan to quit, in-house systems might guess your plans and warn your managers that they should try to make you happy.



**ARTIFICIAL
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ILLUSTRATION BY
JUSTIN METZ



Companies are delegating considerable responsibility to these machines, and the list of personnel tasks in which A.I. plays a role is likely only to grow. Low unemployment and tight labor markets are putting employers under pressure to take any technological advantage they can get in the war for talent.

In a LinkedIn survey of hiring managers and recruiters who use A.I., 67% said they embraced the tech because it helped them save time. And a smaller cohort, 43%, cited an arguably more important motivation: A.I., they said, would help them combat bias in their decision-making. “People are inherently biased,” says Schalkwijk. “I wanted less biased hiring decisions and more data-driven hiring decisions.”

At its best, its creators and adopters argue, A.I. can eliminate bias from the hiring process. This can foster greater gender and racial diversity—both of which are associated with better business performance and employee engagement. A.I. can also purportedly look past another kind of bias, providing more opportunities to applicants who don’t have expensive brand-name educations. Before using Pymetrics, Kraft Heinz recruiters tended to scan résumés looking for top-tier universi-

GAMES WITH GOALS
Frida Polli’s startup, Pymetrics, designs games that work in conjunction with A.I. to assess job candidates’ personality traits. She says the system helps companies make more diverse hires—and, consequently, perform better.

PHOTOGRAPH BY
DESEAN
MCCLINTON-HOLLAND

ties. Now, Schalkwijk says, “it doesn’t matter if you’re from Cambridge.”

More broadly, A.I. can help employers better perceive their workers’ strengths. Contenders including LinkedIn and enterprise-cloud specialist Workday have built A.I.-enabled tools that they say can help human managers better recognize or track employees’ skills. “We can use technology to find patterns that I wouldn’t as a team leader be able to find in the past, to coach and develop people in a more thoughtful way,” says Greg Pryor, a senior vice president overseeing Workday’s internal talent-management programs. (In addition to selling it, Workday uses this technology with its own employees.)

Still, for all its potential, many employers are approaching A.I. warily. They’re confronting the promise-and-peril irony of applying A.I. to human populations: Done correctly, it has the potential to eliminate bias and discrimination; done injudiciously, it can amplify those same problems. And in a new, very much unregulated market, such problems may be hard to spot until it’s too late. Even some executives who are using A.I. express skepticism in private about what the technology can do—or what its drawbacks might be.

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“We’re in sort of the primordial ooze of how A.I. is going to find its way,” says Gordon Ritter, founder of venture firm Emergence Capital and an investor in several A.I. startups. “Is it friend or foe?” Ritter is betting that A.I. will prove beneficial, but for now, to many executives, the ooze still looks murky.

● **“A.I. IS LIKE TEENAGE SEX,”** says Frida Polli. “Everyone says they’re doing it, and nobody really knows what it is.”

The joke has been making the rounds in A.I. circles for a while, and Polli, the cofounder and CEO of Pymetrics, has been around long enough to see the truth in it. After getting a Ph.D. in neuropsychology and working in Harvard and MIT research labs, Polli found herself divorced, supporting a young daughter, and burned out on academia’s low paychecks. She went back to Harvard for business school, and in 2013 she started a cognitive assessment company with a former MIT colleague. Pymetrics promises to help employers make better, more diverse hires, based on what applicants could do rather than what their résumé says or what college they graduated from. The venture-funded New York startup now has a valuation of \$190 million, according to PitchBook, and between \$10 million and \$20 million in annual revenues; its games are used by about 100 employers.

A fierce A.I. evangelist, whose clear blue eyes and near-platinum hair match the intensity of her conversational speed, Polli acknowledges—and parries—critiques of the technology’s potential for misuse. Yes, bad A.I. actors exist, she says. But it’s not like humans are so much better, as demonstrated by enduring gender, racial, and class disparities. “There’s a front door to hiring and a back door,” Polli argues, “and the front door’s broken.”

Hiring is where A.I. currently is most widely used in personnel management. In this arena, “artificial intelligence” often gets lumped together with basic automation, such as keyword searches of résumés. But it more specifically refers to machine learning—where software teaches itself about correlations between applicants’ backgrounds and behavior and their potential performance.

The problem, notes Matissa Hollister, an assistant professor of organizational behavior at McGill University, is that a machine-learning system is only as unbiased as the

information it learns from. “To the extent that the real world contains bias,” she says, “there’s the risk that the algorithm will learn that bias and perpetuate it.”

That has already happened in some prominent cases. Amazon spent years building a résumé-analysis algorithm—one that it never used, because it turned out it discriminated against women. Because most of the previously submitted résumés it assessed were from men, the algorithm taught itself that men were always preferable hires.

More recently, HireVue, which uses A.I. to vet video interviews, has drawn scrutiny around bias issues. HireVue’s system asks applicants to use smartphone or laptop cameras to record answers to automated questions; its software then analyzes factors including word choice and facial expression. The Utah-based vendor, majority-owned since October by private equity firm the Carlyle Group, introduced its facial-analysis product in 2014. It has since been used by roughly 100 employers to assess more than 1 million applicants.

“A machine-learning algorithm is like a toddler; it will learn from its environment. We haven’t had a diverse group at the table creating this technology to date.”

FRIDA POLLI, COFOUNDER AND CEO, PYMETRICS

Its use hasn’t gone uncriticized. A.I. that relies on facial recognition can often misidentify or misread faces of color, especially those of darker-skinned women. HireVue says that its facial-analysis technology doesn’t extend to facial recognition. But a prominent privacy watchdog has asked the Federal Trade Commission to investigate HireVue for “unfair and deceptive practices”—challenging its use of facial analysis and of algorithmic assessments that are not transparent.

HireVue CEO Kevin Parker downplays the importance of facial analysis to HireVue’s assessments, and he argues that his company is “very focused on eliminating bias.” By standardizing how candidates are assessed, he argues, HireVue provides a superior alternative to ordinary hiring. “It’s certainly better than the typical ‘I know it when I see it’” snap judgment, he says.

But the criticism HireVue faces points to the problem highlighted by Hollister: Machines are as likely to amplify biases as they are to sidestep them. That's especially problematic when the people designing the tools are predominantly white and male, as is the case in much of the tech industry. "A machine-learning algorithm is like a toddler; it will learn from its environment," Polli says. "We haven't had a diverse group at the table creating this technology to date."

Equally unsettling to labor advocates is that most A.I. technology is both unregulated and opaque to the workers affected by it. Employers and vendors have to comply with antidiscrimination guidelines from the Equal Employment Opportunity Commission, but the EEOC has no A.I.-specific rules. Illinois recently passed a law that requires disclosure when employers use automated video interviewing. Industry members and critics agree it's a good first step—but only a first step.

"We may not have proof of bias. We also don't have proof of benevolence," says Meredith Whittaker, a former Google employee and cofounder of the AI Now Institute at New York University. A.I.-enabled hiring systems are "sold to employers, not to workers," she points out.

Even so, employers are still figuring out whether A.I. will advance those interests. Most have been using A.I. in human resources for only a few years, if that. "It's a trend that's here to stay," says Ifeoma Ajunwa, an assistant professor at Cornell who studies automation in hiring. "But A.I.'s still a blunt tool."

● **IN A TOWER** at the heart of Times Square, with remnants of New Year's Eve crowds still dispersing from the streets below, Eric Miller is talking back to his computer. It doesn't love what he's typed. "It's currently 'comparing this writing to 102 million job posts.' So thank you for that," Miller snarks, mock-offended. A few minutes later, a different bit of writing passes machine muster: "It liked me! That's a first."

Of course, Miller is one of the people who invited this critic into his company in the first place. He's the vice president of global talent acquisition for ViacomCBS, and he's scanning through Viacom's library of more than 200 A.I.-assisted job listings. For the past year his team has fed these listings

FIVE WAYS THAT A.I. IS REMAKING THE WORKPLACE

More companies are relying on artificial intelligence (often created by nimble startups) to help with the more time-consuming and complex elements of finding and managing talent. Here are five arenas where A.I.'s role is growing.

1

CHATBOT RECRUITERS

These tools are aimed at big employers seeking to hire part-time or low-wage employees en masse: Think call centers, or retailers staffing up seasonally. A.I.-enabled chatbot Mya Systems helps clients including L'Oréal and PepsiCo do vetting and interview-scheduling.

2

DEEP BACKGROUND CHECKS

Think twice about that Tweet. Fama Technologies uses A.I. to analyze the social media feeds of potential hires and current employees, looking for signs of racism, misogyny, or toxic behavior. Checkr provides general A.I.-enabled background checks for employers including Uber and Lyft.

3

EMPLOYEE ADVISERS

More companies are deploying A.I. to monitor and help people they've already hired. Workday is rolling out technology to track workers' skills (and proactively offer them chances for advancement); talent-acquisition startup Eightfold.ai says its similar platform can reduce unwanted attrition by 25%.

4

MANAGEMENT COACHES

As employers try to improve employee engagement, many are enlisting A.I. to figure out and fix what's wrong. Technology from Microsoft's LinkedIn regularly surveys employees; it then flags a decline in morale or unusual underperformance and offers suggestions about how managers could improve.

5

PERFORMANCE (REVIEW) ARTISTS

Employers have begun to introduce more A.I. into what remains a largely human-driven process. LinkedIn in September launched a product that allows employers and workers to check in on performance goals and feedback more regularly (and to compare accomplishments across an entire company).

through A.I. technology produced by startup Textio. A Seattle-based company founded by Microsoft veterans, Textio makes what's essentially a woke word processor.

Textio's program compares job listings and other communications with those written by other employers throughout its system (hence those 102 million other posts). The machine-learning technology measures the response that different posts attract, and from whom, and constantly assesses whether



ARTIFICIAL INTELLIGENCE

certain words and phrases attract or repel candidates—owing to subtle linguistic bias or just plain bad writing.

In the job description Miller is working on, the word “expert” is highlighted in light blue, to signify that it conveys a slightly masculine tone; swapping in “authority” makes the language more gender neutral. Loaded terms like “aggressive” are out, even though Miller may want recruits who can “meet aggressive deadlines.” (“You probably don’t think about that,” he explains, “but Textio thinks a *lot* about it.”) The software even flags corporate jargon like “drive results,” which can turn off potential applicants; Textio prefers asking them to “get results.”

Which ViacomCBS is doing. The company has seen a 28% increase in applications to jobs whose descriptions Textio rates as “neutral” in tone and is filling jobs with high Textio scores 11 days faster, Miller says. It’s seeing a measurable increase in gender diversity among applicants, too, including in traditionally male-dominated engineering roles.

It all seems like a benign first step in bringing A.I. into the HR process. Yet ViacomCBS has taken about a year to roll it out. And Miller has words of caution for fellow human resources executives who want to embrace A.I. “HR is already looked at as ‘those people,’ the bad guys, right?” he says. “If you start to introduce something that feels mechanical and employees pick up on that, that’s not a good look.” His advice for a better look? “Do your research. Check. Check again.” Miller’s biggest piece of advice echoes that of academics and critics: Make sure you or your vendors conduct regular audits, ideally by independent third parties, to ensure that the A.I. itself isn’t discriminating against specific groups.

But who exactly are the auditors? Cornell’s Ajunwa foresees a day when an independent agency gives out “fair automated hiring” certifications. For now, though, audits are largely self-imposed. Polli says she has an academic auditor lined up for Pymetrics and is in talks with a second; HireVue’s Parker says he hopes to hire an auditor by the end of March.

It all adds up to the kind of gray area that makes corporate legal departments nervous. “You have to be methodical about [A.I.], or you’re going to be doing damage,” Miller says. “But the rewards are huge if you get it right.”

● **A.I. PROVIDERS** haven’t proved that those rewards translate into bottom-line gains—but they say that day is coming. Pymetrics, for one, claims its technology can lead to better overall business performance. According to an anonymized case study provided by Polli, one insurance customer found that sales employees who had been “highly recommended” by Pymetrics generated 33% more annual sales than other hires.

In Amsterdam, Pieter Schalkwijk is measuring rewards by other metrics. Kraft Heinz has been able to hire talent with a broader mix of expertise: Before implementing the Pymetrics tests, about 70% of trainee hires had business degrees. Last year, only about half did, and around 40% had engineering degrees. Kraft Heinz has been so pleased with early results, Schalkwijk says, that it’s using Pymetrics tests in some U.S. hiring efforts.

