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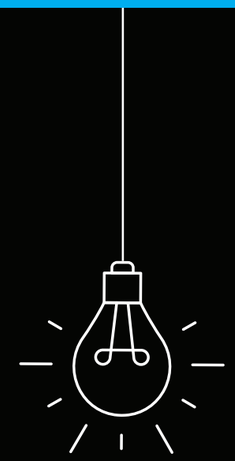

COWEN RESEARCH THEMES 2023

DEGLOBALIZATION & REGLOBALIZATION SUPPLY CHAIN
ENERGY TRANSITION INFLATION & THE CONSUMER MOBILITY
THERAPEUTICS, TOOLS & DIAGNOSTICS INNOVATION TECHNOLOGY INNOVATION
ROBOTICS & AUTOMATION DIGITAL ASSETS FUTURE OF HEALTH CARE DELIVERY
ESG FUTURE OF PUBLIC HEALTH FUTURE OF WAR CANNABIS

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2022 marked another year of global disorder. Russia's invasion of Ukraine, which escalated in February, has become the largest armed conflict in Europe since World War II, and has exacted a massive human and economic toll, with the displacement of 15.7 million people and disruption in agricultural, energy, and metals markets. Inflation has surged, driven by product shortages resulting from global supply chain challenges, strong consumer demand (driven in part by COVID-related financial aid), and low unemployment. Numerous geopolitical rifts (such as United States-China relations) and elections further increased market tension and uncertainty.

Amidst this tumultuous environment, Cowen Research has sought to be a reliable and consistent source of stable and prescient thematic research. Our analysts work together to identify cross-sector themes, and rise above the noise to spot opportunity and risk. We have continued to expand our Thematic Research team in an effort to help investors "connect the dots" and see the bigger picture.

In this year's edition of **Cowen Research Themes**, we once again feature areas of investor focus where Cowen's domain expertise has been central to the discussion and debate. In all cases, Cowen Research offered its hallmark collaborative approach to help inform our viewpoints, working across teams to provide valuable perspective. Each theme highlighted is accompanied by a listing of relevant Cowen reports and events, which we hope supports deeper engagement on these pivotal issues.

Our approach also overlays the views of our Washington Research Group. The global political environment that has characterized the last several years has highlighted a populace deeply divided. Absent a more collective will, divining the outcome of key policy debates has become even more critical to forecasting financial markets, particularly in the face of inflationary forces and a U.S. government spending program of extraordinary magnitude.

Cowen has also made ESG and sustainability central to our research agenda. We have invested heavily in our ESG Research capabilities by building our team, offering clients even more relevant data, and hosting over 25 ESG-focused events designed to help investors separate hype from investability. Please read more about Cowen's ESG Research initiative: **https://www.cowen.com/esg-research/**

As we enter 2023, Cowen Research will continue to keep a sharp focus on our Ahead Of The Curve® mission, looking through a wide lens to develop a comprehensive view of the key themes we expect to drive investment gains and losses.

With best wishes,

Robert Fagin
Director of Research
Cowen

COWEN RESEARCH **THEMES 2023**

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DEGLOBALIZATION & REGLOBALIZATION

COWEN RESEARCH THEMES 2023

"Nations are rethinking alliances and supply chains to ensure their security."

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The onset of COVID and resulting workforce and supply chain disruptions highlighted the extraordinary reliance the United States and European economies have on China. The associated angst has been exacerbated by escalating political tensions between the United States and China. The Infrastructure Investment and Jobs Act (signed into law in November 2021) and predecessors to the CHIPS and Science Act (ultimately passed in August 2022) are in part a growing acknowledgment by the U.S. government that it has to reestablish domestic manufacturing, R&D and modern infrastructure to delink from China and support critical industries.

Russia's invasion of Ukraine set off immediate alarm bells, particularly since Europe, over the last two decades, has sourced a significant proportion of its energy needs from Russia. Russia-Ukraine has forced the EU to choose sides; dependence on or linkage to Russia is risky. Cowen estimates that pre-invasion, Europe was importing 4 million barrels per day of oil (crude and products) — more than one-quarter of its approximately 15 million bpd pre-COVID demand. These imports did not fall off meaningfully post-invasion. Regarding gas, Russia was exporting 15bcf/d to Europe —over 30% of its 49bcf/d consumption. Several months post-invasion, those exports fell to about 8 to 9 bcf/d. Developing a strategy to find alternative sources of energy (clean and carbon) has become an urgent mission to support the EU economy and populace.

Trump Administration policies, BREXIT, and ongoing events have increased the deglobalization drumbeat — the feeling on the part of many countries that they need to be delinked, less vulnerable and more self-sufficient, or at the very least, that they must increase the diversity of sources for critical goods (what we refer to as "reglobalization"). The fact that China and Russia, two global superpowers with political systems often at odds with the West, are at the center of the tension has only served to heighten political and economic strain. As Blackrock chairman Larry Fink wrote in his 2022 letter to shareholders:

> ***In the early 1990s, as the world emerged from the Cold War, Russia was welcomed into the global financial system and given access to global capital markets. In time, Russia became interconnected with the world and deeply linked to Western Europe. The world benefitted from a global peace dividend and the expansion of globalization. These were powerful trends that accelerated international trade, expanded global capital markets, increased economic growth, and helped to reduce poverty in nations around the world… But the Russian invasion of Ukraine has put an end to the globalization we have experienced over the last three decades.***

Supply chain disruption, intensifying geopolitical tensions, and the race for advantage in critical emerging technologies have set the stage for reglobalization. We are at the advent of a new era of economic statecraft which will have broad implications for inflation, corporate margins, global shifts in production, and capital flows, among other things. Cowen analysts have been at the forefront of evaluating the investment implications of these macro trends and opining on the impact of geopolitical shifts on trade, supply chains, and energy pricing.

"Supply chain disruption, intensifying geopolitical tensions, and the race for advantage in critical emerging technologies have set the stage for reglobalization."

WHAT WE'RE WATCHING

Russia

Russia's invasion of Ukraine has taken a massive human toll and impacted economies in the EU and around the world. For example, David Beasley, executive director of the U.N. World Food Program, told the U.N. Security Council in September that since Russia invaded its neighbor on February 24, soaring

SNAPSHOT: EU ENERGY IMPORTS

CRUDE OIL

26.9%

Russia was the world's third largest producer of oil in 2020, after the U.S. and Saudi Arabia.

Iraq	9.0%
Nigeria	7.9%
Saudi Arabia	7.7%
Kazakhstan	7.3%
Norway	7.0%
Libya	6.2%
United States	5.3%
United Kingdom	4.9%
Azerbaijan	4.5%
Algeria	2.4%
Others	10.9%

SOLID FUEL (COAL)

46.7%

Russia mined 328M metric tons of coal in 2020, making it the sixth largest producer in the world.

United States	17.7%
Australia	13.7%
Colombia	8.2%
South Africa	2.8%
Others	10.9%

NATURAL GAS

41.1%

The Nord Stream 2 pipeline (constructed in September 2021) would have doubled the flow of Russian gas to the EU. The project was halted by Germany in February 2022.

Norway	16.2%
Algeria	7.6%
Qatar	5.2%
Others	29.9%

Source: Cowen and Company, Eurostat, eia, Statista

"Russia accounts for about 10% of global oil production, according to the Dallas Federal Reserve. Russia and Ukraine together exported more than 25% of the world's wheat, according to the Observatory of Economic Complexity database."

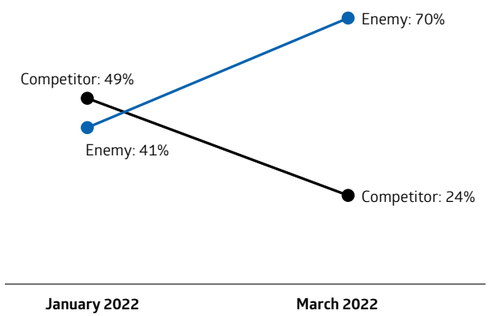
food, fuel and fertilizer costs have driven 70 million people closer to starvation.

Pew Research noted a sharp decline in public opinion of Russia in the United States. Before Russia's invasion of Ukraine, 41% of those polled in the U.S. considered Russia an "enemy." By late March, this sentiment shifted to 70%. Pew polls indicate that 92% of Americans have an unfavorable view of Russia (including 69% who have a "very unfavorable" view).

While Russia's once-vaunted military has proven to be much less capable than previously thought and Russia's economy is smaller than that of Canada or Italy, Russia still has large conventional and nuclear forces. As a result of its invasion of Ukraine, the U.S., EU and other countries imposed stringent sanctions and export controls on Russia, affecting trade both ways. These sanctions continue to be a significant contributor to spikes in global commodity costs.

Russia accounts for about 10% of global oil production, according to the Dallas Federal Reserve. In addition, Russia and Ukraine together exported more than 25% of the world's wheat, according to the Observatory of Economic Complexity database. Russia is also a huge exporter of fertilizers. According to the World Bank, in 2019, Russia exported 5.5 billion kilograms of fertilizers, more than double the amount of the second biggest exporter, the European Union. Russia is responsible for 22% of global ammonia exports, 14% of global urea exports, and 14% of phosphate (MAP) exports. Russia and Belarus each account for about

Since Russia's Invasion Of Ukraine, Americans Are Much More Likely To Consider Russians "An Enemy"



Source: Pew Research Center, April 2022

20% of global exports of potash. Additionally, Russia accounts for 13% of global titanium production, an important material to global aerospace, with China the dominant player at 57% of global production. Importantly, Russia's attempted land-grab in Ukraine has forced a wake-up call for the U.S. regarding China, a far larger and more integrated global trading partner.

China

If Russia's invasion of Ukraine has caused severe and sudden geopolitical and economic turmoil, the U.S. and global response to a potential Chinese invasion of Taiwan would cause far more disruption because of the size of China's economy and degree of global trade integration. China ranks second only to the United States in GDP and military spending and is poised to overtake the United States as the largest economy on earth by 2030.

As former Australian Prime Minister Kevin Rudd writes in his book, *The Avoidable War*, President Xi is "a man in a hurry when it comes to Taiwan." If current Taiwanese Vice President Lai Ching-te (who China has labeled a separatist) becomes president of Taiwan in 2024, speculation on the part of some observers is that the odds of China taking military action against Taiwan will grow. There is a debate growing about whether or not Russia's experience in Ukraine will impact China's calculations about a Taiwan invasion or blockade. There is also debate about whether U.S. policy to build its military presence in Asia and build up Taiwan's defense may influence China's timeline.

A successful Chinese invasion (or absorption of Taiwan by some other means) would be disruptive on many fronts. Politically, it could dramatically reduce the standing of the U.S. as a global superpower capable of defending its allies in the face of military threats. Some reports have shown the United States losing to China in a Taiwan conflict 19 out of 19 times in simulations according to Rudd's book. Australia, Japan, and South Korea would need to reconsider their global posture and alliances and whether or not they should acquire nuclear weapons. Furthermore, one-third of Taiwan's exports are electronics. An invasion of Taiwan would throw any industry dependent on semiconductors and electronics into turmoil.

To help mitigate the risk of China controlling Taiwan's semiconductor output, President Biden signed the CHIPS and Science bill into law in August, authorizing $52 billion in grants to "reshore" semiconductor production to the U.S. and to fund advanced research. But building new semiconductor fabs and creating the complex ecosystem of suppliers to support them in the U.S. will not be accomplished overnight or even in just a few years. In the meantime, the Biden Administration continues to tighten export restrictions of advanced semiconductors to China, such as those used for machine learning and artificial intelligence.

One potential constraint to a near-term invasion of Taiwan may be the overall health of the Chinese economy. Over the last decade, construction and real estate have been the foremost engine of Chinese economic growth, leading to a six-fold increase in average home prices over the past 15 years and speculative buying, according to Bloomberg. Real estate related activities account for nearly 30% of China's GDP today, up from less than 10% at the start of the century. Cities like Shenzhen became less affordable on a price-to-income basis than London or New York, leading to consumer frustration. By one

"While the U.S. and Europe constitute the majority of today's global middle class, China, India, and Asia (ex-Japan) will comprise the majority of global consumer purchasing power by 2030."

estimate, 70% of Chinese household wealth is tied up in real estate. To slow the speculation and growth, the Chinese government began pushing more restrictive bank lending policies beginning in 2020, but it may have been too late. In the last decade, annual sales of dollar-denominated offshore bonds grew 94%, to $64.7 billion, and developers had a collective $207 billion in offshore debt outstanding. More than 18 developers defaulted on their bonds, including China Evergrande Group (the country's largest developer) in December 2021. One press report indicated there are 50 million empty or unfinished housing units in China bought on "spec" (to put that in context, there are about 142 million housing units in the United States).