“HR is already looked at as ‘those people,’ the bad guys, right? If you start to introduce something that feels mechanical and employees pick up on that, that’s not a good look.”

ERIC MILLER, VP OF GLOBAL TALENT ACQUISITION, VIACOMCBS

Still, he too is proceeding cautiously. For example, Kraft Heinz will likely never make all potential hires play the Pymetrics games. “For generations that haven’t grown up gaming, there’s still a risk” of age discrimination, Schalkwijk says.

He’s reserving judgment on the effectiveness of Pymetrics until this summer’s performance reviews, when he’ll get the first full assessment of whether this machine-assisted class of recruits is better or worse than previous, human-hired ones. The performance reviews will be data-driven but conducted by managers with recent training in avoiding unconscious bias. There’s a limit to what the company will delegate to the machines.

A.I. “can help us and it will help us, but we need to keep checking that it’s doing the right thing,” Schalkwijk says. “Humans will still be involved for quite some time to come.” ■



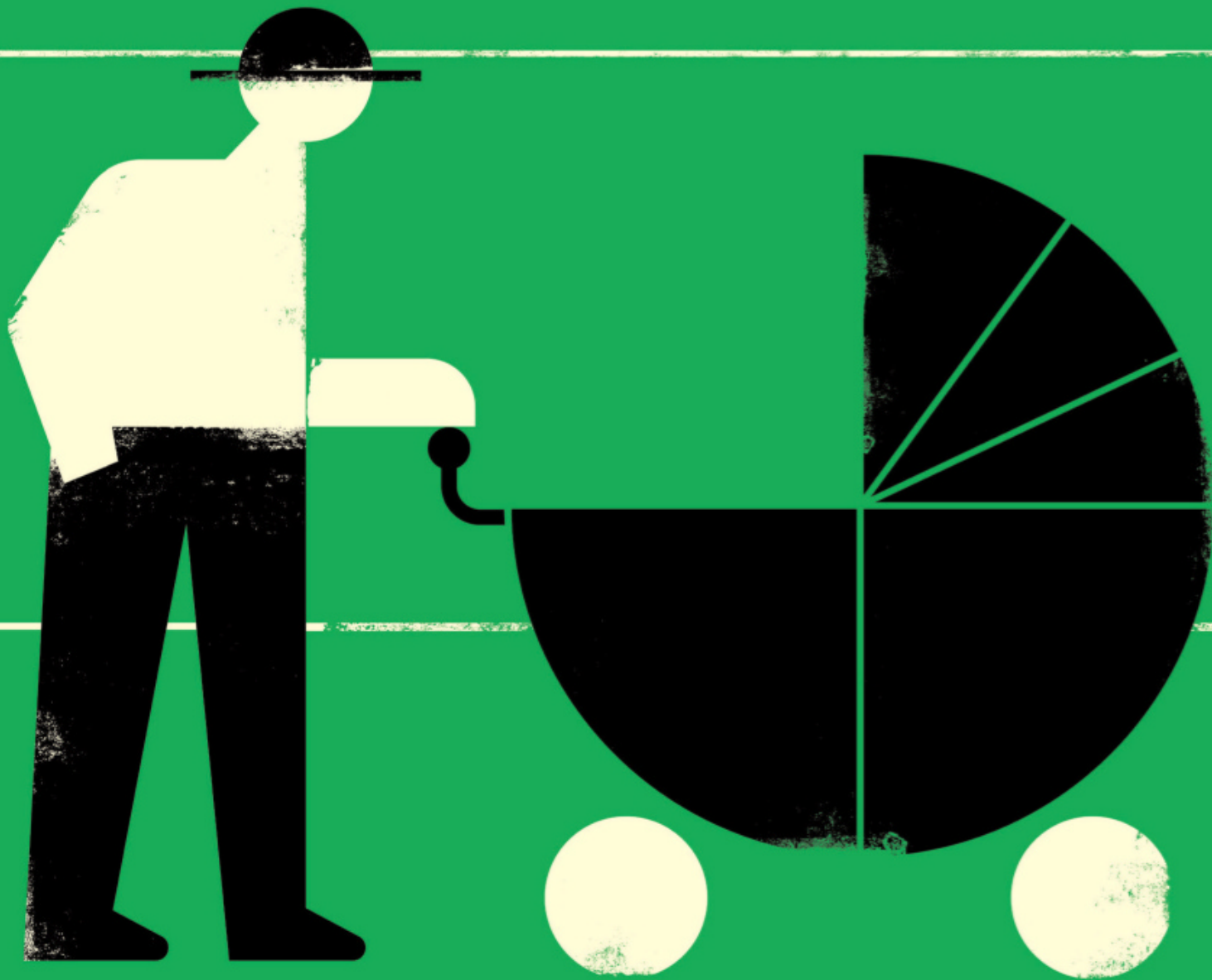
SPERM AND EGGS have invaded the Pennsylvania Convention Center.

At one end of the hall, a giant sperm poised to fertilize an ovum the size of a small weather balloon rotates above a booth marketing egg banking services. Nearby, an enormous mobile composed of more sperm and eggs—this time wearing eerie human faces—grins down from the rafters. Another booth is handing out stress balls with unmissable squiggly tails, while attendees crowd around an arcade game for the chance to win T-shirts stashed inside—what else?—golden eggs.

Granted, there's only so much iconography the fertility world has to draw on, but the sheer volume of genetic material floating around the convention center is a sign that the industry, once considered niche and boutique, is ready to go mass market.

It was mid-October, and the 8,000 doctors, nurses, bloggers, investors, and health care

executives milling about the exhibit hall had descended on Philadelphia for the American Society for Reproductive Medicine's annual confab—what one industry executive described as the "Super Bowl of fertility conferences." They attended seminars on topics like the trauma of infertility and team building in the embryology lab. They chatted



and exchanged business cards with exhibitors touting services ranging from at-home sperm testing to surrogacy agencies.

On the first afternoon, the crowd shuffled into the ballroom for one of the keynotes, which focused not on any major scientific development but rather on “IVF as a Business.” The talk was given by David Sable, who runs a health care–focused investment fund. “It’s not a bad time to think big,” Sable told the audience, laying out his vision for how the industry must embrace entrepreneurship to help in vitro fertilization—the medical process in which a woman’s eggs are harvested and fertilized, and a resulting embryo is implanted in her uterus—reach its full potential. He ended with a call to action: “We are, I think, at a pivot point in terms of IVF as a business. We’re not really thinking about these enormous new patient populations that are coming into our arena. We need to start planning for the future.”

Sable first attended the ASRM conference in 1988 as a resident about to embark on his training as a fertility doctor—just 10 years after the birth of the first IVF baby. In the decades since, the sector has gone from living outside the traditional health care system, viewed almost as a luxury good, to a serious industry garnering serious money. Piper Sandler research puts the U.S. fertility market at \$15.4 billion by 2023, up from almost \$7 billion in 2017. Millennials, now the primary demographic having babies, are aging into fertility treatment and are set to reshape the space in the same ways they’ve transformed so many other parts of our economy.

Investors have taken notice, funneling \$646 million into the sector in 2018, according to PitchBook. “Real dollars are starting to flow into this category,” says Stephanie Palmeri, a partner with VC firm Uncork Capital. The past few years have seen the launch of businesses encompassing everything from simple ovulation trackers to research plays attempting to discover links between genetics and reproductive disorders. Private equity firms, drawn to the industry’s high margins and increased success rates, are rolling up fragmented mom-and-pop fertility clinics. In October, fertility benefits provider Progyny became one of the first startups in the industry to go public; its stock is up more than 150% since the IPO.

Meanwhile, the high price tag for pa-



370%
INCREASE IN
CAPITAL INVESTED
IN THE FERTILITY
INDUSTRY
BETWEEN 2013
AND 2018

1 IN 8
COUPLES SUFFERS
FROM INFERTILITY

130%
PROJECTED
REVENUE GROWTH
OF U.S. FERTILITY
SECTOR BY 2023

**\$40,000–
\$60,000**
AVERAGE COST OF
LIVE BIRTH VIA IVF

tients—the average IVF baby costs \$40,000 to \$60,000, which comes out of pocket for most people—has allowed founders and investors to frame their work as democratizing treatment and improving access, all while positioning themselves to make a lot of money doing it. “Some people really care about having genetic children, which both makes it a huge source of suffering—and a huge market,” says Hank Greely, a professor focusing on bioethics at Stanford Law School.

The driving force behind the sector’s growth is the increasing age at which women are having their first child—age being one of the few factors in the under-researched field that doctors are certain affects a couple’s ability to conceive. In the U.S., women in their early thirties are now more likely to give birth than women in their twenties, and the only cohorts that saw increased fertility rates in 2018 were women in their late thirties and early forties. “I used to go to investors and say sex is great but not for making babies in your thirties and forties, and I think people are realizing that,” says Martin Varsavsky, a serial tech entrepreneur who has founded two fertility startups. “We have to let women have their babies later.” With increasing life expectancy, “is it fair to say you can only have babies until you’re 35? The window is so narrow,” he adds. Society at large is starting to recognize that there’s nothing fringe about fretting over or treating infertility. According to Progyny, one in eight couples suffers from infertility, making it more common than asthma or diabetes. By some estimates, IVF babies will account for just over 1% of the global population by the turn of the century, up from about 0.1% today. Many of those children won’t be born to parents diagnosed with infertility, but rather to nontraditional families, such as the LGBTQ+ population and single parents, who rely on the same technology.

For all its momentum, the modern fertility industry remains a relative newborn. That freshness is part of its potential, but also its risk. There are medical insiders who say it’s still the Wild West of medicine, under-regulated and commercially driven, with certain players overpromising what treatment can do. While some cheer the sector’s focus on women’s health, others say it has reinforced stereotypes that equate women’s worth with their ability to reproduce. And it is women



whom the industry targets: Despite the fact that men cause or contribute to infertility in about half of cases, companies have only recently turned their attention to male partners. There's no denying that fertility is emotionally complicated in ways most other areas of the health care system are not. "There's little we care about more than our children, which makes this a particularly fraught and charged area," says Greely. "The stakes are just higher when you play for babies."

A FEW WEEKS after the ASRM conference, I visit Sable at his office in Midtown Manhattan. The 26th-floor conference room offers sweeping views of New York City, the fertility capital of the U.S. The metropolis is a microcosm of some of the sector's key drivers—high incomes, the rising age

WHEN BUSINESS IS PERSONAL:

Modern Fertility cofounder and CEO Afton Vechery launched her testing startup after being diagnosed with a hormonal disorder that can cause infertility.

of first-time parents. More IVF is done here than anywhere else in the country.

Sable's past as a reproductive endocrinologist (medical speak for fertility doctor) means he's unfazed by the recorder sitting between us on the conference room table—a hazard of his old job. "Patients used to come in and record," he explains. "No one is more knowledgeable or motivated as a patient than an IVF patient." That drive is unusual in health care and makes the sector appealing to investors. "Most of the time, people are avoiding care," explains Sara Deshpande, a partner at Maven Ventures, which has invested in the fertility space. "They don't think actions will really improve lives." No one is running off to get fitted for orthotics or have that mole removed with the same desperation that couples launch into treatment for infertility.

In 2004, Sable took a sabbatical from practicing. Soon after, he was recruited by Special Situations Funds, an investment firm, to launch a health care fund. He kept up with what was happening in the

fertility world, but for a long time, there wasn't much to see. Science and outcomes were improving, he says, but the sector was "not transforming."

It was a decade before Sable saw his old field start to change. In 2012, ASRM declared egg-freezing no longer experimental. In the years that followed, private equity began to up its investment in the industry and an ever-tightening labor market prompted more employers to implement fertility benefits to retain talent. A third of U.S. states now mandate some form of infertility coverage—most recently New York, which as of Jan. 1 requires that fully insured employers with more than 100 employees cover three rounds of IVF. Sable, sensing a sea change, launched an IVF-only venture fund in 2018.

Right now, women in the U.S. undergo

nearly 300,000 treatment cycles of IVF annually. But that figure could eventually grow to something closer to 1.1 million by Sable's calculations. (A cycle refers to the process of egg extraction and fertilization, followed by embryo implantation; it takes the average woman 2.2 cycles to get pregnant.) His estimate takes into account the 7 million people struggling with infertility, many of whom don't seek care because of the expense. It also includes LGBTQ+ people who rely on assisted-reproductive technology to build their families, cancer patients who want to preserve their fertility as they undergo treatment, and carriers of devastating genetic diseases who could use IVF to select for embryos without, say, cystic fibrosis.

About 2% of U.S. babies are born via IVF—one of the lowest rates in the Western world. Increasing cycles to 1.1 million would put the U.S. more on par with Denmark, where that figure is approaching 10%. The difference? In Denmark, treatment is paid for by the state, while care in the U.S. has typically been out



of pocket. "It's a messy consumer marketplace. If you can afford to write a check for \$20,000 every few months, it's great care," Sable says. "What hasn't improved is access." There are just 450 fertility clinics in the U.S., and a handful of states have none at all. Sable says more efficiency and automation could bring down costs, but that's never been a priority for such a small market.

A prime example is the antiquated technology used to store frozen embryos and eggs. Historically, many embryologists started out in animal husbandry, and they brought their storage system with them when they began working with human embryos: glorified farm tanks full of liquid nitrogen, sometimes labeled by hand.

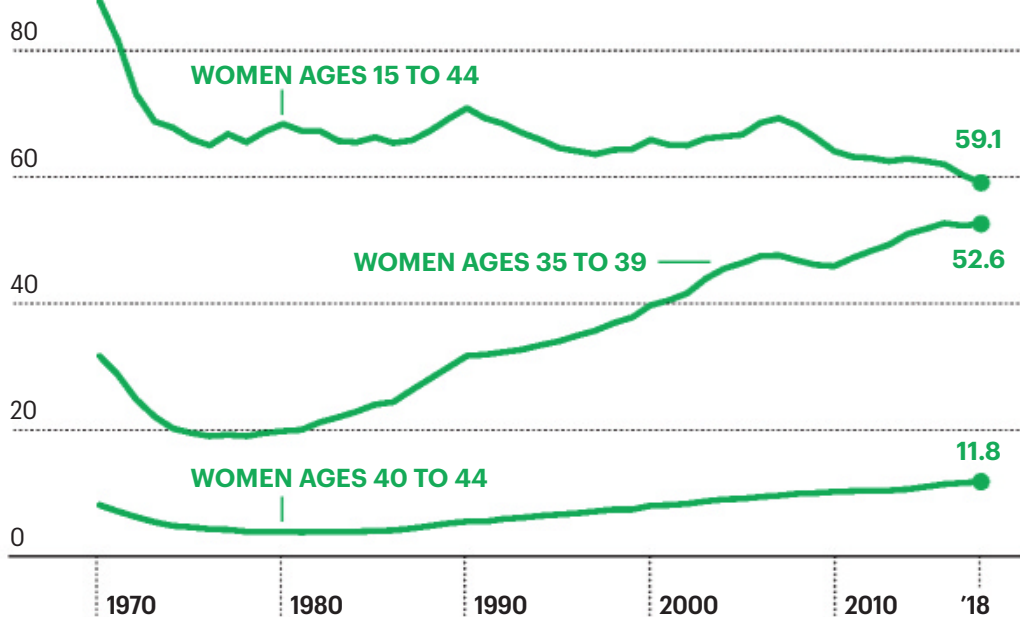
One of Sable's portfolio companies, TMRW, is attempting to bring that system into the 21st century with robotic cryostorage. Better freezing technology for eggs and embryos has resulted in a spike in usage, leaving the old infrastructure struggling to keep up. TMRW estimates that the number of U.S. patients storing eggs or embryos ballooned from 17,000 in 2005 to nearly 700,000 in 2017. By 2025, the company expects that number to hit 2.6 million.

Sable's fertility-focused fund backed the startup as one of its first investments, leading its \$12 million Series A round in May. TMRW's automated system for storing and tracking is designed to prevent the kinds of tank failures that in 2018 resulted in the loss of 4,000 eggs and embryos at a Cleveland clinic, and eliminate mixups that have led doctors to implant the wrong embryos. "It's a service business," says founder and co-CEO Joshua Abram, "that's moving from artisanal practices into a standardized regime."

Birth of a New Era

WHILE THE OVERALL BIRTH RATE IS FALLING, WOMEN AGE 35 TO 44 ARE BUCKING THE TREND.

U.S. BIRTH RATE PER 1,000 WOMEN



SOURCE: CDC

ONE OF THE MORE shocking aspects of fertility is how little most of us know about it—a holdover from a health system that traditionally focused on educating women about *avoiding* pregnancy. One founder in the space told me that she has to give what amounts to a basic biology lesson at the beginning of every pitch so investors can keep up. Attempts to bring potential customers up to speed have therefore become a requirement for most startups, but it can lead to an uncomfortable muddling of education and marketing.

The Baby Business Grows Up

FOR MANY, IT TAKES A VILLAGE TO CONCEIVE A CHILD. THERE'S MORE TO THE FERTILITY SECTOR THAN IVF.

AT-HOME TESTING

MODERN FERTILITY: The provider of hormone fertility tests was founded in 2017 and has raised a total of \$22 million. Investors include Forerunner Ventures, which has backed hot consumer startups like Glossier.

WEARABLES

AVA: Known as the "Fitbit of fertility," Ava's bracelet tracks factors including skin temperature, pulse, and heart rate to help determine a woman's fertile window. Founded in 2014, the company says its technology is responsible for 30,000 pregnancies.

INSURANCE

PROGYNY: A fertility benefits provider for employers, Progyny raised nearly \$100 million in venture capital from the likes of Kleiner Perkins, TPG, and Merck Ventures before going public in October. The company is profitable and has a market cap approaching \$3 billion.

DIAGNOSTICS

NEXTGEN JANE: The maker of a smart tampon is researching reproductive disorders like endometriosis by analyzing cells that are shed during menstruation. Founded in 2014, the startup raised a \$9 million Series A last year.

EGG FREEZING

EXTEND FERTILITY: The New York City-based clinic claims to be the largest egg-freezing practice in the nation. Last year it raised \$15 million from private equity firm Regal Healthcare Capital Partners to expand into other services like IVF.

One night last November, New York-based startup Kindbody was attempting to tread that line. Kindbody bills itself as a women's health network, but it's primarily known for egg freezing, a topic that's clearly of interest to the 50 women and two men who have gathered at its Flatiron location for an event billed as Fertility 101. The space's aesthetic—modern and spa-like—shares more in common with the Drybar salon around the corner than it does with a typical doctor's office ("Health care doesn't have to be ugly," notes founder and CEO Gina Bartasi). Fahimeh Sasan, Kindbody's founding physician, standing next to a wall mural instructing visitors to "own your future," told attendees to grab a glass of Prosecco, get some cheese, and relax.

Sasan got down to business. "The first point before any conversations about IVF or talking about getting someone pregnant or preserving fertility is just understanding the basics," she told the crowd. "Unfortunately, no one teaches us the basics. We go to Google, and Google freaks us out." Sasan got some knowing laughs before diving into such a comprehensive overview of fertility and egg-freezing that it was jarring when she finally made her pitch: Attendees who signed up that night for a fertility assessment would get \$100 off and a \$500 reduction in their \$6,500 bill for egg freezing—a figure that

does not include medication or storage. So many women lined up for promo codes at the end of the evening that getting out the door was a struggle.

After the talk, attendees asked Sasan about everything from pregnancy loss to needle phobia. One woman's question, though, hinted at a more fundamental worry about the industry: "Not to be negative, but what if you freeze your eggs with a company and that company goes bankrupt or out of business?"

Her concern was well-founded. Two weeks earlier, Trellis, a boutique egg-freezing-only studio a three-minute walk up Fifth Avenue, had sent out an email alerting customers that it was shutting down. Private equity-backed fertility-clinic network IntegraMed had launched Trellis based on the idea that women who freeze their eggs are vastly different from those seeking treatment for infertility and should receive specifically tailored care in their own separate space. "These are people coming in to be empowered," Pam Schumann, who was the chief development officer at Trellis, had said when I visited the clinic last spring.

The studio had been open less than a year, and Schumann told me that no clients had yet come back to use their frozen eggs. "It's a little bit of a dilemma in the space," she said. Trellis's parent company, IntegraMed,

declined requests for an interview but in an email said that “enrollment numbers were not sufficient to keep pace with the rising cost of doing business in New York City as a stand-alone operation.” (Eggs frozen at Trellis are being stored at one of the fertility clinics in IntegraMed’s network.) The explanation tracks with national trends: Egg freezing is fast-growing—but off a very low base. In 2017, the most recent data available, women underwent nearly 11,000 egg-freezing cycles, up from 475 in 2009. Sector wide, 90% of frozen eggs have not been used, and industry experts say the field is too new to say anything conclusive about success rates. “There’s a lot of nuance to egg freezing, and what scares me right now is a lot of people think it’s as easy as 1-2-3,” says Brian Levine, founding partner and practice director of fertility clinic CCRM-New York. “Women are being oversold and don’t even know what



THE DOCTOR IS IN(VESTING):

Former fertility practitioner David Sable launched an IVF-only venture fund in 2018.



the metric of success is.”

The debate over egg freezing hints at a more philosophical intra-industry fight. On one side are companies like Kindbody and now-defunct Trellis, with their language of empowerment and go-girl inspirational wall art. These founders want to rebrand fertility issues from a problem to be treated to an opportunity to be grasped. “A lot of startups are saying, We are not infertility clinics,” says Lucy van de Wiel, who works in the reproductive sociology research group at the University of Cambridge. “We are fertility clinics where you can come to manage your fertility.” On the other pole are those who argue that procedures related to fertility should be considered serious medical undertakings. Both sides have an economic interest in how egg freezing—and fertility more broadly—is ultimately framed. It wasn’t until 2009 that the World Health Organization designated infertility a disease and not until 2017 that the American Medical Association followed. Before that, treatment was considered a consumer good, says Tammy Sun, cofounder and CEO of Carrot Fertility, a fertility benefits provider for employers. The change in status helped legitimize the field and the increase in insurance coverage that followed.

But in their own way, companies like Carrot are also seeking to expand fertility treatment beyond women with an infertility diagnosis, which has traditionally been a prerequisite for insurance coverage. Their targets: the LGBTQ+ population and people choosing to have a baby on their own, groups that suffer from what’s termed “social infertility,” or the inability to have children for reasons that extend beyond biology. Now, inclusive companies are increasingly covering their treatment too. “The opportunity is much bigger than what we had previously assumed,” says Sun. “Fast-forward another five years, and this will be table stakes.”

THE AVERAGE PERSON should be forgiven for not knowing much about fertility—science doesn’t know much either. The egg is the largest cell in the body, but it’s arguably the least researched. One reason: the culture wars. The government has no interest in funding research that could involve discarding human embryos. “I’ve been living in that ethical can of worms

for 30 years,” says Sable. “When we started reproductive genetics, I started getting hate mail.” Research backed by the private sector is happening, but it can skew the types of studies that get tackled. To attract funding, projects must be based on a potential business application rather than on pure scientific curiosity or an interest in improving the life of womankind—a state of affairs some see as hampering innovation. “I don’t think we’ve seen the dollars flow into technology that improves birth rates or dramatically lowers costs,” says Jake Anderson-Bialis, cofounder of industry tracker FertilityIQ. A lot of startups are simply repackaging a test or redecorating a waiting room, he says. For example, menstrual-tracking apps, though buzzy, mimic what women have been doing on their paper calendars for decades. “The most potent weapon we have is IVF,” Anderson-Bialis says, “and it works 20% to 30% of the time.”

The lack of resources has relegated fertility to what Sable calls a “know-it-when-I-see-it level of thinking.” Consider the industry definition of infertility: the inability to have a child after six months of trying for women over the age of 35, or one year for those under 35. The cause cannot definitively be diagnosed by anything as straightforward as a blood test. Indeed, a third of the time, it’s simply chalked up to “unexplained infertility.”