India

The United Nations' July report, World Population Prospects, projected that in 2023, India is likely to surpass China as the world's most populous country.

While the U.S. and Europe constitute the majority of today's global middle class, China, India, and Asia (ex-Japan) will comprise the majority of global consumer purchasing power by 2030. Indeed, by the end of this decade, India will be one of the two largest consumer markets on the planet. India is also a key supplier of goods to the United States. One example is pharmaceutical ingredients. Of the 100 drugs most used by Americans, 83 have no production source in the United States. A recent U.S. Food and Drug Administration report indicated that India accounts for the manufacture of 20% of all active pharmaceutical ingredients used in the United States (and 24% of "essential medicines"), as well as 20% of all finished

DEGLOBALIZATION & REGLOBALIZATION

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dose form medications used. In short, the U.S. is likely to increasingly court India as a political and economic partner. A 3,488 km shared border with China only increases the need for the U.S. to effectively ally with India.

India is a key pillar of the U.S.-led Indo-Pacific Economic Framework (IPEF), a 14-country economic agreement announced in May 2022 that is designed to strengthen allyship and economic cooperation in the region. However, the war in Ukraine and resulting increase in energy prices also saw India become a significantly larger customer of cheaper Russian oil, positioning itself to make billions by exporting refined petroleum products such as diesel and gasoline. In July, India urged Iran to activate the 7,200-kilometer International North-South Transportation Corridor (INSTC), a multimodal transportation network of sea, road, and rail routes between Russia and India.

In the fiscal year ending March 2022, bilateral trade between the U.S. and India stood at $119.4 billion, up from $80.5 billion in the previous year, according to the Indian commerce ministry. This surpassed India's bilateral trade with China, which was $115.4 billion in the same period.

The Middle East

According to the European Council on Foreign Relations, the Middle East produces a quarter of world oil supplies and holds between two-thirds and three-quarters of all known oil reserves. Global calls for a reduction in fossil fuel consumption present a long-term existential threat to Middle Eastern economies and the stability of the region. Saudi Arabia, for example, derives 90% of its export earnings and 42% of GDP from oil. Fostering economic diversification in the region is a priority.

The most significant geopolitical issue in the Middle East is Iran. Indeed, in many ways, Middle Eastern geopolitics have been reshaped in alignment with or against Iran in recent years. The United States and Israel have publicly stated that it would be unacceptable for Iran to become a nuclear power. This policy has received the tacit support of numerous Middle Eastern countries such as Saudi Arabia and the UAE. It is not inconceivable that

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some combination of the United States, Israel and other countries could directly attack Iran's nuclear infrastructure. Beyond the extraordinary geopolitical implications of such a move, it is important to keep in mind that Iran is a founding member of OPEC, and an attack on the country would shock global oil markets. Nearly half of Iran's annual oil exports are to China (followed by India, at 12%). At the very least, an Israeli strike would draw a swift and likely massive reaction from Hezbollah, Hamas and other militia groups, not to mention Iran itself. In March 2022, U.S. General Kenneth McKenzie, then commander of U.S. Central Command, testified in a Senate hearing that Iran has "3,000 ballistic missiles," including variants capable of reaching Tel Aviv.

The Dollar

The Bretton Woods Agreement of 1944 established the U.S. dollar as the world's foremost reserve currency, a status that has continued even after the dollar was decoupled from the price of gold in 1971. The dollar today comprises about 60% of global foreign exchange reserves.

Bretton Woods concurrently set up the modern monetary system by establishing procedures and rules for conducting international trade and accessing the global capital markets using the U.S. dollar. The status of the dollar has caused persistent and increasing tension. Other governments have long argued that the United States government is capable of borrowing money at minimal interest rates and with virtually zero default risk, while other countries who cannot raise money in their local currencies are forced to issue dollar-denominated debt at higher interest rates.

The U.S Department of the Treasury exercises oversight of the SWIFT financial transfers network, with the ability to impose sanctions on foreign entities and individuals. The influence of this role played out in recent sanctions against Russia and numerous Russian citizens. Russia responded by attempting to insist on payments for energy resources in rubles instead of dollars. In recent years, China threatened to sell its dollar reserves in response to American threats of trade sanctions designed to revalue the Chinese yuan. Countries such as China have undoubtedly watched sanctions imposed on Russia and the "weaponization" of the global monetary system with keen interest and are considering how to reduce U.S. dollar exposure.

A desire by some entities to reduce reliance on the dollar is one of the existential battles represented by cryptocurrencies, which at their heart are international, decentralized monetary systems. It is no surprise that the United States has significant interest in regulating cryptocurrencies. In addition, we believe that a digital dollar is inevitable because having a digital Euro but no digital dollar would put the United States' position in global trade at risk. Cowen's Washington Research Group has carefully tracked these regulatory and legislative efforts.

Energy Independence

Alongside health security, bioterrorism, and cybersecurity, energy independence has emerged as a leading national security issue due to its global financial and safety implications. "A new alignment of world politics is unfolding across the globe that is being drawn with oil and gas," Daniel Yergin, author of *The New Map: Energy, Climate, and the Clash of Nations* was quoted as saying in The New York Times.

Alternative energy is high on the national agendas of net importers. According to BNEF estimates, wind, solar, hydro and other renewables are projected to make up 28% of global energy usage in 2030, up from 12% today. Cowen has consistently written about newer, promising technologies such as small modular nuclear reactors (SMRs) emerging as viable alternatives to fossil fuels (SMR developer NuScale estimates a range of $41-64/MWh per reactor).

NATO

The North Atlantic Treaty Organization, or NATO, is a military alliance between 30 member states established in the aftermath of World War II. Russia's invasion of Ukraine and NATO's perceived effectiveness as a deterrent to Russia has given the alliance renewed importance.

In 2008, NATO leaders promised Ukraine (and Georgia) that they would one day join the alliance after

> "A desire by some entities to reduce reliance on the dollar is one of the existential battles represented by cryptocurrencies, which at their heart are international, decentralized monetary systems. "

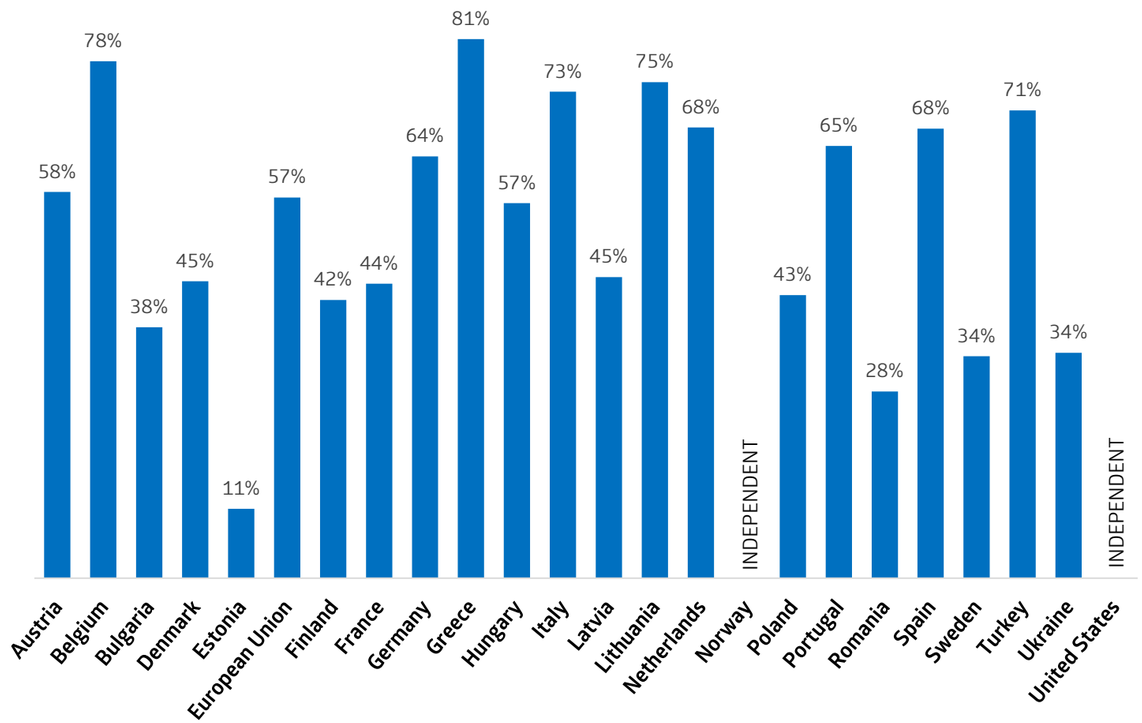
rebuffing U.S. demands to put the countries on an immediate path to membership. Ironically, at the time, internal polls showed that only 30% of Ukrainians were in favor of joining NATO. But Russia's incursion pushed Ukraine to urgently request membership. In addition, post Russia's invasion, Finland and Sweden submitted applications to join NATO, which were approved in June. Post invasion, NATO's stature has grown.

In a Pew Research poll published in April 2022, 67% of respondents held a favorable opinion of NATO, up from 61% in 2021, and 69% said that the United States benefits "a great deal" or "a fair amount" from being a NATO member.

The United Nations

In response to Russia's invasion of Ukraine, the United Nations launched a multi-agency response, including a $1.7 billion fundraising campaign coordinated by the U.N.'s Office for the Coordination of Humanitarian Affairs (OCHA). However, the invasion has called into question the ability of the United Nations to effectively preserve world peace. In particular, the war in Ukraine has renewed focus on the effectiveness of the U.N. Security Council. Russia's Security Council veto power meant that the U.S. and its allies could impose sanctions only through a "coalition of the willing" rather than a Security Council-enforced structure of global sanctions. This has led to increased calls for structural reforms at the U.N. Should China (another of the five permanent members of the United Nations Security Council) invade Taiwan, the United Nations would be similarly hamstrung.

Theoretical Energy Import Dependency For Select Countries, 2020
(imports minus exports)



Source: Eurostat; U.S. Energy Information Administration.
Note: Data include all energy sources, including crude oil, petroleum products, natural gas/LNG and coal. The U.S., for example, is a net exporter of coal, natural gas and petroleum products (gasoline) but a net importer of crude oil used to make refined products.

A fracture of globalization and a reshuffling into Cold War-esque bilateral trade networks is underway as the U.S. places greater emphasis on "friend-shoring." Realignment will take time, perhaps several years if not a decade or longer. "China Plus" manufacturing strategies (i.e., maintaining China production while adding capacity and building out supply chains elsewhere) are in the nascent stages. There is a point to President Biden's "Democracies vs. Autocracies" framework. But it is not without complications because there are U.S./EU/Quad allies that aren't democracies. Geopolitically, it seems the world is splitting into two camps: 1) U.S., EU/NATO, Japan, Australia and others. 2) China, Russia, Iran, North Korean and others. But there is a group of undecideds that are straddling the fence and, in some cases, playing both sides. These countries are important and could swing the balance of power in many ways. They include Turkey, India, Brazil, and GCC (Gulf Cooperation Council, comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates).

COWEN **EVENTS**

Cowen's 43rd Annual Aerospace/Defense & Industrials Conference
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July 19, 2022

U.S./China: Update & Outlook On Key Policies Into Year-End
September 13, 2022

SUPPLY CHAIN

COWEN RESEARCH THEMES 2023

"An extensive Cowen survey of shippers illustrates how pandemic stress is reconfiguring logistics networks and setting inventory trends."

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COVID disruption to global supply chains, including factory shut-downs, product shortages, and shipping backups, has eased somewhat. But the pandemic left indelible marks on how corporations approach inventory and logistics, including a shift away from just-in-time to just-in-case inventory management. CEOs who once viewed supply chains as cost centers are now making supply chain resiliency a strategic priority and investing in streamlining technology. The urgency of these actions has been heightened by geopolitical rifts (such as Russia-Ukraine and U.S.-China) which disrupted, or threatened to disrupt, the flow of goods. Changes to the supply chain are also being driven by a massive U.S. government stimulus that in part encourages onshoring. In general, companies are looking to geographically diversify manufacturing and sourcing, bringing it closer to the end-consumer where possible.