Many of the startup founders in the field launched their companies after receiving similarly ambiguous answers about their own reproductive health. When Afton Vechery requested a baseline fertility assessment, her doctor told her to simply wait and see if she had issues once she was ready to have a baby. Vechery decided to pursue the testing herself. She ended up with a diagnosis of polycystic ovary syndrome, a hormonal disorder that can cause infertility, and a \$1,500 bill—an experience that led her to cofound Modern Fertility. “I felt like the entire conversation about fertility today was very reactive as opposed to proactive,” she says. The San Francisco-based startup lets customers take the same hormone test at home that’s typically done in a fertility clinic, but for \$159.

The test isn’t without controversy. One of the things it measures is anti-Müllerian hormone (AMH), which can be useful for women looking to evaluate how their ovarian reserve is changing, but doctors worry that taking the

\$15,000
AVERAGE COST
OF ONE EGG-
FREEZING CYCLE

300,000
ESTIMATED ROUNDS
OF IVF PERFORMED
IN U.S. ANNUALLY

2% VS. 10%
BABIES BORN
VIA IVF IN THE U.S.
VS. DENMARK

test only once—and without the counsel of a physician—fails to provide a clear picture of the taker’s fertility and can cause undue alarm. Modern Fertility says AMH, while not a perfect predictor of fertility, remains the best known marker of ovarian reserve, and it recommends users track the hormone over time. What’s more, Vechery says that the anonymized data the company is collecting from customers who opt in will be used in clinical research that could result in better predictors of future fertility.

Despite doctors’ misgivings, there’s a reason women are seeking out at-home tests and other nontraditional ways of addressing fertility. “Navigating the medical system as a female is fraught,” says NextGen Jane CEO and cofounder Ridhi Tariyal, pointing to studies showing that it takes longer for women’s pain to be acknowledged and treated in emergency room settings. “There’s some mistrust there.” Tariyal’s startup collects tampons from women who have endometriosis in order to analyze their menstrual blood and provide insight into the underpinnings of the painful disorder.

When Tariyal was trying to raise funding for NextGen Jane—challenging enough considering she was pitching period blood—she realized she got more interest from investors when she highlighted endometriosis’s impact on fertility rather than just the ways it was affecting the quality of women’s lives. “It sends the message that your greatest value is your ability to reproduce,” she says. She worries that the growing investor focus on pregnancy and fertility will draw away what little attention the rest of the women’s health field has struggled to garner—including issues such as the maternal mortality rates of black women, which are truly dire and mostly ignored.

It’s a reminder that the fertility industry has yet to disentangle itself from the very paradigms that advancements in reproductive health were supposed to dismantle: the conflation of womanhood and motherhood, the belief that biological ties are the best way to create a family, the implication that the burden of reproduction lies with women. It remains unclear that any amount of investment could ever shift those archetypes. But for the industry overall, that would truly be a major breakthrough. ■

WHEN GPS

THE MARITIME SHIPPING INDUSTRY WOULDN'T BE THE BEHEMOTH IT IS TODAY WITHOUT SATELLITE NAVIGATION. THAT'S WHY A RISING TIDE OF MYSTERIOUS GPS OUTAGES IS A DISASTER WAITING TO HAPPEN.



GETS LOST

BY KATHERINE DUNN



“HOW MUCH RISK ARE YOU WILLING TO TAKE TO

T

THE CALL CAME in by radio one evening last September, at around 9 p.m. On the line was the master of a tanker, approaching the end of a monthlong journey from the Port of South Louisiana and carrying more than 5,000 metric tons of ethanol. The message was urgent: The ship's GPS signal had suddenly disappeared—leaving the crew to navigate Cyprus's shoreline in the dark.

On the other end of the line was the pilots' office at the Vasiliko oil terminal, whose staff oversees shipping traffic at Vasiliko's harbor on Cyprus's arid, palm-fringed southern coast. Stelios Christoforou, the pilot on duty, recognized the gravity of the situation right away. In daylight, an experienced ship captain can maneuver using paper maps, markers, and the coastline as guides. But at night, GPS becomes a critical tool in

unfamiliar waters—especially near Cyprus, where NATO and Russian warships roam. And any accident could spill the tanker's cargo across miles of coastline.

Christoforou gave the tanker's master detailed instructions over the radio. It was crucial that the ship avoid a hard-to-see fish farm that could block its path to the west, he explained. He then went out to meet the ship by tugboat; there, he assumed the controls and guided the tanker into the harbor. Christoforou knew the coast's ins and outs intimately, having worked in the port for six years. Still, these situations made him uneasy. In years past, GPS had occasionally disappeared near Vasiliko for a few seconds, but lately it was vanishing for hours or entire days at a time. “It's not normal,” the pilot says.

In Cyprus, the not-normal has become routine: The global positioning system signal has been unreliable for much of the past two years. The outages have turned the tiny Mediterranean nation into a case study for a growing global problem: intentional interference with the planet's most widely used navigation aid.

The sources of such disruptions are hard to trace. But navigation experts agree that they're on the rise, often in conjunction with crime or armed conflict. And the expanding interfer-

ence has exposed vulnerabilities for GPS and for the oceangoing shippers who depend on it—an industry that handles more than 80% of global trade, according to the International Maritime Organization, the United Nations regulatory agency.

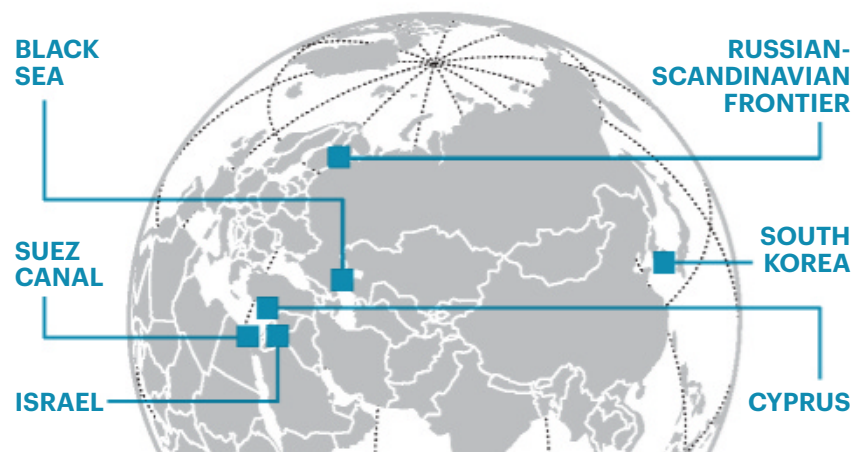
In recent years, GPS has become so reliable and so ubiquitous that you can forget it's even there—much less that it can fail. But it's surprisingly easy, it turns out, to knock the system into disarray. The shipping industry, meanwhile, appears underprepared to cope with breakdowns and unwilling to invest in self-defense in the absence of the kind of *Exxon Valdez*-like disaster it has so far been fortunate to avoid. Rick Hamilton, GPS information analysis team lead at the U.S. Coast Guard Navigation Center, says shippers and governments alike face an existential question: “How much risk are you willing to take to avoid spending a whole lot of money?”

L

LIKE ANOTHER revolutionary technology, the Internet, the global positioning system began as a Pentagon project; it's still maintained

Every Year, More Dead Zones

GPS outages have gradually grown more prevalent over the past four years; many have occurred near global conflict zones.



FEBRUARY 2016

Black Sea ports

Hundreds of ships report seeing their GPS locations suddenly migrate dozens of miles inland. A report by U.S. researchers later links many of the incidents to visits to Russian-annexed Crimea by President Vladimir Putin and other senior Russian officials.

AVOID SPENDING A WHOLE LOT OF MONEY?”

by the U.S. Air Force. But in the mid-1990s, it was opened to civilians, and in 2000 the government stopped degrading the civilian signal, making GPS stronger and more reliable and hastening its adoption worldwide.

The system has rivals in Russia, China, and the EU—collectively known as Global Navigation Satellite Systems (GNSS). But GPS's supreme advantage is its extensive coverage: A network of at least 24 live satellites positioned around the globe means you are always in sight of at least four, and a receiver—whether in an oil tanker or your smartphone—can triangulate your exact location.

Today GPS is ingrained in daily life, and especially so in business. It is used to guide ships, planes, and trains; by cranes in ports to find and stack containers; and by trucks to deliver those goods to warehouses and stores. Farming, mining, drilling for oil: Each depends on GPS in ever-growing degrees.

But as GPS has become commonplace, the risks associated with losing it have grown. In a June 2019 paper prepared for the Department of Commerce, the research nonprofit RTI International estimated the cost of a 30-day GPS outage in the U.S. at \$1 billion per day. The marine industry would be among those hit hardest, because of the bottlenecks an outage

would cause in ports and waterways. And U.S. losses would represent only a fraction of the worldwide impact.

It would take Bond-villain-level exploits to knock GPS offline entirely. But on a local level, all satellite navigation systems are vulnerable. Their signals, which grow weaker as they travel from orbit to earth, are often interrupted accidentally, by atmospheric disturbances or faulty equipment. They can also be interrupted on purpose, by transmitters beaming a conflicting signal, a technique known as “jamming.” Typically, the stronger the conflicting signals, the farther that disruption will reach.

More sophisticated, and more malicious, is “spoofing,” which creates fake signals that convince the receiver it is somewhere it is not. Done correctly, spoofing can go undetected—and is capable of leading an oil tanker, for example, off course in open water.

High-powered jamming and spoofing are usually the work of armies and intelligence services. Military ships employ sophisticated anti-jamming technology; as GNSS-guided missiles and drones assume growing roles in combat, the cat-and-mouse of satellite disruption has become a given. Indeed, as tensions mounted between the U.S. and Iran in 2019, what appeared to be jamming and spoofing occurred

in and near the Strait of Hormuz, the oil-shipping choke point between Iran and the Persian Gulf states.

But commercial vessels seldom carry such technology. That's worrisome, because small-scale GPS disruption has become something almost anyone can do. Off-the-shelf jammers, though illegal in the U.S. and many other countries, are easy to find online for as little as \$20, with prices rising as their range increases. Drug-smuggling networks use jammers to mask their activities; illegal fishing operations use them to obscure where they got their catch. And thieves who steal shipping containers deploy jammers to block the trackers hidden inside them.

Perhaps more unsettling, spoofing is no longer particularly difficult either. In 2013, Todd Humphreys, director of the Radionavigation Laboratory at the University of Texas at Austin, spoofed a 213-foot, \$80 million yacht. Last June, an Israeli cybersecurity firm called Regulus announced that it had spoofed a Tesla Model 3. (Tesla dismissed the report as a marketing ploy and said it did not have any safety concerns related to the report.)

As GPS has become democratized, in other words, so has disruption—making interference difficult to track or even quantify. In 2018, the Coast

MARCH–APRIL 2016

South Korea

A six-day outage near the North Korean border affects more than 1,000 planes and 700 ships.

LATE 2017–PRESENT

Suez Canal

Persistent GPS outages plague the Egyptian ship-

ping artery. Potential causes include an insurgency in the nearby Sinai Peninsula and illegal fishing operations.

FALL 2017 & FALL 2018

Russian-Scandinavian frontier

Finnish and Norwegian authorities complain about jamming and spoofing of GPS signals near their borders with Russia

during NATO military exercises in the region. Russian officials deny responsibility.

JANUARY 2018– SEPTEMBER 2019

Cyprus and the “East Med”

Sporadic outages across the eastern Mediterranean, concentrated around Cyprus and near Lebanon and Israel. Cypriot and U.S. investigators

link the disruption to military activity in Syria.

JUNE–JULY 2019

Israel

Weeks of disruptions are reported by pilots taking off and landing at Tel Aviv's Ben Gurion airport. An Israeli official publicly blames Russia; a Russian official calls the charge “fake news.”



Christopher Nolan teaches “celestial navigation” to mid-career ship officers, most of whom have rarely or never had to use it.

Guard began publishing excerpts from reports about GPS outages, including those involving “unknown interference”—a category that includes suspected jamming or spoofing. Those published reports number in the low hundreds worldwide, but Rick Hamilton adds that that’s “a very, very, very small subset of what’s going on out there.” An EU-funded project, Strike3, underscores how much bigger the problem may be. From December 2017 to October 2018, it recorded 15,200 interference “events”—of which “many hundreds” were strong enough to disrupt satellite navigation systems entirely.

B

BEGINNING IN FEBRUARY 2016, ships near the city of Kerch and other ports along the Black Sea began

experiencing odd navigation glitches. Over the following months, GPS locations for thousands of ships appeared to suddenly accelerate and move dozens of miles inland—usually to airports. These “spoofs” all took place near a geopolitical hotspot: Kerch is in Crimea, which Russia annexed from Ukraine in 2014.

Those incidents turned out to be the leading edge of a wave of GPS interference events involving commercial ships and aircraft. (See the accompanying timeline.) Many took place near contested borders or zones of armed conflict. And one particular region became a locus of anxiety: the eastern Mediterranean.

The region’s biggest shipping conduit is the Suez Canal, which conveys around 1,500 ships a month between the Red Sea and the Mediterranean, many of them oil tankers bound for Asia or the EU. The “East Med” is also ringed by areas of active combat, including a simmering in-

surgency on Egypt’s Sinai Peninsula and the devastating multisided conflict in Syria. And at the hub of this troubled region is Cyprus—whose strategically important ports are refueling points not just for ships using the Suez but also for warships patrolling Syria’s waters.

On the south coast of Cyprus, where Stelios Christoforou works, GPS began to act strangely in January 2018. On vessels offshore or in port, loud alarms would sound as their captains lost the ability to see their GPS location. The alarms would blare as long as GPS was absent: hours, even entire days. Other times, the ships’ GPS locations would be visible—but in impossible places. “Sometimes you see the tugboats in the mountains,” Christoforou says.

The disruptions weren’t confined to Cyprus. Beginning in 2018, NATO and the U.S. Coast Guard registered outages across much of the East Med—as far north as Turkey, east

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“LOOK OUT THE WINDOW, LOOK AT THE CHART,”

CHRISTOPHER NOLAN : NAVIGATION INSTRUCTOR (QUOTING HIS WIFE, COAST GUARD OFFICER KELLEE NOLAN)

to Lebanon and Israel, and south to the Mediterranean entrance of the Suez Canal, across a range of at least 65,000 square miles. “It’s a very congested area, and disruption in GPS and navigation could have devastating consequences,” says Chronis Kapalidis, a former lieutenant commander in the Greek Navy and a maritime security researcher at shipping consultancy HudsonAnalytix. By the end of 2019, GPS disruptions across the Mediterranean had been reported to the Coast Guard 38 times, referencing hundreds of incidents, including some farther to the west, to the coasts of Libya and Malta.

Unlike with most GPS interference, authorities believe they’ve tracked some East Med disruptions to their source. Investigations by the European aviation agency Eurocontrol and the Cypriot Department of Electronic Communications connected the outages to jamming signals from Syria and concluded they were a by-product of the conflict there. (Neither agency has widely publicized the finding, but both confirmed it to *Fortune*.)

In March 2019, a report by Humphreys, the Texas GPS expert, and the Center for Advanced Defense Studies, a research center in Washington, D.C., went further in assigning blame. The authors traced the jamming to the Khmeimim air base on Syria’s coast, the “nerve center” of Russia’s military operations in that country—around 137 nautical miles from Vasiliko. The disruptions were unusually strong and sophisticated, and the authors surmised that they were intended to protect Khmeimim from missiles and drones. The same report pointed to a Russian role in the 2016 Black Sea spoofing. It noted that many of those incidents coincided with visits by top Russian of-

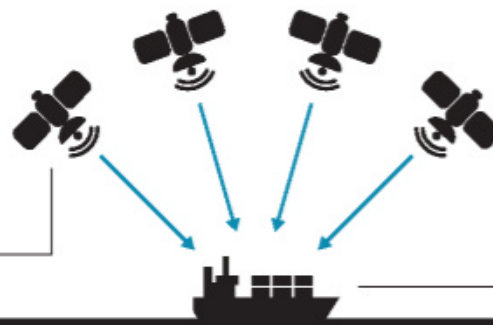
THE BREAKDOWN

How Sinister Signals Stop Ships

THE GLOBAL POSITIONING SYSTEM, a network of satellites maintained by the U.S. Air Force, is widely seen as both reliable and nearly impregnable. But even the strongest satellite signals grow weaker as they get closer to earth’s surface, and that creates opportunities for mischief. Here’s how military forces, spies, and even criminal networks can interfere with GPS and other navigation systems.

HOW THE GPS SYSTEM WORKS

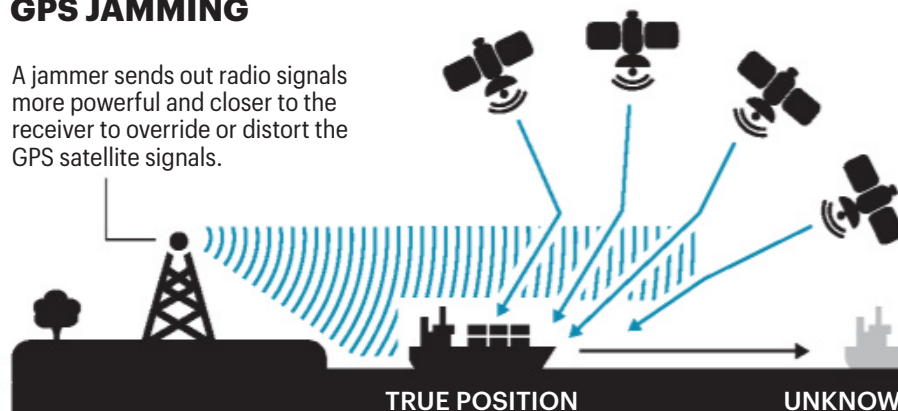
Satellites in orbit send radio signals detailing their position and the exact time.



The receiver on earth compares the time each signal was sent with the time it was received and calculates its distance from each satellite. From this data the receiver calculates its position.

GPS JAMMING

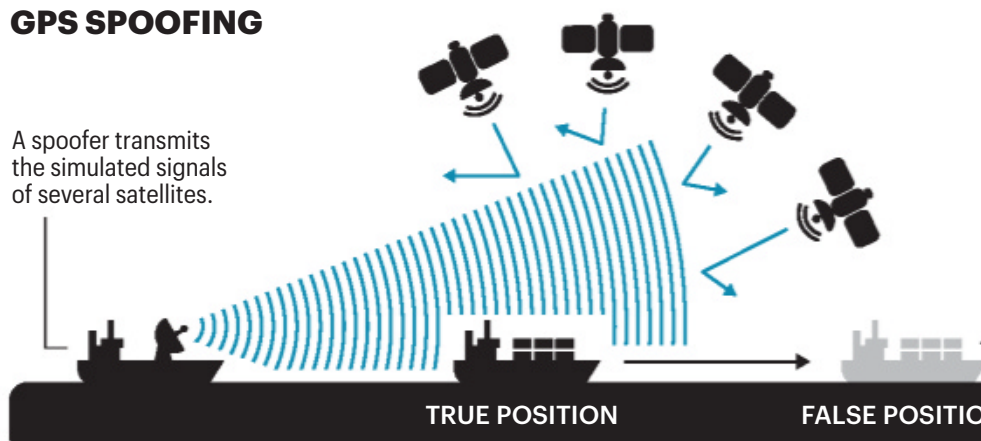
A jammer sends out radio signals more powerful and closer to the receiver to override or distort the GPS satellite signals.



Inaccurate positional information could lead to a maritime accident.

GPS SPOOFING

A spoofer transmits the simulated signals of several satellites.



If the signals are strong enough to override those from real satellites, the receiver calculates erroneous coordinates.

AND LOOK AT THE GPS. IN THAT ORDER.”

officials, including President Vladimir Putin—suggesting a protective effort of another kind.

Russia has consistently denied roles in GPS disruptions; Russian authorities did not respond to requests for comment from *Fortune*. But experts caution that Russia’s emergence as a plausible culprit for some interference doesn’t account for the phenomenon’s growing frequency. In other hotspots, questions about culpability persist. In the Suez, outages have been variously (and speculatively) blamed on Egyptian authorities fighting insurgents and on illegal fishing.

In December, the NATO Shipping Centre, which works with commercial shippers, said that interference continued in the East Med, with “potentially dangerous consequences.” In Vasiliko, outages have tapered off recently. Still, Christoforou and his fellow pilots remain on alert in case something goes wrong. “I worry a little bit when the vessels approach in the night,” he confesses.

At the governmental level, concern over interference is growing, but action isn’t imminent. Last June, 14 maritime groups wrote to the Coast Guard, asking it to work with the International Maritime Organization to resolve the GPS outage issue. In December, the Coast Guard told *Fortune* it was still in talks with the State Department about how to proceed.

With state actors sluggish, responsibility falls to shipowners and ship-management companies. Shippers have been reluctant to speak openly about the GPS issue, however, or about what they’re doing to bolster their defenses. Of the 26 ship-management companies contacted for this story, only two, Cyprus’s Lavar Shipping and Norway-based Wilhelmsen, admitted on the record

that their ships had experienced GPS interference.

Multiple shipping experts described an industry in transition. Generally, captains and crews have the skills to cope with GPS outages. But broader changes over the past 25 years have increased shippers’ dependence on satellite navigation. Ships have become bigger, faster, and more automated, while crews have shrunk. Offshore infrastructure has proliferated—think undersea cables, aquaculture, and wind farms—making marine space much more crowded. At the same time, says Jonathan Turner, director of the English marine consultancy NLA International, a younger generation of sailors “are switching from dependency on their own skills to rely on some machines,” leaving older crew members worried about a “skill fade” among sailors unprepared for life without GPS.

No one interviewed for this story thought the disruptions outweighed GPS’s advantages: charting a course across open waters, making ports more efficient, and rescuing crews in emergencies. But while a constellation of reinforcement options exist—including more robust anti-jamming receivers, land-based backup systems, or more training—those options cost serious money. A military-grade anti-jamming antenna, for example, costs about 10 times as much as a regular antenna.

Such investments can seem daunting in an industry that reported profit margins of less than 1% in 2019. The shipping world is grappling with slowing trade, overcapacity, and new, costly fuel regulations. The upshot, sources tell *Fortune*, is that shipowners will be loath to pay much for GPS defenses until outages cross over from a nuisance to a crisis—that is, until a major accident occurs.

M

MORE THAN 5,000 miles from Cyprus, in Beaufort, N.C., Christopher Nolan has made a career of showing merchant mariners how to navigate without GPS. The former Coast Guard officer teaches “celestial navigation,” which involves determining one’s location using little more than the position of astronomical bodies in relation to the horizon—in essence, the way Magellan did it.

Nolan’s students include college-age kids and amateurs but also mid-career officers. For them the two-week courses are a requirement for licenses to command large vessels outside U.S. coastal waters. Some have studied traditional navigation, but they tend to be rusty. “It’s a perishable skill,” says Nolan. “Once you’ve passed your exam, you’re never tested on it again.” And many younger mariners have never operated in a GPS-free world.

Nolan isn’t alone in bringing old-school methods back into the curriculum. In 2015, the U.S. Naval Academy resumed teaching celestial navigation to all incoming officers. The academy attributed the decision in part to the rise of cyberthreats that could impede electronic navigation. The class of 2017 was the first in at least 15 years to graduate with core training in the discipline.

Navigating by the stars is far less accurate than GPS, and far more time-consuming. But these basic seafaring skills may soon be tested more frequently than ever before in the GPS era. Nolan says his wife, Kellee, a commander in the Coast Guard, teaches her subordinates a timeless rule of thumb. “Look out the window, look at the chart, and look at the GPS,” he says. “In that order.” ■

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BESPOKE

A Suit of One's Own

With these forward-thinking tailors breaking up the bespoke boys' club, women no longer have to settle for off the rack. **BY KRISTEN BELLSTROM**

PHOTOGRAPHS BY **HARRY MITCHELL**

LUXURY IS NOT ONE SIZE FITS ALL. One person's lifetime dream of an Antarctic cruise is another's frozen nightmare. Your storybook 18th-century villa is my creaky old dump. So while some fashionistas thrill to personal shoppers' ferrying flutes of Veuve Clicquot, my most indulgent shopping experience involves the revelation that my left leg is almost an inch—an inch!—shorter than my right.