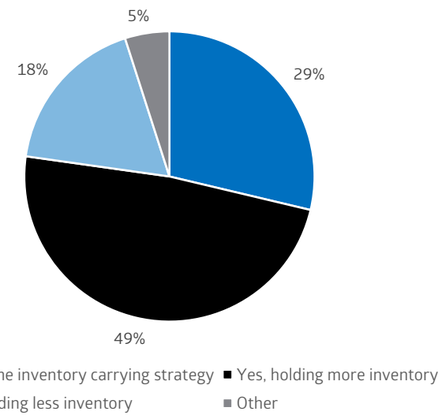
Management teams are now more willing to think bigger and deploy technologies that are geared to efficiency and resilience. The pursuit of lean management, cost reduction, and productivity enhancement has been revisited and the notion of working capital impact on free cash-flow has become less important than the prospect of business continuity. We believe a paradigm shift is underway, and below we discuss a few of the areas where we see this transformation having the biggest impact.

WHAT WE'RE WATCHING

Transport and Logistics

An extensive Cowen survey of shippers illustrates how pandemic stress is reconfiguring logistics networks and setting inventory trends. When asked whether their inventory carrying strategies have shifted due to the pandemic, close to 50% of large shippers reported a permanent switch to holding more inventory, which means shippers are increasingly using just-in-case strategies. Additionally, 41% of companies surveyed said they are considering hiring a third-party logistics company given the complexity of post-pandemic supply chain issues.

Has Your/Your Customer's Inventory Carrying Strategy Changed Permanently Due To Pandemic Related Disruptions? (3Q22)

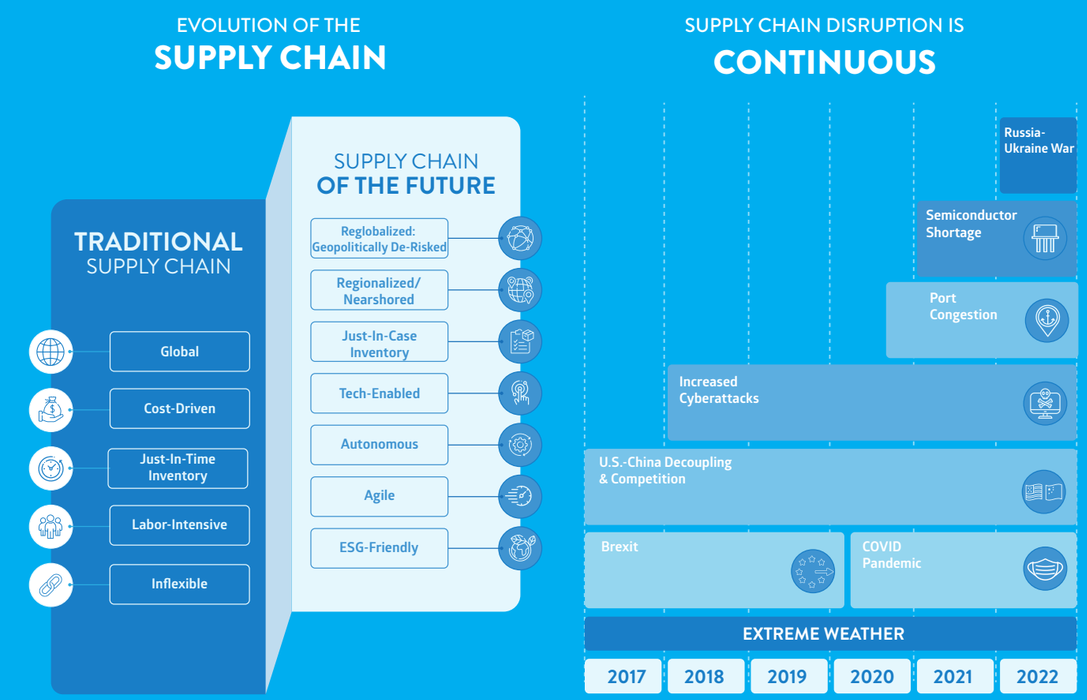


Source: Cowen Carrier Survey, 3Q22; SurveyPlanet.com

Shippers are reorganizing their supply chains using multiple ports of entry to reduce reliance on West Coast ports that suffered from pandemic-induced congestion. Per Cowen's survey, 32% of railroad shippers diverted freight away from the San Pedro Bay Port Complex on the West Coast of the U.S., with New York/ New Jersey and Houston being the largest beneficiaries. In our view, while the West Coast has natural advantages that offer it a predominant position among ports, the East Coast ports will gain some share permanently. We also see new infrastructure coming online, with ports and inland waterways expected to receive $17 billion in U.S. federal funding over five years by way of the Bipartisan Infrastructure Law.

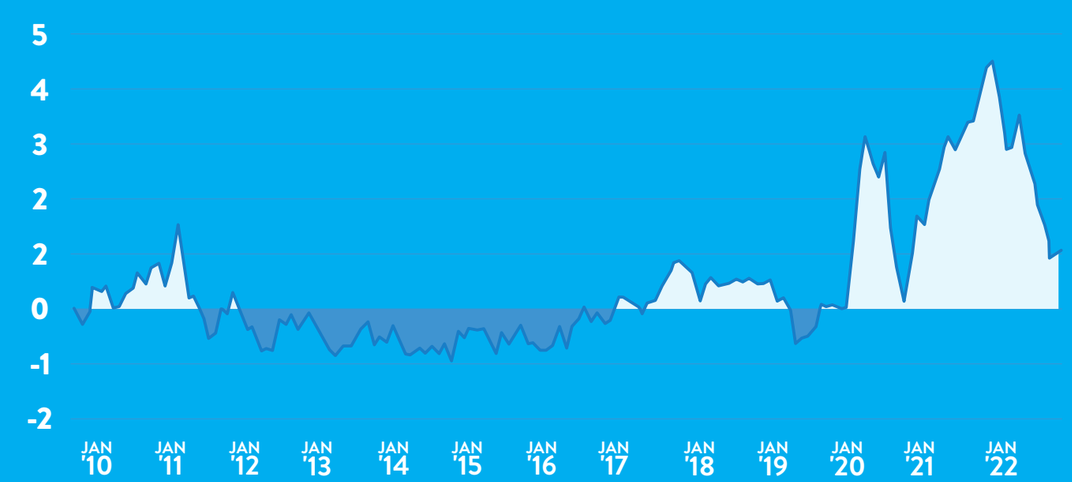
While manufacturers will still primarily rely on Asia for production, recent datapoints suggest that it may pay to diversify manufacturing and logistics

SNAPSHOT: DISRUPTIONS ARE RESHAPING SUPPLY CHAINS



GLOBAL SUPPLY CHAIN PRESSURE INDEX

(Standard Deviations From Average Value)



Source: Federal Reserve Bank of New York, Cowen and Company

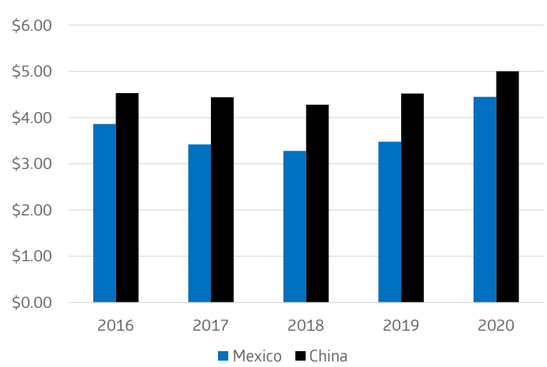
Major Port Infrastructure Projects Currently In Development

LOCATION	PROJECT DETAILS	CAPEX ESTIMATED
Los Angeles & Long Beach, CA	Four-lane rail-roadway grade separation. Estimated to reduce delays by 2500 truck hours/day.	$20 million
	Goods Movement Training Campus at San Pedro	$110 million
	Zero-emission equipment and infrastructure including trucks and other equipment	$760 million
	Mojave Inland Port with capacity of 3MM TEUs/year to be fully operational in 2024	$75 million
	Commercial Driver's Licenses capacity enhancement to allow more truckers to operate at the port	$40 million
	Barstow International Gateway Facility including intermodal facility, rail yard and warehousing being built by BNSF	$1.5 billion
Savannah, GA	Expansion of Garden City Terminal West adding 1MM TEUs in capacity during 2023 and 2024	$200 million+
	Construction of ship berth at Garden City Terminal adding 1.4MM TEUs in capacity in July 2023	ND
	Raising/replacing Talmadge Memorial Bridge to enable handling of post-Panamax vessels	TBD
Houston, TX	Project 11 - Widening and deepening channel to accommodate post-Panamax ships	$1 billion
	Expansion of Bayport Wharf 6 including building of 1000 ft long wharf; completion expected in 2023	$86 million
	Rehabilitation of Container Yard 3N at Barbours Cut Terminal; increase footprint by a third	$14 million
Mobile, AL	Phase IV expansion program bringing annual throughput capacity to 1MM TEUs; completion by early 2025	$104 million
	Dredging Mobile Harbor to 50 ft draft allowing neo-Panamax vessels up to 14,000 TEUs; completion by early 2025	$366 million

Source: Port of LA/LB, JOC, Cowen and Company

footprints. We think Mexico could offer a close yet affordable manufacturing hub for the United States. In May 2022, Canada Pacific Railway debuted its first rail service between the port city of Lazaro Cardenas, Mexico to Chicago, potentially paving the way for a rail freight route linking Mexico to both coasts of Canada via U.S. hubs.

Hourly Wages In Mexico vs. China



Source: Statista, Cowen and Company

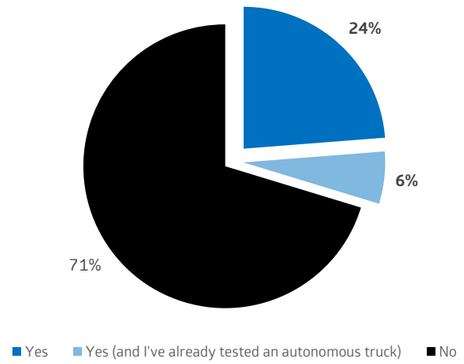
Automation & Robotics

The pandemic-induced supply chain congestion brought technological enhancement to the forefront of the supply chain conversation across industries. Tight labor markets and increasing e-commerce (Cowen forecasts 11% growth per year from 2022-2027) are adding pressure on companies to streamline the movement of products and compete with the quick turnaround times of native e-commerce vendors such as Amazon. This has led to considerable supply chain technology investment in robotics and automation. CB Insights reports that, at the end of 1Q22, funding for the prior 12 months reached nearly $38 billion, reflecting investor focus on this market segment.

At U.S. ports, automation efforts are underway, though we expect pressure from unions to slow widespread adoption. Automation is also emerging as a source of differentiation in the warehousing and logistics business. Our discussions with major integrators suggest that globally, only ~10% of warehouses are fully automated, 30-40% have some automation (mainly infrastructure like conveyors), while the remaining 50-60% are completely manual. Cowen analysts forecast growing adoption of robots that can scale racks, pack boxes and move autonomously around a warehouse. This can be combined with machine vision technology that can "see" (rather than simply scan) items, identifying details like a bruised box or a misplaced SKU. Automated pallet packers can put together shipments more quickly and densely than using traditional methods.

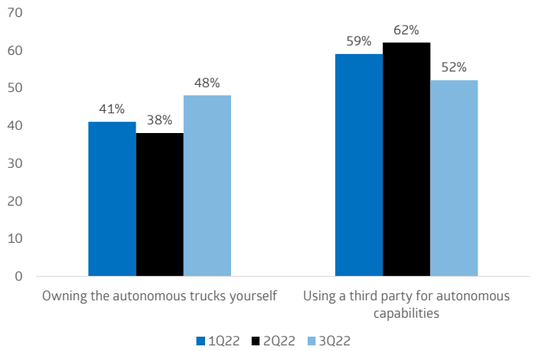
At the same time, a shortage of truck drivers is widening the opportunity for autonomous innovation. Cowen's proprietary carriers survey shows that 30% of carriers are willing to test autonomous trucks. Major trucking companies have made significant autonomous investments, and a number of U.S. states are passing new regulations allowing autonomous vehicles to be fully deployed. Technological advancements continue apace, such as the successful completion of the world's first fully autonomous semi-truck run on public roads in December 2021, which took place from Tucson, Arizona to Phoenix, Arizona, a journey of more than 80 miles.

Are You Open To Testing Autonomous Trucks?