That news, delivered by New York City-based designer Shao Yang, is followed by a running commentary on my apparent grab bag of a physique: shoulders (right about a quarter inch higher than left), hips (slightly askew), and posture (the word "concave" was used). A bit disconcerting, yes, but there is luxury in being so precisely seen after years of frustration about why I could never find pants or jackets that fit just so.

majority of her clients—are women. Yang’s business, The Tailory, is part of a small but growing cadre of tailors and custom-suiting companies catering to women who want their own spin on what has long been the official uniform of the old boys’ club.

Today, the universe of women’s custom attire echoes the options available to men, though on a far more modest scale. There’s the traditional bespoke, an elite strata that includes tailors like Kathryn Sargent, the first woman to rise to the title of head cutter on London’s Savile Row, and New York’s Dara Lamb, who’s dressed some of the most recognizable female chiefs of the *Fortune* 500. Bespoke, like many tailoring terms, tends to vary slightly depending on who’s wielding it but is generally agreed to include the process of making a hand-cut-from-scratch pattern and creating a basted (loosely sewed) garment for the first of multiple fittings to make sure the details are perfect.

More affordable is made-to-measure, which has experienced something of a boomlet in recent years. This more simplified—and e-commerce friendly—method generally involves a standard pattern, which is adjusted based on an individual’s measurements and preferences. Women can now order customized suits from companies like SuitKits (where the process starts online with a “virtual stylist”), Blue-

suits (which also offers bespoke), Sene (men’s and women’s options in stretchy athleisure fabrics), Gormley & Gamble (headquartered on Savile Row), and a handful of others.

Finally, there are those that exist somewhere in between—usually referred to by the catchall phrase “custom.” This group, which includes The Tailory, creates individual patterns rather than starting with an existing template but relies on technology to trim away some of the more time-consuming and technical aspects of the bespoke process.


As different as these approaches—and their starting price points, which range from a few hundred dollars to \$5,000 or more—may be, they’re all trying to solve the same problem, one laid out neatly by professor Lynn M. Boorady, head of apparel design at Oklahoma State University: “As women, we’re all walking around wearing suits that don’t fit us.”

THE TAILORY is designed to put the uninitiated at ease. While the small office contains some of the clubby touches you’d expect from a menswear purveyor—stocked bar, mannequins draped in trenches and tweedy blazers—the velvety pink upholstery and a delicate china tea set nestled on the bottom shelf of the bar cart reject the cigar-chomping cliché. Noting that the majority of her customers come from the LGBTQ+ community,

Yang says she wanted the space to feel familiar and welcoming to everyone in a way the hypermasculine world of suit tailoring often does not. And as we launch into the custom process, I begin to see another reason that creating a sense of comfort is essential—and, perhaps, a reason that cart is full of liquor: A head-spinning number of decisions are required to create a single garment.

The process starts simply enough: Yang asks me about my personal style, and where and when I might wear the suit. Then out comes a towering stack of fabric books, each one packed with dozens of samples. (I’ve opted to stick to the house fabrics for a \$995 suit, which limits my choices to *just* 500.) From there, we flip through a multitude of lining options (I admire, but do not choose, one silky sample covered in roaring lions), piping colors, buttons, embroidery threads, and monogram fonts. Then it’s time for the design of the suit itself. Jacket pockets, lapels, vents, and length all need to be considered. How should the legs be cut? Where should the waist hit? Do I want cuffs on ankles or cinches on the hips? Belt loops: yes or no?

When all the decisions are made, and Yang’s tape measure has been draped around 34 places along my arms, legs, and torso, it’s over—for today. A few taps to her iPad, and my measurements are fed into her



A basted garment, loosely sewn with white thread, is a hallmark of the bespoke suiting process.

And the real delight was still to come: Yang’s assessment is a first step in building a luxurious scaffolding designed to bring symmetry to my stubbornly asymmetric frame—a custom-made suit.

Men have known the airbrushing power of custom tailoring for centuries. But there was something new about what was transpiring in Yang’s Flatiron studio that afternoon: She and I—as well as the vast

[1] Tools of the cutter's trade. No lasers or CAD here. [2] Kathryn Sargent in her eponymous Mayfair atelier. [3] The author at her final fitting for a custom suit at The Tailory New York. Sharp.



1



2

proprietary pattern algorithm, then tucked into a “tech pack”—specifying the measurements and all materials—that will soon be winging its way to her partner factory in Qingdao. I’ll get my first look at the results in two and a half weeks when I return for my fitting.

SO WHY, GIVEN the many “Women be shoppin’!” jokes we’ve all endured, has the world of custom suiting spent most of the past century giving women the cold—if impeccably tailored—shoulder? Sargent, whose clientele is about a third female, points

The very curves that stump so many tailors are one of the reasons custom tailoring can help professional women stand apart.

to the history of tailoring in England, where many of our modern conceptions about suiting were formed. She says women’s bespoke has historically been viewed “as country attire—something you’d wear horseback riding or to a society event, which is quite ... I’m going to use the word ‘frumpy’ in the nicest possible way.” Modern women wanted nothing to do with these looks (“a bit Mary Poppins,” notes Sargent), and traditional tailors have done little to attempt to woo them back to the atelier with more tempting garments.

The might of the Fashion Industrial Complex

has also played a role. Women’s ready-to-wear sheds its skin twice a year, burying shoppers in a deluge of new fabrics, cuts, and hems. Newness is the nemesis of custom—particularly on the bespoke side of the business, where it’s shockingly easy to drop \$10,000 on a single suit—and which requires the buyer to believe she’s investing in a garment she’ll wear for years, even decades.

But perhaps the biggest factor holding women’s tailoring back is less cultural—and more anatomical. “There’s a lot that happens in 10 inches on a woman from



3

READY TO SUIT UP?

The world of custom tailoring can be overwhelming. Follow these three tips for getting the most out of your first appointment.

FIND A GOOD LISTENER Personality matters. You will be leaning on your tailor for advice, so seek out someone you can be honest with, even when it comes to sensitive topics like insecurity about your physique. Your tailor should be engaged and curious about what you want—as opposed to telling you what you *should* want.

KNOW YOUR TASTE The number of decisions a shopper must make in custom tailoring can be gobsmacking to someone used to buying off the rack. The more focused you are going into the process, the more likely you are to come out of it with something you love. Yang encourages customers to create a Pinterest board.

FOCUS ON FABRICS Don't fall into the trap of choosing the finest fabrics. Yes, they'll be softer and more luxurious, but going too fine can make your suit less durable and more likely to wrinkle.

here to here," says Lamb, gesturing at the expanse between her shoulder and bust. "And from here to here," she continues, dropping her hands to her waist and hip. "It's that simple." The accumulated knowledge and skill set of master tailors is based on the relative simplicity of men's bodies. Women's physiques vary far more dramatically, making them a far "harder nut to crack," says Lamb. For decades, the overwhelmingly male

tailoring establishment didn't bother to try.

Ironically, the very curves that stump so many tailors are also one of the reasons custom tailoring can help professional women stand apart. Jamak Khazra, founder of Bluesuits, says her bespoke business revolves around women who because of their size ranges "just can't buy off the rack"—e.g., her client Martine Rothblatt, founder of United Therapeutics, a transgender

woman who stands a statuesque six-two. At The Tailory, Yang specializes in a different, if equally tricky, fit, creating a purposefully androgynous silhouette.

The undeniably luxe materials of high-end custom have other advantages as well. A "powerful fabric" can help the wearer communicate, says Lamb as she reaches for a jacket made of a deep blue English wool shot through with silvery pinstripes. "For a senior woman, a large

part of her audience may be men," she says. "Most of them have gotten their suits custom made, most of them have seen fabrics like that." Lamb believes this kind of visual familiarity can "take the walls down—it really does allow you a greater level of influence."

Such messaging isn't lost on Dr. Susan Nicholson, VP of Women's Health at Johnson & Johnson, who purchased her first suit from Kathryn Sargent last year—a two-piece in "a classic Prince of Wales brown-and-black check with lavender lining." She says, "For me, co-opting that male symbol of power and influence says, 'Hey, I'm influential too.'" Nicholson made the decision to go bespoke after years of "getting clothes that didn't quite fit and then spending a couple hundred dollars on tailoring. It just didn't make sense." Of her dream suit, she told Sargent: "I want to be able to walk into any meeting and feel absolutely confident ... to feel like I belong there."

IT'S THE MOMENT of sartorial truth. I step out from behind The Tailory's dressing screen at my final fitting and peer into the mirror. Looking back, an elegant, if faintly rakish, figure. Her shoulders cut a smooth, crisp line. Her pants skim down her legs before ending neatly, with the slightest flare, just above the ankles. Something Sargent told me rings in my ears: "Men have had it good for so long." Now, it seems, women do too. ■



FEEL THE

ROAR

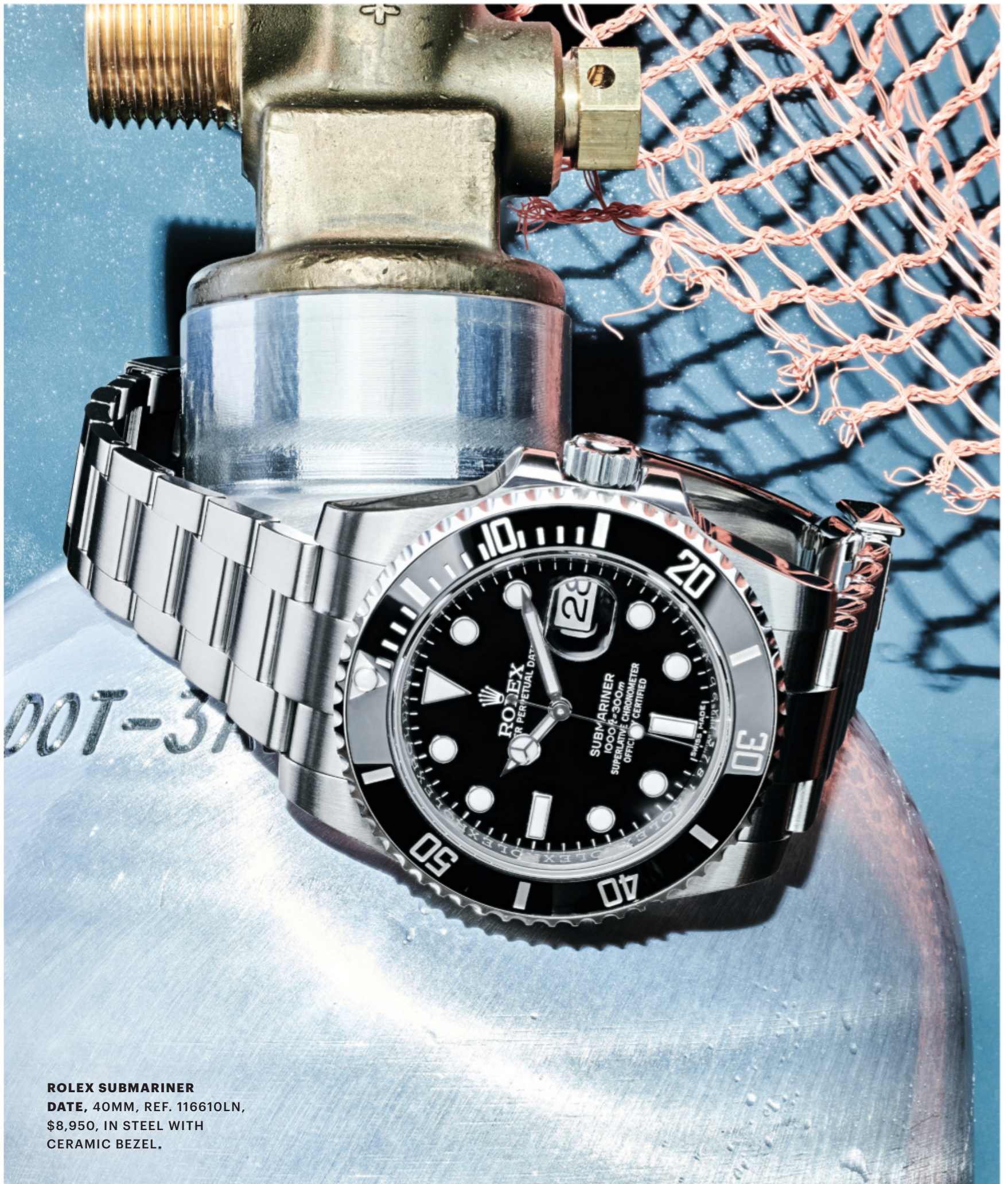


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The Ascent of Dive Watches

How tools created for military and commercial divers became luxury timepieces. **BY ALLEN FARMELO**

PHOTOGRAPHS BY **KEIRNAN MONAGHAN & THEO VAMVOUNAKIS**



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▶ **AFTER WORLD WAR II**, men's daily fashion began to evolve toward the casual look we enjoy today. Denim jeans, leather jackets, and rugged boots all derive from either military garb or workwear that, before the 1960s, men rarely sported outside the workplace. Teenagers shook off Dad's suit, looking to Marlon Brando in *The Wild One* (1953) and James Dean in *Rebel Without a Cause* (1955) for an edgier dress code. But what young men wore on their

wrists remained dainty (by modern standards): dress watches with cases barely larger than a quarter, made of gold-capped steel and offering little to no water resistance.

Then, in 1964, the James Bond thriller *Goldfinger* featured Sean Connery sporting a **Rolex Submariner** Ref. 6538 under the cuff of a white tuxedo

jacket, a striking combo that perfectly captured the character's elegance and ruggedness in just a few frames of celluloid.

The Submariner had been introduced a decade earlier. Its oversize, 38mm waterproof "Oyster" case was a radical departure from contemporary wristwatches. Legendary scuba pioneer Jacques Cousteau



BLANCPAIN FIFTY FATHOMS, REF. 5015 1130 52A, 45MM CASE, STEEL ON SAIL CANVAS STRAP, \$14,500.

and the British Ministry of Defence were early adopters, and though constantly revised and improved—the case has grown to 40mm and features a scratch-resistant ceramic bezel—the Submariner design remains relatively unchanged.

But while the Submariner may be the archetype of the dive watch, it

wasn't the genesis. The **Blancpain Fifty Fathoms** came first, in 1953, as a response to a military contract from the French navy's elite combat swimmers. Blancpain took an existing watch and added the required rotating timing bezel, a water-resistant case with a screw-down crown, and an automatic-winding movement. After

being dropped from the brand's catalog in the 1990s, the Fifty Fathoms was reissued in 2007, and the line now spans more than 20 unique models.

Both the Fifty Fathoms and the Submariner were endlessly imitated, leaving meaningful deviation from these foundational designs until the late 1960s, when Doxa—a company that

was better known for dress watches—issued the first ground-up dive-watch design aimed at professional divers. The **Doxa SUB 300** included a funky (and very comfortable) cushion case, a versatile beads-of-rice bracelet, a clever bezel that included the U.S. Navy's dive time scale, a category-leading depth rating, and unabashedly bright colors. Cousteau and the red-beaned crew of his *Calypso* research vessel were fans, and the Doxa SUB quickly became a totem of 1970s scuba culture.

By the 1980s, as the well-heeled began to flaunt their wealth, dive watches, especially Rolex models in gold, had become status symbols among preppies killing time at yacht and golf clubs. In the 1990s, massive dive watches with cases the diameter of jar lids were as prevalent in boardrooms as they were on the wrists of action heroes like Sylvester Stallone. Mercifully, modern tastes have shrunk dive watches to more vintage diameters.

That these tools of the 20th century became high-fashion items of the 21st is a curious pop culture phenomenon—dive watches having long outlived their original purpose as diving tools. All modern scuba divers rely on digital computers, leaving the mechanical dive watch to persist solely—and quite successfully—as a trusted staple in our wardrobes today. ■



Kasu-cured Spanish mackerel, a creation of chef Nicholas Elmi at Laurel.

EATS

Beyond the Cheesesteak

A native son of South Philadelphia shows *Fortune* around the old-school neighborhoods that embrace the new. **BY ADAM ERACE**

PHOTOGRAPHS BY WILLIAM MEBANE

▶ **IN M. NIGHT SHYAMALAN'S** Apple TV+ horror series, *Servant*, Dorothy Turner, a Philadelphia newscaster on the precipice of a psychotic break, laments from her posh Rittenhouse Square brownstone: “Every time I visit South Philly, I realize how blessed we are.”

Plenty of people still treat South Philly like the Tijuana of the Delaware Valley—catch an Eagles game and a cheesesteak, then get the hell out before your BMW gets clipped—but in reality, Dorothy’s dig is staler than a week-old Wawa pretzel. The character’s husband, Sean, a chef, should know South Philly is full of culinary blessings. In a more authentic script, he might bring up **Kalaya**, where chef Nok

South Philly's culinary roots are like Rocky's: blue-collar, gutsy, Italian-American. That tradition, combined with newer arrivals, makes it the city's best spot to eat in.

Suntaranon has hooked the city on her sapphire butterfly pea dumplings, or **Angelo's Pizzeria**, where Danny DiGiampietro deals chicken cutlet epiphanies on crusty, house-baked rolls. But because Sean is busy coping with an eerie nanny who has turned a doll into a human infant, this South Philly native will step up.

Located on the trendy commercial corridor East Passyunk Avenue—where you can buy imported *scamorza* cheese and status succulents in a single trip—is **Laurel**, a relaxed salon where *Top Chef* winner Nicholas Elmi expresses his cerebral yet fun vision of modern mid-Atlantic cooking in six- and nine-course tastings: nutty acorn-flour blini crowned with bowfin caviar and smoked maple syrup; whole fish with hidden ripples of mushroom *duxelles*; a tepee of malted meringue sheltering yuzu custard.

Joey Baldino, meanwhile, grew up around the corner from **Palizzi Social Club**, one of the last members-only Italian social clubs to survive the white flight from South Philly to the suburbs in the 1970s and '80s. In the past 20 years, a reverse of this exodus has fueled

East Passyunk's revival and Palizzi's resurrection. Baldino took over the cozy, century-old hangout at the request of his dying uncle in 2016, changed the charter to welcome people of all backgrounds (not just Italians), and began serving his family recipes: crabs and spaghetti, *stromboli*, escarole and beans, and more. Palizzi's rarely released lifetime

memberships go for a democratic \$20 and are so coveted, Baldino had to snuff out an eBay black market last year.

Around the corner from Palizzi, a chain-link gate in the middle of the street leads into the concrete courtyard of **Mighty Bread Co.**, Chris DiPiazza's year-old alleyway bakery. On weekends, pit-mixes patiently wait for their owners to drop crumbs of yeasted jam doughnuts and dark sourdough toast smothered in mushrooms. A few blocks north at **South Philly Barbacoa**, Cristina Martinez turns Pennsylvania-grown Mexican heirloom corn into the most hypnotically

fragrant tortillas filled with traditional slow-cooked lamb. They've earned Martinez, an outspoken undocumented person, a James Beard Award nomination and an episode of Netflix's *Chef's Table*. Over in Pennsport, South Philly's historically Irish-American enclave, the Tapia family, from Morelos, Mexico, runs the bijou **Crème Brûlée Bistro & Café**. Paging M. Night: Come find me there any cold winter evening. We can discuss my consulting fee over onion soup and pistachio éclairs. ■

Arancini with ragù and peas, served family style (naturally) at Palizzi Social Club. Mangia!





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THE WORLD'S MOST ADMIRABLE COMPANIES



FOR AN ASTOUNDING 13TH STRAIGHT YEAR, Apple claims the top spot in *Fortune's* annual ranking of corporate reputation, based on a survey of almost 3,800 executives, directors, and analysts. It's anything but an unlucky number: The streak reflects Apple's consistent, potent performance; it also coincides almost exactly with the life span of the indomitably profitable iPhone. But the stability at No. 1 belies the drama elsewhere on our All-Stars list. Microsoft, rejuvenated by its success in cloud computing, cracks the top three for the first time in 16 years. Warehouse retailer Costco and enterprise software pioneer Salesforce make their debuts in the top 10. And Boeing and Facebook tumble entirely out of the top 50, as concerns over the trustworthiness of their products and services erode their standing with peers. (FOR MORE DETAILED RANKINGS, VISIT [FORTUNE.COM](https://www.fortune.com).)

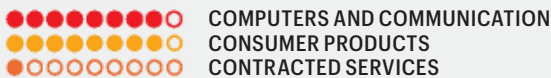
THE 50 ALL-STARS

THESE COMPANIES WON ADMIRING VOTES FROM INSIDE AND OUTSIDE THEIR INDUSTRIES.

1 ● APPLE 1* COMPUTERS AND COMMUNICATION	18 ● WALMART 25 STORES AND DISTRIBUTORS	27 ● GOLDMAN SACHS GROUP 26 FINANCIALS	36 ● VISA 42 FINANCIALS	45 ● L'ORÉAL N.R. CONSUMER PRODUCTS
2 ● AMAZON 2 COMPUTERS AND COMMUNICATION	19 ● DELTA AIR LINES 28 TRANSPORT	28 ● SINGAPORE AIRLINES 18 TRANSPORT	37 ● CHARLES SCHWAB 49 FINANCIALS	46 ● LOCKHEED MARTIN N.R. TRANSPORT
3 ● MICROSOFT 6 COMPUTERS AND COMMUNICATION	20 ● NORDSTROM 20 STORES AND DISTRIBUTORS	29 ● 3M 27 NATURAL RESOURCES	38 ● CVS HEALTH 35 CONTRACTED SERVICES	47 ● ADOBE N.R. COMPUTERS AND COMMUNICATION
4 ● WALT DISNEY 4 MEDIA AND ENTERTAINMENT	21 ● HOME DEPOT 21 STORES AND DISTRIBUTORS	30 ● TOYOTA MOTOR 30 TRANSPORT	39 ● NESTLÉ 47 CONSUMER PRODUCTS	48 ● PUBLIX SUPER MARKETS 45 STORES AND DISTRIBUTORS
5 ● BERKSHIRE HATHAWAY 3 FINANCIALS	22 ● TARGET 32 STORES AND DISTRIBUTORS	31 ● UNILEVER 39 CONSUMER PRODUCTS	40 ● ADIDAS 38 CONSUMER PRODUCTS	49 ● MERCK N.R. NATURAL RESOURCES
6 ● STARBUCKS 5 STORES AND DISTRIBUTORS	23 ● PROCTER & GAMBLE 31 CONSUMER PRODUCTS	32 ● BMW 29 TRANSPORT	41 ● MCDONALD'S 37 STORES AND DISTRIBUTORS	50 ● EXXON MOBIL 50* POWER
7 ● ALPHABET 7 COMPUTERS AND COMMUNICATION	24 ● USAA 24 FINANCIALS	33 ● UPS 33 TRANSPORT	42 ● MASTERCARD 48 FINANCIALS	
8 ● JPMORGAN CHASE 9 FINANCIALS	25 ● BLACKROCK 22 FINANCIALS	34 ● ACCENTURE 36 COMPUTERS AND COMMUNICATION	43 ● PEPSICO 41 CONSUMER PRODUCTS	
9 ● COSTCO WHOLESALE 12 STORES AND DISTRIBUTORS	26 ● JOHNSON & JOHNSON 17 NATURAL RESOURCES	35 ● IBM 40 COMPUTERS AND COMMUNICATION	44 ● CATERPILLAR 43 TRANSPORT	
10 ● SALESFORCE 14 COMPUTERS AND COMMUNICATION	11 ● SOUTHWEST AIRLINES 11 TRANSPORT			
11 ● SOUTHWEST AIRLINES 11 TRANSPORT	12 ● COCA-COLA 15 CONSUMER PRODUCTS			
12 ● COCA-COLA 15 CONSUMER PRODUCTS	13 ● NIKE 13 CONSUMER PRODUCTS			
13 ● NIKE 13 CONSUMER PRODUCTS	14 [†] ● AMERICAN EXPRESS 16 FINANCIALS			
14 [†] ● AMERICAN EXPRESS 16 FINANCIALS	14 [†] ● FEDEX 10 TRANSPORT			
14 [†] ● FEDEX 10 TRANSPORT	14 [†] ● NETFLIX 8 MEDIA AND ENTERTAINMENT			
14 [†] ● NETFLIX 8 MEDIA AND ENTERTAINMENT	17 ● MARRIOTT INTERNATIONAL 23 MEDIA AND ENTERTAINMENT			

*LAST YEAR'S RANK
 N.R.: COMPANY NOT RANKED LAST YEAR
 †A TIE IN RANK
 DROPPED OUT OF THE TOP 50: ALIBABA GROUP HOLDING (RANKED 34 LAST YEAR), BOEING (19), FACEBOOK (44), SAMSUNG ELECTRONICS (50*), AND UNITEDHEALTH GROUP (46)

THE 50 ALL-STARS BY CATEGORY



INDUSTRY STANDOUTS AS RANKED BY THEIR PEERS

EVEN THEIR RIVALS ADMIRE THESE LEADERS

THE SCORING SYSTEM for *Fortune's* Most Admired Companies survey favors companies whose peers recognize that they do many different things well. (See the adjoining column for more on our methodology.) No company illustrates that point better than **Apple**, which topped our All-Stars list. We ask survey respondents to rate companies on nine performance criteria. This year, Apple earned scores in the top 10—across all industries—on eight of those criteria, and it got the highest scores of any company in any industry in the talent-attraction category.