Source: Cowen Carrier Survey, 3Q22; SurveyPlanet.com

Do You Plan (in the next five years) To Own Autonomous Trucks Yourself, Or Use A Third Party?



Source: Cowen Carrier Survey, 3Q22; SurveyPlanet.com

Emerging Industrial Policy Imperatives: Semis, Clean Energy and Next-Gen Materials

Stabilizing supply chain vulnerabilities has become a critical issue of national security for the U.S., as expressed in an industrial policy of subsidies, tariffs and sanctions. Legislative measures such as the Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022 ("CHIPS Act") allocated nearly $60 billion to rebuild U.S. semiconductor capacity. As the semiconductor industry attempts to reduce reliance on China, there are nearly $110 billion of semiconductor fabs, primarily in the U.S., that started or will start construction in 2022 and 2023 before beginning to go online in 2024, according to Cowen estimates.

Clean tech and renewable energy supply chains are also targets for support. The Inflation Reduction Act includes incentives aimed at tripling U.S. domestic solar manufacturing by 2024. Since China controls about 80% of lithium refining, the Biden Administration is also pushing to secure a homegrown lithium supply to support production of batteries for electric vehicles.

SUPPLY CHAIN

Retailers And Supply Chain Investment

For retailers, shifts to digital and direct to consumer models, accelerated by the pandemic, are enabling brands to scale with increasing growth rates and higher returns on capital. Resulting margin expansion can then be reinvested into supply chain transformation, innovation and technology. Cowen's research suggests that company capex as a percentage of sales at some of the largest retailers is rising.

When we look at how large retailers are spending, some common themes emerge. Speed and efficiency are paramount, prompting investment in sortation centers, distribution centers and logistics platforms. Retailers are expanding capacity outside of stores to support a growing sales base. At the same time, they are reconfiguring and upgrading stores to make them function more efficiently. One large retailer, for instance, is investing in automation systems that help its sales associates more quickly retrieve products from the stockroom and get them out to the sales floor.

Reverse logistics refers to operations related to the "upstream" movement of products and materials, such as returns. Greater e-commerce activity has generated the need for effective reverse logistics solutions for retailers across the globe. According to the National Retail Federation, the reverse logistics market is expected to reach $604 billion by 2025, accelerated by online purchases of apparel in particular (30% of deliveries in fashion e-commerce are reportedly returned). Third party logistics players who serve this market such as Optoro, Trove and Loop Returns stand to benefit.

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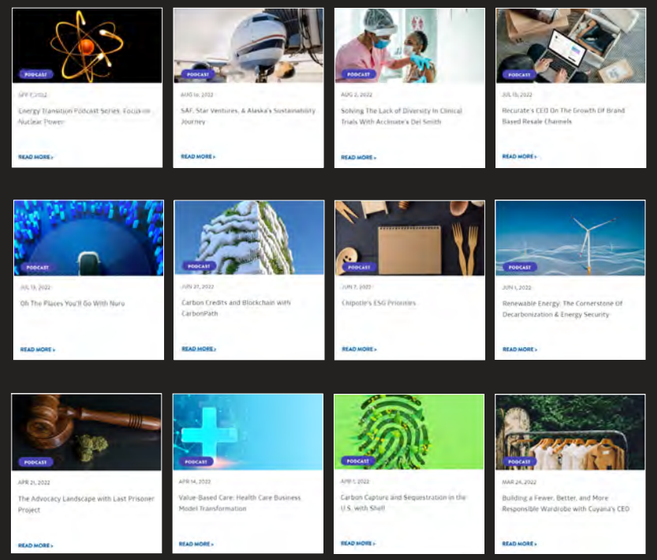


ENERGY TRANSITION

COWEN RESEARCH THEMES 2023

"Against the backdrop of a looming carbon fuel crisis and the subsequent scramble toward energy independence, the Inflation Reduction Act provides the U.S. 10-plus years of policy direction."

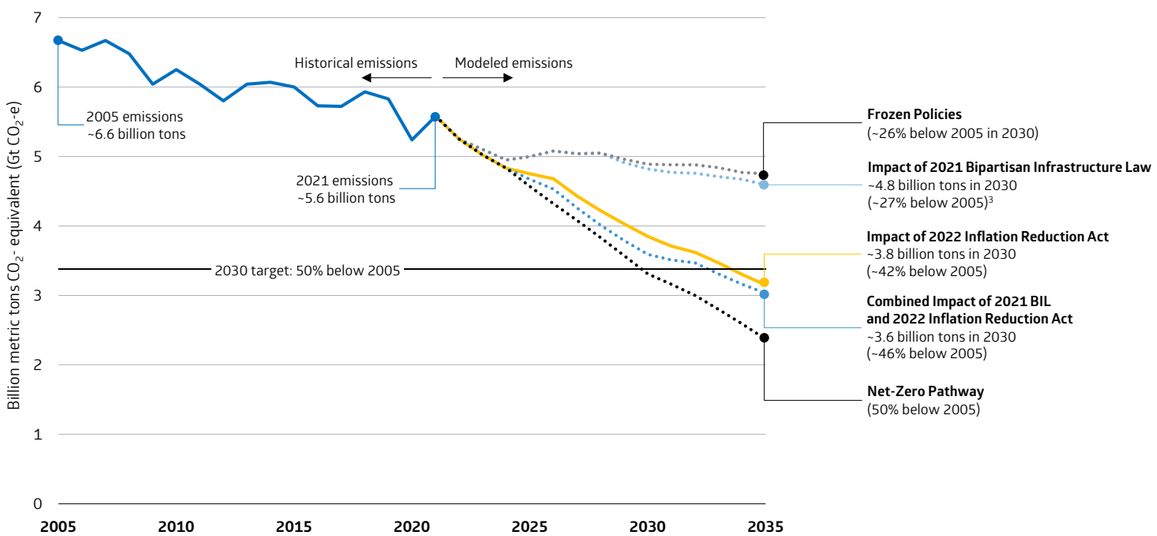
COWEN

2022 has emerged as a transformative year for global energy transition, catalyzed by Russia's invasion of Ukraine in February, and furthered by the United States' passage of the Inflation Reduction Act (IRA) in August. Going forward, we believe that energy transition can no longer be defined solely in terms of achieving least-cost greenhouse gas (GHG) reductions, but will increasingly be defined in terms of GHG reductions achieved through energy independence.

Against the backdrop of a looming global carbon fuel crisis – felt most acutely in Europe – and the subsequent scramble toward energy independence away from Russia's fossil fuel exports, the IRA provides the U.S. 10-plus years of policy direction. The IRA's top-line investment funding of $369 billion for domestic producers and equipment manufacturers associated with renewable and transitional energy technologies serves as a force-multiplier to turbocharge the $60 billion in direct clean energy and transportation funding created by the 2021 U.S. Bipartisan Infrastructure Law (BIL). Moreover, added lending capacity of up to $250 billion from the Department of Energy (DOE)'s Loan Programs Office (LPO) represents further incremental capital available to targeted industries such as advanced vehicle manufacturing, critical chemicals and metals, and nuclear power.

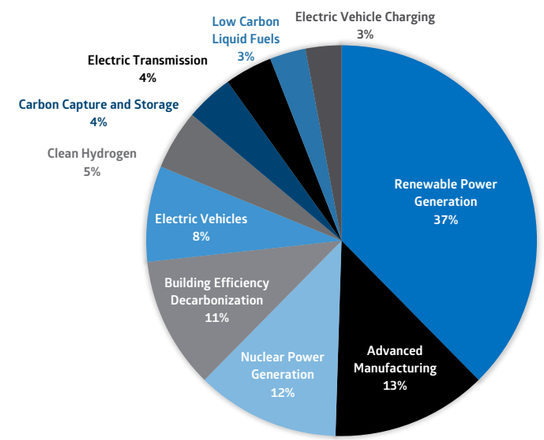
We believe global efforts by sovereign nations to achieve both GHG reductions and energy independence is resulting in the emergence of multiple competing energy transition pathways. Wedge issues, including geopolitics, trade protectionism and industrial policy, along with human rights concerns, are raising the value of resilient supply chains and domestic manufacturing. While unlikely to result in the lowest cost global energy transition, we believe these re-shoring or regionalization trends will hasten the development and deployment of government-supported clean energy sources. As a result, Cowen expects that many different industries touching energy transition will benefit from these unprecedented levels of new, domestically focused investment. We believe IRA and BIL funding will provide critical benefit for players in solar, clean hydrogen, carbon capture and sequestration, grid infrastructure, battery manufacturing, nuclear and EV charging investments.

Historical & Modeled Net U.S. Greenhouse Gas Emissions (Including Land Carbon Sinks)



Source: REPEAT, Cowen and Company

Key Industries & Energy Types Benefiting From Funding Under Combined Inflation Reduction Act & Bipartisan Infrastructure Law



Source: Cowen and Company

WHAT WE'RE WATCHING

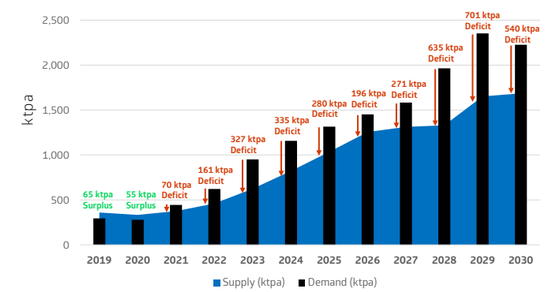
U.S. Access To Lithium-Ion Batteries

Years of significant government support and incentivized EV demand have led China to dominate the lithium-ion battery (LiB) industry. China now controls over half of the world's lithium, cobalt, and graphite refining capacity. With EV adoption standing as a key pillar of global strategies for the reduction of GHG emissions from the transportation sector, governments are squarely focused on reducing dependence on China for access to LiB capacity through development of stable domestic supply chains.

We expect the plethora of gigafactory plans announced in the U.S. and EU will drive substantial demand growth on the back of aggressive OEM and governmental EV sales targets, bolstered by the combined impact of the IRA and BIL (such as the IRA's $35/kWh cell assembly credit).

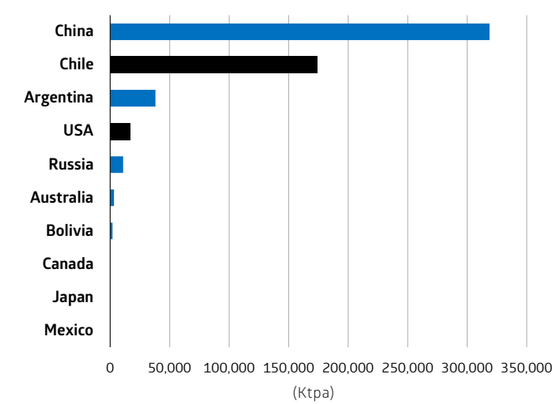
However, despite redoubled efforts, U.S. LiB capacity remains far behind China's and is not likely to catch up anytime soon, creating a clear risk to EV adoption targets and broader U.S. security interests. EV-related lithium demand is set to grow by more than 310% between 2022 and 2030, with Cowen estimating EV sales to comprise 33.2% of global new vehicle sales by 2030 vs. 13.1% in 2022.

Cowen's Lithium Supply & Demand Forecast, 2019-2030



Source: Cowen and Company

Current Lithium Chemical Processing Capacity By Country



Source: Bloomberg, Benchmark Mineral Intelligence, Cowen and Company

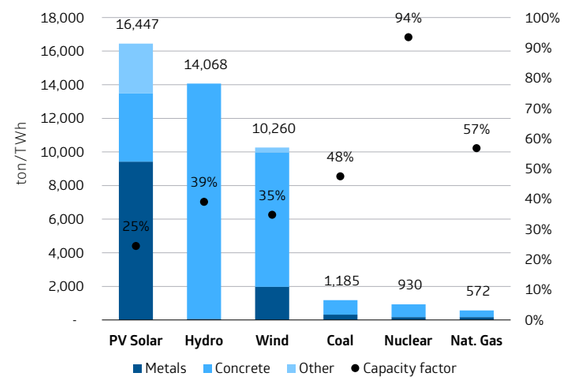
While LiB battery plant construction requires an average of 2 years' lead time, the upstream mining buildout required to secure the raw component materials for battery end products requires a much longer lead time of 5-10 years. As a result, even with favorable industrial and consumer demand dynamics, we expect mismatched, slower raw materials supply growth to ultimately constrain EV sales, with Cowen forecasting an average lithium supply deficit of 24% from 2023 to 2030.