Walt Disney also cracked the top 10 in eight categories. That stellar performance helped The Mouse win the No. 1 ranking in the entertainment industry for the 17th consecutive year. Disney earned the very highest score across all industries for “quality of products and services,” finishing just ahead of **Toyota** (No. 1, motor vehicles industry) and **Apple** (No. 1, computers).

Another company garnering respect on multiple fronts: **Microsoft** (No. 1 in the computer software industry). It earned the highest scores across all industries in *four* criteria, including global business effectiveness and management quality. On the latter front, Microsoft's Satya Nadella was chosen once again by his peers as the business world's most underrated CEO (see next page).

Newcomers earned the No. 1 ranking this year in several of the 52 industry groups that the Most Admired Companies survey tracks. **Raytheon** finished first in aerospace and defense, an outcome that reflects both the ongoing woes at Boeing (last year's No. 1) and the antici-

pated benefits of Raytheon's merger with United Technologies, which is expected to wrap up in the first half of 2020. South Korea's **Samsung Electronics**, the world's 15th-largest company by revenue, made its first appearance in the top spot in the electronics industry.

In 2019, several big-box retailers demonstrated that they could go toe-to-toe with Amazon. One of those, consumer-electronics emporium **Best Buy**, took the No. 1 slot in the specialty retailers industry for the first time, capping a year in which its share price rose nearly 70% even as the company handed the reins to a new CEO, Corie Barry. Elsewhere in the retail aisles, toolmaker **Stanley Black & Decker** was the top-ranked company for the first time in the home equipment and furnishings industry.

Hilton Worldwide Holdings, which celebrated its 100th anniversary in 2019, earned its first No. 1 ranking in the hotels, casinos, and resorts industry. And **Compass Group**, a British multinational specializing in food service, earned its first top honors in the diversified outsourcing services industry.

Change is a constant in the Most Admired Companies rankings—but it isn't the only constant. In addition to Apple and Disney, companies with durable winning streaks include **Nestlé** (15 consecutive years at No. 1 in the consumer food products industry) and **Berkshire Hathaway**, Warren Buffett's famed holding company (No. 1 in health and life insurance for 22 years running). Berkshire also joins Microsoft, **Johnson & Johnson**, **Coca-Cola**, and Toyota in sharing a noteworthy distinction: Those five companies have appeared on our Top 50 All-Stars list every year since 1998. —*Matt Heimer and Scott DeCarlo*

HOW WE DETERMINE THE LIST

AS WE HAVE in the past, *Fortune* collaborated with our partner Korn Ferry on this survey of corporate reputation. We began with a universe of about 1,500 candidates: the 1,000 largest U.S. companies by revenue, along with non-U.S. companies in *Fortune's* Global 500 database that have revenues of \$10 billion or more. We winnowed the assortment to the highest-revenue companies in each industry, a total of 680 in 30 countries. The top-rated companies were picked from that pool; the executives who voted work at the companies in that group.

To determine the best-regarded companies in 52 industries, Korn Ferry asked executives, directors, and analysts to rate enterprises in their own industry on nine criteria, from investment value and quality of management and products to social responsibility and ability to attract talent. (For the complete rankings, visit Fortune.com.)

Results were not published in the following categories owing to insufficient response rates: cable and satellite providers, petroleum refining, pipelines, and U.S. energy.

To select our 50 All-Stars, Korn Ferry asked 3,770 executives, directors, and securities analysts who had responded to the industry surveys to select the 10 companies they admired most. They chose from a list made up of companies that ranked in the top 25% in last year's surveys, plus those that finished in the top 20% of their industry. Anyone could vote for any company in any industry.

The difference in the voting rolls explains why some results can seem at odds with each other. For example, UnitedHealth Group fell off the All-Stars list this year but ranked No. 1 within the insurance and managed care category when votes from only those in that industry were counted. —*S.D.*

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FORTUNE
WORLD'S MOST
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UNDERRATED / OVERRATED

WHICH CEOs DO OTHER LEADERS ADMIRE, AND WHICH DO THEY DOUBT? FORTUNE ASKED EXECUTIVES AND DIRECTORS FOR THEIR VOTES.



MOST UNDERRATED CEOs BASED ON 4,825 RESPONSES

SATYA NADELLA MICROSOFT

375 VOTES

IF YOUR PEERS VOTE YOU “most underrated” year after year, are you still underrated? That’s the happy riddle facing Nadella, who has earned that title four years running in this survey. Microsoft’s success since Nadella took the helm in 2014 is certainly no secret: The company has profited enormously from a big bet on cloud computing while undergoing a cultural overhaul to become nimbler and more innovative. Microsoft’s share price, meanwhile, has more than quadrupled, with the company now valued at \$1.2 trillion. If commentators overlook Nadella, it may be because he’s scrupulous about delegating authority and sharing credit. As he told Fortune when we named him Businessperson of the Year in November, “I’m wired to be fairly confident in myself and to let others shine.”



DOUG MCMILLON WALMART

123 VOTES

McMillon is the first chief of a traditional retailer to crack the “most underrated” top three.



MARY BARRA GENERAL MOTORS

113 VOTES

Few CEOs make decisions under a brighter or less forgiving political spotlight than Barra.



JAMIE DIMON JPMORGAN CHASE

106 VOTES

Among the Fortune 500, only Apple made more profit than Dimon’s megabank.



MOST OVERRATED CEOs BASED ON 4,492 RESPONSES

MARK ZUCKERBERG FACEBOOK

785 VOTES

IT’S HARD TO QUIBBLE with Facebook’s financial results under Zuckerberg’s leadership. Neither the bungled handling of users’ personal data nor the social media platform’s role in spreading misinformation has scared users or (more important) advertisers away in meaningful numbers. Analysts expect Facebook to report about \$70 billion in sales for 2019, up 26% from the previous year. But at a time when more executives say that addressing social problems is one of their core responsibilities, Zuckerberg’s reluctance to take a stronger stand against false and incendiary content has undoubtedly rankled his peers. Last year’s clumsy rollout of the Libra cryptocurrency project, meanwhile, put an operational black mark on the Facebook founder’s record. (For more on Libra, see our feature at Fortune.com.)



JEFF BEZOS AMAZON

364 VOTES

Respondents still admire Amazon, but they may distrust its growing clout.



JAMIE DIMON JPMORGAN CHASE

249 VOTES

To some, “Bank Rakes in Profits in a Hot Economy” is a “Dog Bites Man” headline.



DENNIS MUILENBURG BOEING (UNTIL RECENTLY)

241 VOTES

Boeing’s board came to agree with our respondents, ousting Muilenburg on Dec. 23.

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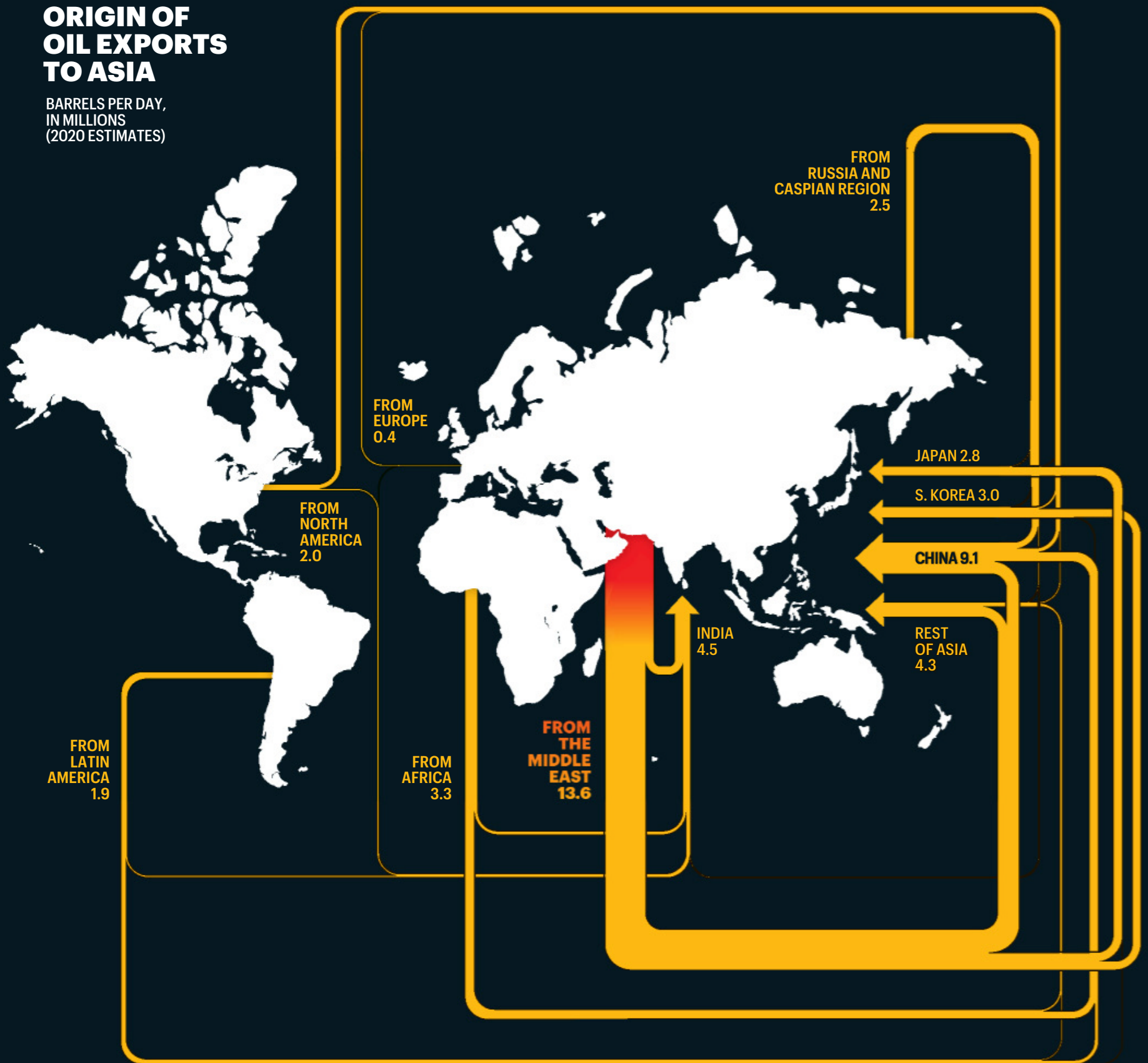
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BARRELS PER DAY, IN MILLIONS (2020 ESTIMATES)



THE CARTOGRAPHER CHINA GUZZLES MIDDLE EAST CRUDE

OVER THE LAST FEW YEARS, CHINA HAS SURGED past the U.S. to become the world's largest importer of foreign oil. A hefty portion of that supply originates from Saudi Arabia, Iraq, and other Middle East exporters. Research firm Wood Mackenzie estimates that China will import 9.1 million barrels per day of crude in 2020, with some 3.5 million barrels, or 38%, of that total coming from the Middle East. (Russia and Africa, the next biggest suppliers to the globe's second-biggest economy, are each expected to send 1.8 million barrels per day to China in 2020.) But China's neighbors are even more dependent on the region: WoodMac projects that 57% of the total daily oil imports to Asia in 2020 will originate from the Middle East. —BRIAN O'KEEFE



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