We believe the race to find IRA-compliant ways of passing along available government-subsidized savings to consumers amidst an extremely under-developed domestic processing base will be a secular theme for the next several years. While the IRA offers substantial benefits to the lithium industry, many of these benefits will be difficult to access while domestic sourcing is constrained. The IRA's EV tax credits for OEMs of $3,750 per vehicle can only be met if 40% of battery materials are sourced from North America or Free Trade countries by 2023, expanding to 80% by 2027. Available investment tax credits for capex and manufacturing production credits under the IRA are also limited by currently qualifying lithium content, given that ~56% is processed in China and only ~30% from IRA-compliant nations. The U.S. is anticipated to triple EV sales within the next three years alone and show an 8x increase by 2030, effectively requiring the equivalent of China's lithium processing capacity today.

Nuclear Power Generation

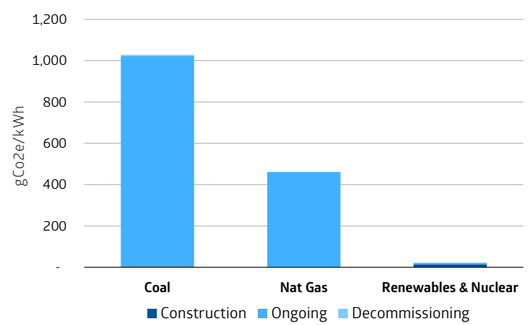
We believe providing affordable, reliable energy for all is a necessary condition for achieving net zero CO2 targets, and we see nuclear power as a vital enabler of these goals. Public and investor aversion to nuclear has been a hurdle to new investment, but that opposition may be lessened by data debunking traditional safety concerns and establishing nuclear as a power source with low life cycle GHG intensity, high reliability, low land use, and a sound safety record. Furthermore, we see the increased urgency for European energy security and ensuing energy inflation in the wake of Russia's invasion of Ukraine as key catalysts spurring a new openness to nuclear in an emerging energy transition matrix.

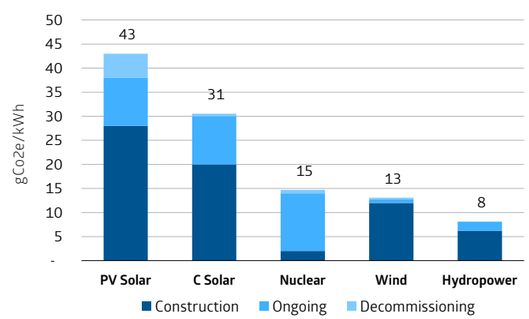
Relative Construction Intensity of Nuclear vs. Other Energy Sources



Source: DOE, Cowen and Company

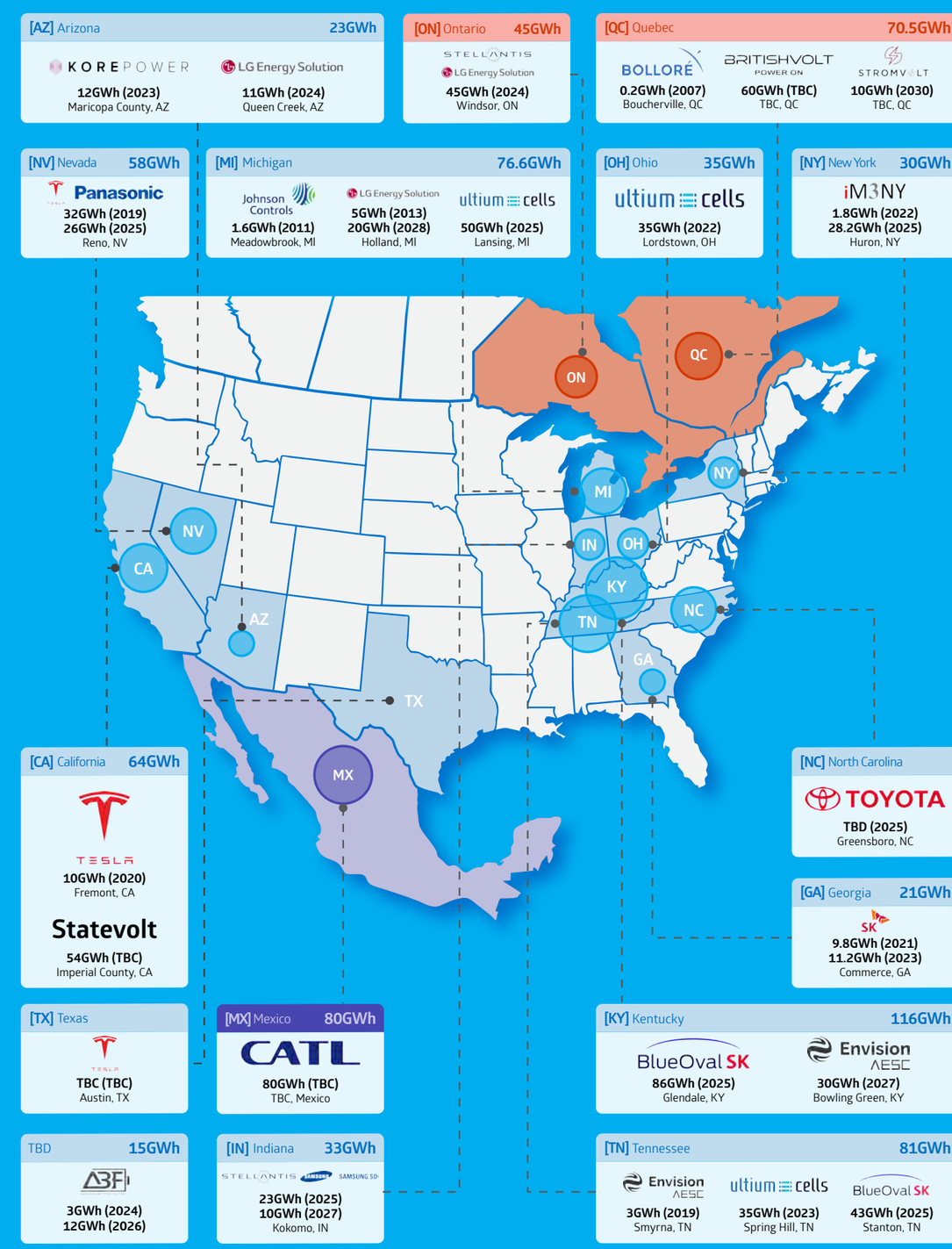
Relative GHG Intensity Of Nuclear vs. Other Energy Sources





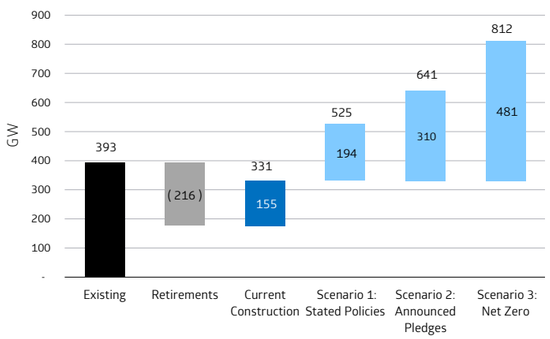
Source: NREL, Cowen and Company

SNAPSHOT: ANNOUNCED U.S. GIGAFACTORY PLANS



Source: BNEF, Cowen and Company

Projected Nuclear Capacity Retirements And Additions On The Path to Net-Zero (2020 to 2050)



Source: IEA, IAEA, World Nuclear Association, Cowen and Company

Moreover, we see advances in nuclear reactor technology, particularly in the small modular and advanced reactor categories, directly addressing public perception hurdles around safety, cost, and construction time. Small modular reactor (SMR) designs help lower cost and construction time through standardization and modularization, while limiting risks via novel cooling and other safety mechanisms that specifically address weaknesses in traditional reactor designs. In addition, the smaller size of SMRs (generally 300MWe or less) lowers the capital investment threshold for new plant constructions and increases the addressable market, while also offering scalability over time with the buildout of incremental modules as demand warrants.

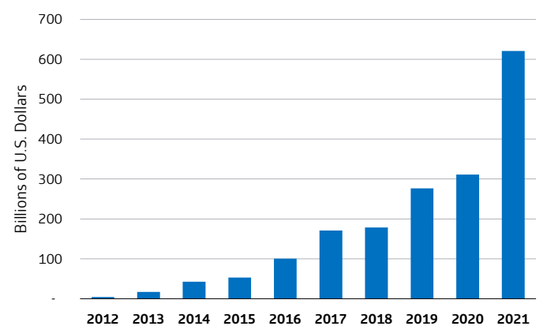
We see these themes potentially accelerating the adoption of nuclear power, and ultimately increasing its contributing share of the overall electricity supply mix. This could represent substantial growth in the context of a broader move to electricity, which most models forecast will represent 80% or more of the total global energy supply by 2050, from 40% today.

Sustainability-Themed Debt Instruments

Funding the energy transition will require trillions of dollars, and the International Energy Agency estimates that roughly 70% of clean energy investment over the next decade will be drawn from private developers, consumers, and financiers. Access to low-cost financing will be critical to companies and organizations faced with the high upfront costs associated with renewable projects. As investors look to broaden their clean energy exposure beyond traditional equities, we have seen significant evolution in available financing alternatives supporting the transition to clean energy.

The growth in sustainability-themed debt financing vehicles has been particularly pronounced, and "green bonds" have risen in popularity over the last decade, exceeding $600 billion in issuance in 2021. These instruments are typically backed by the issuer's entire balance sheet, but are structured to separate proceeds to exclusively provide for deployment of defined sustainability related projects, such as green buildings, renewable energy facilities, pollution prevention initiatives, substantial plan retrofits, and other projects meeting specifications set out in the governing bond documents.

Rise In Sustainable Debt Financing: Annual Green Bond Issuances



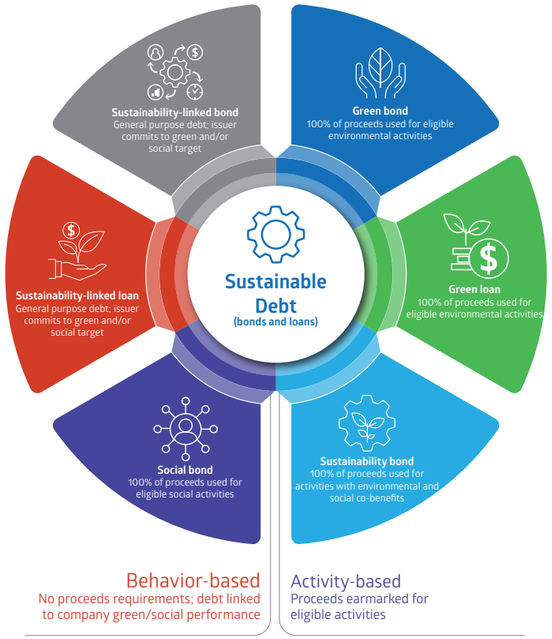
Source: Bloomberg New Energy Finance, Cowen and Company

Renewable Diesel (RD) And Sustainable Aviation Fuel (SAF)

Cowen believes the biofuels industry is on the cusp of an investment inflection driven by the need to decarbonize air travel, presenting a more than 100 billion gallon opportunity. We estimate the current renewable diesel / sustainable aviation fuel (RD/SAF) industry will grow to 9 billion gallons by 2025, buoyed by U.S. passage of the IRA, which extends the RD Blender's Tax Credit (BTC) through 2027 and introduces a new, higher SAF credit through 2027. The U.S. has a 3 billion SAF target by 2030, while the EU is working on an estimated 1 billion gallon SAF mandate (under the EU Fit for 55 initiative) by 2030.

While near-term biofuel growth will be realized through utilization of feedstock-based technologies with finite capacity and geared toward diesel production, we expect the industry to evolve to employ a wider array of technologies to support substantial SAF growth over time. These next-generation technologies present investment opportunities in areas such as ethanol-to-jet, Power-to-X, and Gasification/Fischer-Tropsch, and more companies are expected to come to market in the next few years focused on these new technologies.

Variety Of Sustainability Themed Debt For Investors To Consider



Source: Bloomberg New Energy Finance, Cowen and Company

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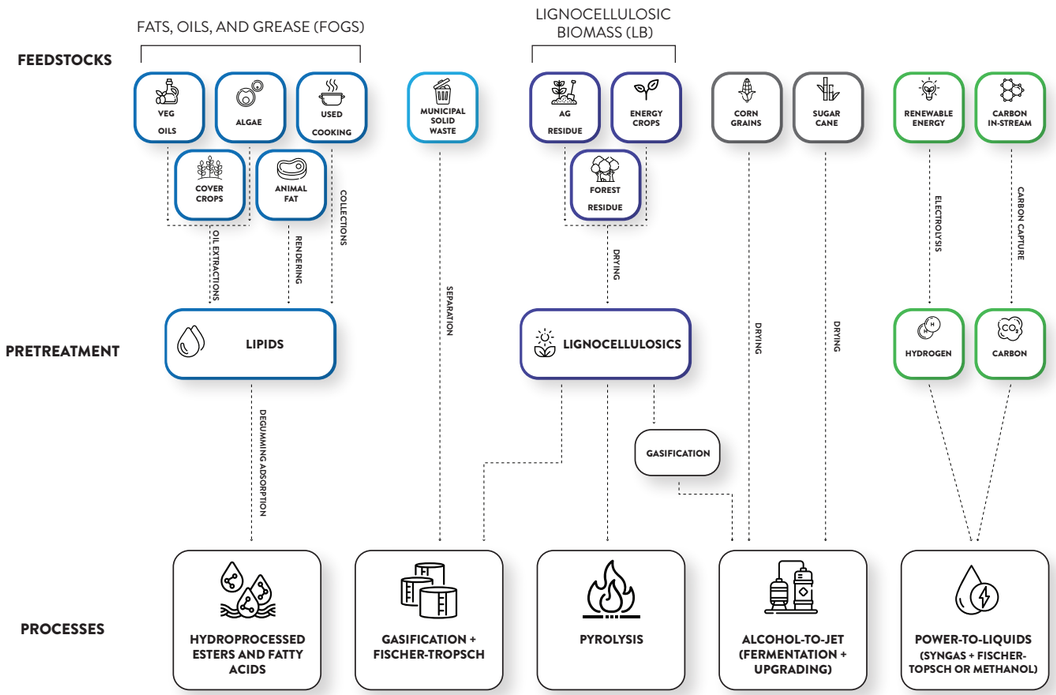

Source: Company Filings, Cowen and Company

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INFLATION
& THE CONSUMER

COWEN RESEARCH THEMES 2023

"It is reasonable to believe that some components of inflation will likely be part of the new normal, including the adoption of ESG standards, deglobalization and reshoring, and energy independence."

COWEN

The United States, and indeed many developed nation economies, have experienced a general 40-year downtrend in interest rates. Current levels are certainly not unprecedented, but have not been seen in a decade.

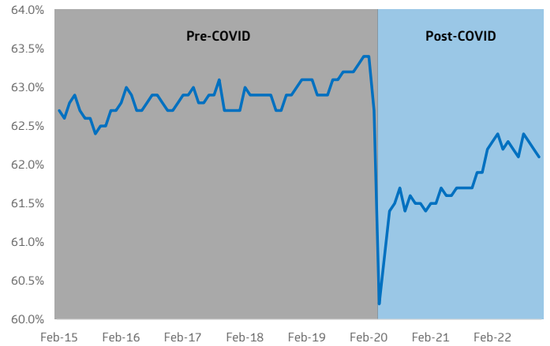
Inflation remains high and persistent (and well above the Fed's long-term 2% target rate), outpacing wage growth and crimping consumer spending power. The good news is that a feared wage-price spiral is not currently in evidence. Remote work appears to have lessened wage growth pressure, at least temporarily, based on a recent Federal Reserve Bank of Atlanta study. Goods inflation is finally trending lower. However, services inflation, closely tied to wages, has generally been trending higher, and medical care is a services category where there is likely more inflation to come.

The U.S. and other economies face an untested path toward normalization. This is the world's first recovery from a pandemic in more than 100 years and there is no clear playbook. Parts of the economy are already in a recession, and the probability is high that the rest of the economy will follow in 2023 given the Fed's resolve to reduce inflation toward its long-term goal. Almost all past tightening cycles have eventually led to a recession. There remains a risk that the Fed could tap the brakes too hard and force the economy into a deeper-than-expected recession.

U.S. 10-Year Treasury Yield, 1980-2022

Source: FRED, Cowen and Company

Labor Force Participation Rate, Pre- And Post-COVID Pandemic Outbreak



Source: U.S. Bureau of Labor Statistics, Cowen and Company

Labor Force Participation Rate Ages 55 Years And Over

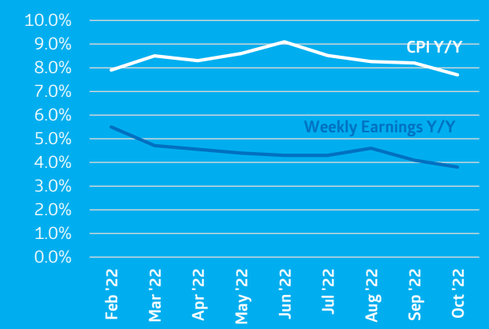
Source: U.S. Bureau of Labor Statistics, Cowen and Company

There continues to be a large supply/demand imbalance in labor. Workers have not come back into the labor force as strongly as expected, and lower post-COVID labor participation is a significant inflationary factor. We estimate that the U.S. has 4.4 million fewer people at work than it should have, given pre-COVID labor force growth. The age 55+ age cohort is partially to blame. Americans are getting older, driving labor force participation lower.

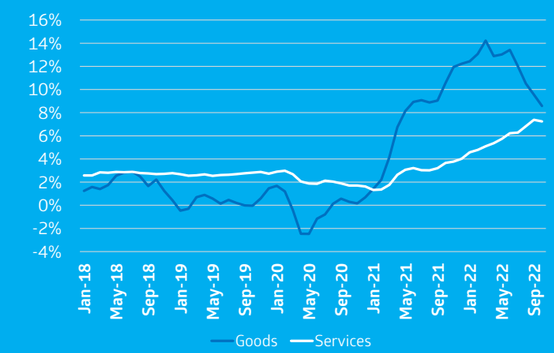
Cowen's proprietary surveys and data show worsening consumer savings sentiment, increased plans to cut spending, and signs of inflation moderation. Elevated

SNAPSHOT: INFLATION AND ITS COMPONENTS

U.S. CPI VS. WEEKLY EARNINGS, Y/Y % CHANGE

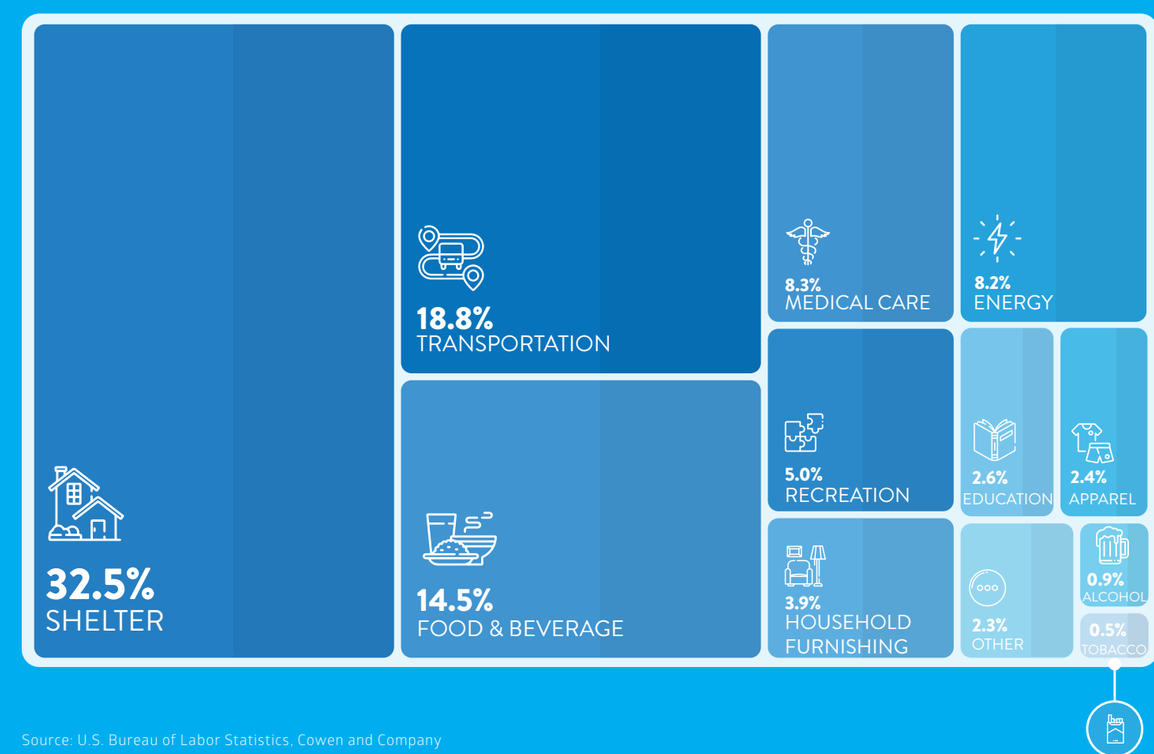


CPI GOODS VS. SERVICES INFLATION, % CHANGE FROM YEAR AGO (2018-2022)



Source: U.S. Bureau of Labor Statistics, Cowen and Company

CPI AND RELATIVE IMPORTANCE BY EXPENDITURE CATEGORY



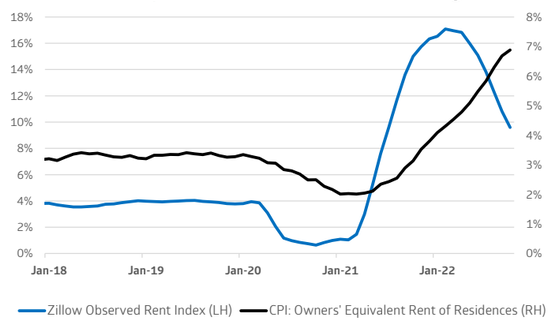
Source: U.S. Bureau of Labor Statistics, Cowen and Company

"Younger consumers' financial discomfort is increasing the fastest, based on Cowen's Gen Z and Millennial survey."

supply chain costs are easing, as ocean and truck spot rates continue to decline due to weakening consumer demand and early signs of industrial softening. After significant commodity price flare-ups, deflationary trends may be underway. Though not yet reflected in CPI, data suggest that shelter costs are weakening. We believe home prices will correct but not crash, based on historically high credit quality and inventory constrained by historically low locked-in rates.

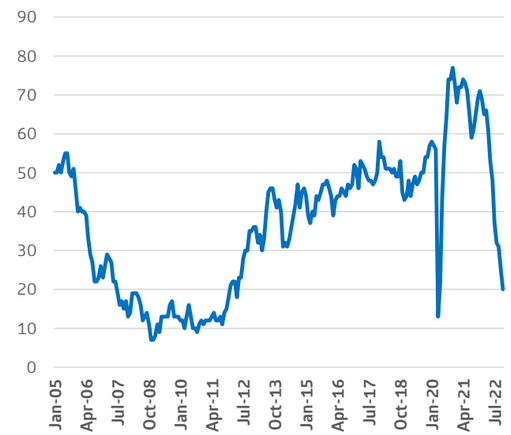
We see a bifurcated macro environment in which lower-income consumers and undifferentiated retailers feel the highest pressure. More differentiated retailers and brands are seeing relatively stronger trends, and the gap is widening. As expected, Cowen's surveys show that lower-income consumers are struggling and plan to cut spending the most. Finances of lower- and middle-income families were hit harder by the pandemic, further reducing their share of aggregate income. Conditions for lower- and middle-income households are likely to worsen as a Fed-induced increase in unemployment would likely be concentrated among disadvantaged workers.

Zillow Observed Rent Index vs. CPI Owner's Equivalent Rent, % Change Y/Y



Source: Zillow, U.S. Bureau of Labor Statistics, Cowen and Company

NAHB/Wells Fargo Housing Market Index, Traffic Of Prospective Buyers (SA)

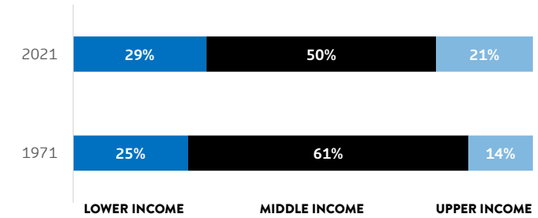


Source: National Association of Home Builders, Zillow, U.S. Bureau of Labor Statistics, Cowen and Company

Younger consumers' financial discomfort is increasing the fastest, based on Cowen's Gen Z and Millennial survey. The most likely areas that younger cohorts intend to cut are dining out, restaurant delivery, and clothing, footwear and accessories, followed closely by luxury goods. In addition, pressure has been evident in premium pet food, plant-based food, and healthy snacks.

It is reasonable to believe that some components of inflation will likely be part of the new normal, including the adoption of ESG standards, deglobalization and reshoring, and energy independence. Longer term, several structural forces could push inflation higher, including lower birth rates, slowing immigration, an aging population, and rising medical costs. For example, since 2014, births in the United States have declined 2% per year. A declining birth rate means eventually, there will be fewer workers to pay the taxes that fund public programs like Medicare and Social Security, an acute issue given the aging population. By 2034, the U.S. Census Bureau projects that people aged 65 and older will outnumber those aged 18 years and younger for the first time in U.S. history.

Share Of U.S. Adults By Income Group



Source: Pew Research Center, Cowen and Company

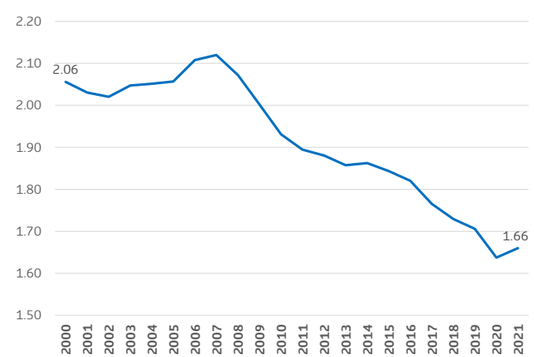
Post-pandemic policy will be important to watch. For example, the high inflation of the 1970s ushered in an era of smaller government in the 1980s, and government spending initiatives and social programs may face greater scrutiny in the future. Additionally, fiscal and monetary intervention in future crises may be more measured, particularly given high U.S. government debt and a deficit that is forecasted to grow.

WHAT WE'RE WATCHING

Consumer Behavior

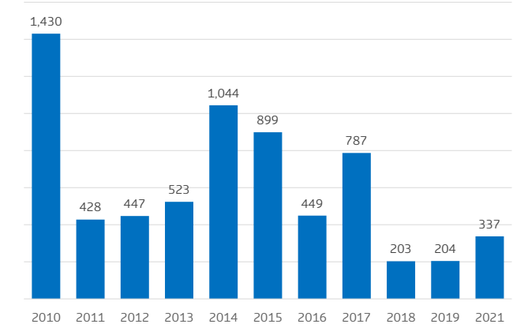
We continue to monitor consumer sentiment and financial health through Cowen's Consumer Tracker, a proprietary monthly survey of 2,500 consumers. Near term, consumer spending anxiety peaked in September (with 75% of consumers cutting spending) and moderately eased in October. As we have seen in the past, when prices change quickly, poorer households are hit hardest, and we believe the lower-income consumer will continue to struggle. A marked increase in high-income consumers' plans to cut spending is also noteworthy.

U.S. Fertility Rate (Births Per Woman), 2000-2022



Source: The World Bank, Cowen and Company

Number Of U.S. Immigrants (Thousands), 2010-2021



Source: Migration Policy Institute, Cowen and Company. Note: Due to COVID-19, data for 2020 are not available.

Pricing Power

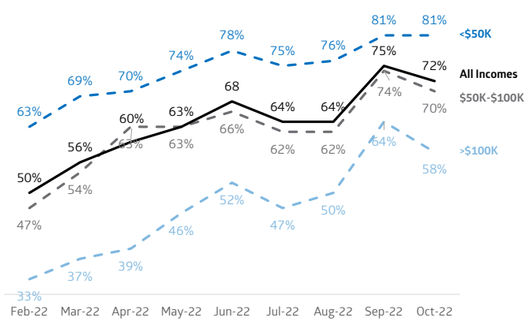
We continue to monitor category price elasticities in the face of record inflation. We are focused on uncovering companies with pricing power and stickiness that can protect their profit margins by passing costs along to customers. Categories with pricing power in evidence include beauty, personal care, health and wellness, carbonated non-alcoholic beverages, salty snacks, and popular consumer brands. In the technology sector, companies with differentiated designs also hold pricing power.

Inventory

The retail sector is still heavily over-inventoried, as demonstrated by retail inventory growth well in excess of sales growth. This dynamic creates margin risk for retailers as high-cost inventory flows off the balance sheet into a slower retail environment. As macro headwinds continue to pressure consumers, we

INFLATION & THE CONSUMER

Respondents Cutting Spending As A Result Of Higher Costs By HH Income

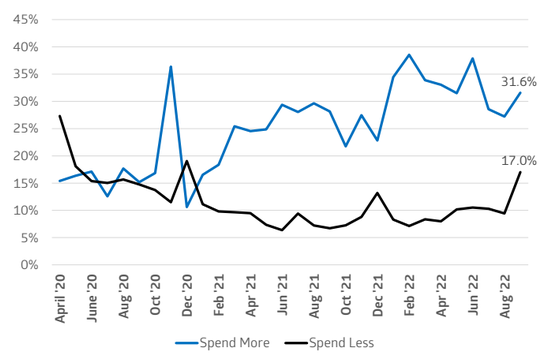


Cowen Consumer Sentiment Survey, Oct '22 (N=~2,500)

believe an opportunity may exist for certain retailers to gain wallet share given an increased number of higher-income consumers that are trading down.

Inventory levels are also believed to be quite high at the manufacturer/brand level. Should recessionary fears become actualized, leading off-price retailers could rebuild pack and hold inventory levels, which are typically margin accretive. In the short term, these retailers are contending with margin pressure and the challenge of passing through price increases to the lower-end consumer.

High-Income Consumer Spending Intentions



Consumers earning >$100,000 and their spending intentions for the coming month.
Source: Cowen COVID-19 U.S. Internet Consumer Tracker, September '22 (N= ~2,500)

Labor

Based on data from the U.S. Bureau of Labor Statistics, there are 1.9 job openings in the U.S. per unemployed person, up 58% from pre-COVID levels. The ratio of job vacancies to unemployment is typically a strong predictor of wage growth. Recently, job openings have been showing signs of slowing, and we continue to monitor whether the Fed reduces labor demand without significantly increasing unemployment.

Supply Chain Costs

The pre-pandemic global consumer environment was characterized by globalization as well as deflation in product, sourcing, and other costs. The war in Ukraine, China's zero COVID policy, and tensions in Taiwan are indicative of a macro and geopolitical environment that is causing increased volatility. Reshaping and hardening brittle supply chains will take time and will deliver sustainable benefits, but will also come at a cost to profitability.

Recently, the commodity complex for retail and consumer brands around freight, fuel, and certain raw material inputs such as cotton, has experienced a deflationary trend as consumer demand is slowing, providing prospects for the development of future margin relief for retail and consumer brands at some point beginning in 2023 (but likely not before the second half of the year).

Elevated shipping costs have eased, as ocean and truck spot freight rates continue to decline due to weakening consumer demand and early signs of industrial softening. Looking ahead, we will be monitoring Cowen's proprietary carrier and rail surveys, as well as our predictive AFS Freight Index, which offers an early look at quarter-ahead rates and which currently suggests softening rate expectations. We will also be watching currently tight warehousing capacity, port congestion (which has eased materially), infrastructure investment, ESG pressures, policy and legislative developments, shifts in inventory management strategies (from "just-in-time" to "just-in-case"), and automation efforts.

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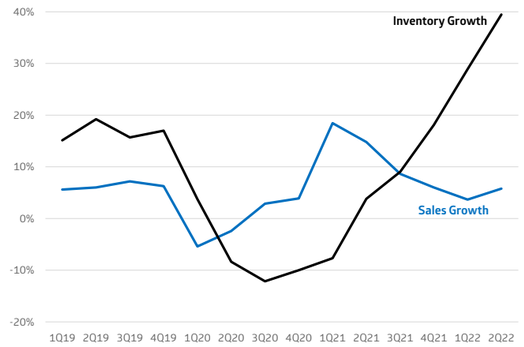
Retail Sales Growth vs. Inventory Growth, Y/Y % Change



Source: Cowen and Company, Corporate Filings. Figures include covered companies in several categories including, department stores, broadlines, sporting goods, footwear, off-price retail, athletic apparel brands, and apparel brands.

Food

Ukraine (known as "the breadbasket of Europe") and Russia combined produce 50% of the world's animal feed, more than 30% of wheat and barley, and 17% of corn. As a result of geopolitical tension and supply chain disruption, food costs remain high, though further price gains may be limited by moderation in energy prices. Over the coming months, high food costs may persist, reorienting supply chains to North America, benefiting Mexico, Canada, and North American transport. Additionally, we are watching private label's share gains versus higher-priced branded products, though the rate of gain has recently moderated as the price gap to branded products narrows. We are also watching agricultural technology (or "AgTech") because of the role it can play in addressing the world's pressing need for sustainable food supply through advances in vertical farming, seed technology, and robotics.

Energy

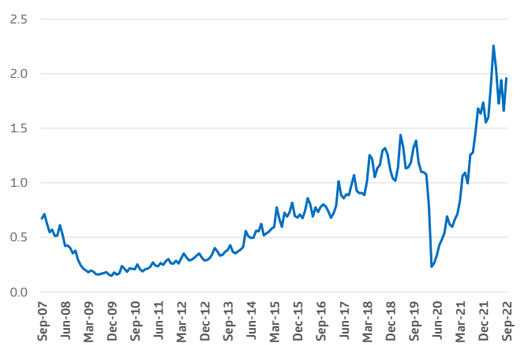
Volatile energy prices have moderated since last summer. Factors we will be monitoring include China's eventual full reopening, Russia sanctions, Organization of the Petroleum Exporting Countries (OPEC) developments, refining capacity, U.S. dollar strength, and policy developments such as the United States' stance toward its Strategic Petroleum Reserve.

In the global gas market, Cowen projects multi-year strength due to supply/demand imbalances despite European efforts to reduce prices. Higher energy prices, which may cost Europe nearly 7% of its gross domestic product, are driven by Russia reducing pipeline exports to Europe, a flow that typically accounts for one-third of Europe's supply and 3.5% of global gas supply. Second order impacts will cut across industries, with several industries beyond traditional energy set to benefit, including sustainable energy and energy storage.

Semiconductors

Semiconductors are the heart of modern electronics, are critical to global economic growth, and are crucial to national security and global competitiveness. Systemic underinvestment in mature technologies underpins the extreme semiconductor supply shortage over the past several years, affecting many industries, particularly the automotive sector. Electrification and digitalization require more analog and microcontroller content. As a result of the supply tightness interrupting supply chains worldwide, numerous semiconductor device companies have announced their intent to build out additional capacity.

Job Openings Per Unemployed Person (Total Non-farm, NSA)



Source: U.S. Bureau of Labor Statistics, Cowen and Company

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MOBILITY

COWEN RESEARCH THEMES 2023

"The U.S. is anticipated to triple EV sales within the next three years alone and show an 8x increase by 2030, effectively requiring the equivalent of China's lithium processing capacity today."

COWEN

Megatrends such as electrification, autonomy, and active safety continue gaining momentum in a broad range of mobility applications. The pandemic has changed the dynamics of mobility. Working from home has decreased public transport usage. Ride sharing usage has increased. Micromobility has grown as people stay closer to home. eCommerce and last-mile delivery have accelerated. And the long-term trend toward urbanization continues, according to a recent UN report.

In addition to the COVID pandemic, Russia's weaponization of energy exposed vulnerabilities and crystallized priorities. Energy security, access to critical materials, de-risking supply chains, and sustainability are materially more important now than they were in 2019. Sustainable mobility solutions align with today's national priorities, and we believe sustained policy support is likely because of a new appreciation of the power created by controlling critical technology inputs.

With a move toward electrified powertrains, Cowen sees significant value flowing to semiconductors, sensors, and domain controllers/central compute systems driven by increased content per vehicle. We also see new business models emerging with recurring revenue potential. And importantly, we continue to see different solutions for different use cases. For example, we expect low-cost green hydrogen to be leveraged for high-power and heavy-duty applications such as trucks, trains, and marine.

With the transition to renewable energy consumption underway, we believe that auto manufacturers will aspire to redesign traditional business models to produce a "circular car"—a vehicle produced with zero material waste and zero pollution during manufacturing, usage, and disposal. Examples of sustainable approaches include the use of lab-produced leather, battery recycling, smart glass, prioritizing composites over metals, and use of "green" steel. A circular business model offers significant economic opportunities by not only reducing waste but also by creating new streams of revenue or reducing costs.

"Cowen sees significant value flowing to semiconductors, sensors, and domain controllers/central compute systems driven by increased content per vehicle."

WHAT WE'RE WATCHING

Electric Vehicles (EVs)

The automotive industry is going through the most dramatic transformation in its history. Cowen forecasts that EVs as a percent of total light vehicles sold will increase to 33% in 2030 vs. 13% in 2022. We see the adoption of EVs continuing to rise as choice for consumers increases, battery range improves, tax credits elevate, and charging infrastructure becomes more robust. Electrification brings opportunity for the tech supply chain (semiconductors/sensors) as well as Tier 1 and 2 suppliers to gain increasing content and expand margins.

The U.S. is proving to be a "fast follower" after consistently lagging China and Europe in EV development and adoption. Policy support is helping close the gap. We believe the Infrastructure Investment and Jobs Act and the Inflation Reduction Act (passed by Congress in 2021 and 2022, respectively) will provide tailwinds, easing range anxiety as more charging infrastructure is built and elevated tax credits stimulate demand. One of the central tenets of our bullishness on EV sales is diversification beyond the sports and luxury markets and into mainstream vehicles like trucks, SUVs, crossovers, and affordable city cars. We see the adoption of EVs continuing to rise as choices for consumers increase. In early 2013, just 27 all-electric BEV models were available for sale globally, relative to a forecast 350 by 3Q23.

Raw Materials Supply

In our view, the most challenging element of the transition to full fleet electrification is the battery supply chain and the striking disconnect between current EV forecasts relative to raw materials supply. For example, Cowen forecasts that lithium supply growth will not keep pace with demand growth. Despite the sixfold increase in lithium carbonate pricing since the summer of 2021, we don't see costs as an impediment. Rather, the issue is an ability to secure supplies of critical materials. Other than Tesla, many OEMs appear to be letting their cell suppliers track down critical raw materials for batteries, and battery factories are being built at a feverish pace. However, factories require 18-24 months to build, and the associated capacity of mining, intermediate chemicals, and manufacturing capacity need to be expanded.

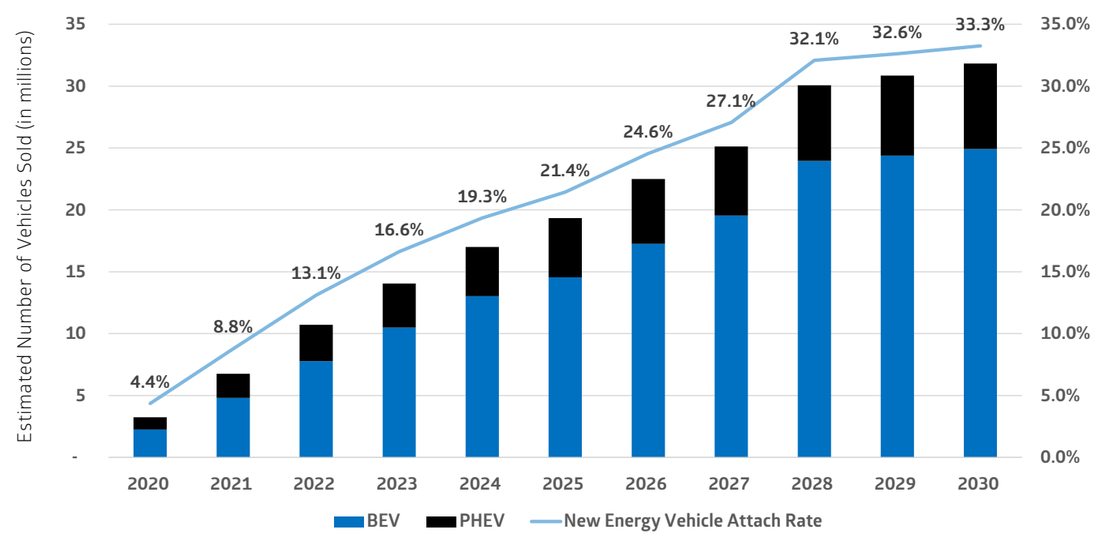
EV success will be determined by those who effectively manage a constrained supply chain. Cowen believes the lithium supply/demand imbalance will create a position of strength for lithium producers and recyclers. We will also be watching geopolitical developments. In a recent interview, Indonesia's investment minister told the Financial Times that "Indonesia is studying the possibility to form a similar governance structure [to OPEC] with regard to the minerals we have, including nickel, cobalt, and manganese." In addition, the U.S. government has recently undertaken several initiatives to support domestic sourcing, including $2.91 billion of funding in the recent infrastructure law for projects that bolster domestic battery manufacturing and recycling.

Battery Tech & EV Charging

Cowen's battery market demand buildup forecasts a 21% CAGR through 2035, culminating in a $365B battery market – large enough to support multiple winners. The market will likely remain dominated by China, but with significant policy support and U.S. urgency to onshore battery supply chains, several next-generation companies outside of China stand to benefit.

Traditional graphite anodes and cathode chemistries are close to reaching their highest theoretical capacity, and there have been a limited number of breakthroughs to increase battery performance since the early 1990s. Next-generation battery start-

EVs Gaining Momentum With ~9% Of Total LCV Sales In '21 Rising To ~33% In '30E



Source: IHS, EV Volumes, Bloomberg New Energy Finance, Cowen and Company

MOBILITY

ups are making advancements toward the objective of delivering more energy and range. However, the timeline to commercialization is uncertain.

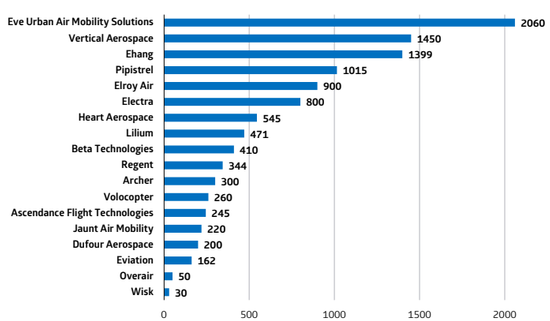
The U.S. continues to lag other regions with approximately 136,000 public vehicle chargers currently versus China and Europe at 1.5 million and 530,000, respectively. However, recent policy initiatives will spark additional buildout, with up to $7.5 billion of government incentives allocated for EV charging and a goal of 500,000 ports deployed by 2030.

Aircraft

Cowen is constructive on the long-term potential for eVTOL (electric vertical takeoff and landing vehicle) aircraft given their performance advantages and ESG-friendly nature. We believe eVTOLs are well suited for urban air mobility and cargo/logistics applications. Last year, some leading eVTOL players (Joby, Lilium, Archer, Beta, Vertical) were the initial entrants into the aircraft market. Since then, traditional aircraft manufacturers have entered the eVTOL space. Since eVTOL certification is the primary hurdle to market development, we believe aircraft OEM incumbents will be formidable competitors because they are more experienced in certifying, manufacturing, and servicing aircraft, and have deeper pockets.

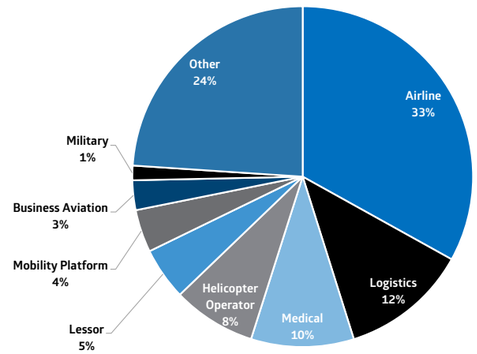
eVTOL industry orders have surged, supportive of healthy interest and demand. Based on conditional

Total eVTOL Orders By OEM



Source: SMS Consulting, Cowen and Company, as of August 10, 2022

eVTOL Orders By Operator



Source: SMS Consulting, Cowen and Company as of August 10, 2022

orders plus aftermarket sales, Cowen estimates an eVTOL addressable market of roughly $18 billion per year in the 2027-2029 timeframe. Many will compete for a share of eVTOL's growth potential by serving multiple end markets and geographies.

We expect eVTOL aircraft to enter service in the second half of this decade as ground transportation replacements. The aircraft have potential to remove cars from the roads and provide the most loyal and highest-value customers with an easy way to get from their homes or offices (or from their home offices) to the airport as quickly and efficiently as possible.

Autonomous Vehicles

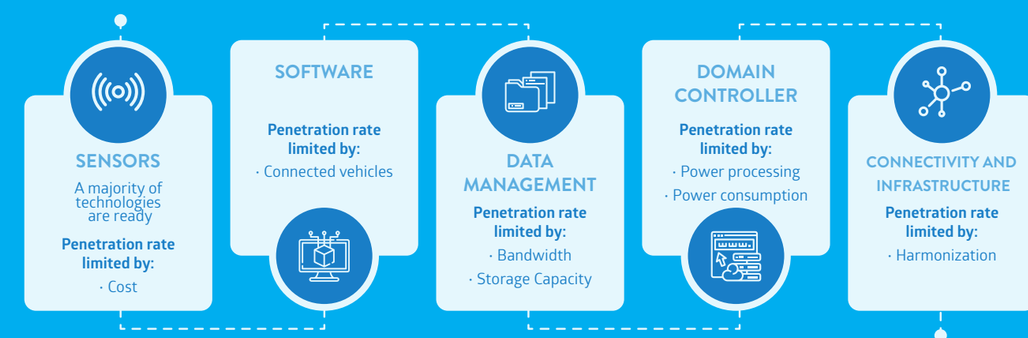
Cowen believes Level 4 ("mind off") autonomy will occur in trucking before consumer cars. Numerous companies have emerged that are looking to disrupt the $4 trillion global truck freight market with an autonomous solution designed to address the "middle mile." In the U.S., long-haul freight applications would essentially have exit-to-exit autonomy on interstate roadways with a driver still on board and ready to take over the controls as needed.

We believe autonomous vehicles will shape the consumer market sometime after 2030. As cars move toward autonomy, how passengers will spend their in-vehicle time is an open question, presenting new

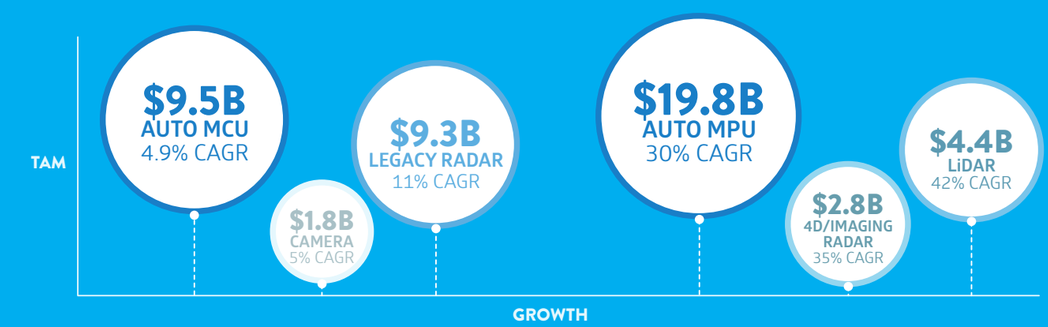
SNAPSHOT: TECHNOLOGY WILL ENABLE THE EVS AND AVS OF THE FUTURE

SIX MEGATRENDS
IN AUTOMOTIVE

TECHNOLOGY BUILDING BLOCKS
FOR AUTOMATION OF VEHICLES IN THE FUTURE



COWEN 2030 AUTO COMPUTING REVENUE
FORECAST BY SUB-SEGMENT



Source: Cowen and Company

growth opportunities. Most of the technology exists today to accomplish the mission of a fully autonomous vehicle. However, for Level 4 and Level 5 ("steering wheel optional") autonomy, hardware, software, semiconductors, and artificial technologies used to "sense" and "compute" are still being formulated. Level 2 ("hands off") and Level 3 ("eyes off") autonomy have largely been defined at this point and are currently being rolled out in higher-end vehicles.

We believe autonomous delivery could be transformational for many sectors, such as the restaurant industry. We also see a great deal of promise in leveraging autonomy for heavy machinery and agriculture applications, given the high cost of drivers and the safety benefits. For example, unlike passenger cars, construction and mining equipment can be converted, not replaced, by adding autonomous sensors and hardware.

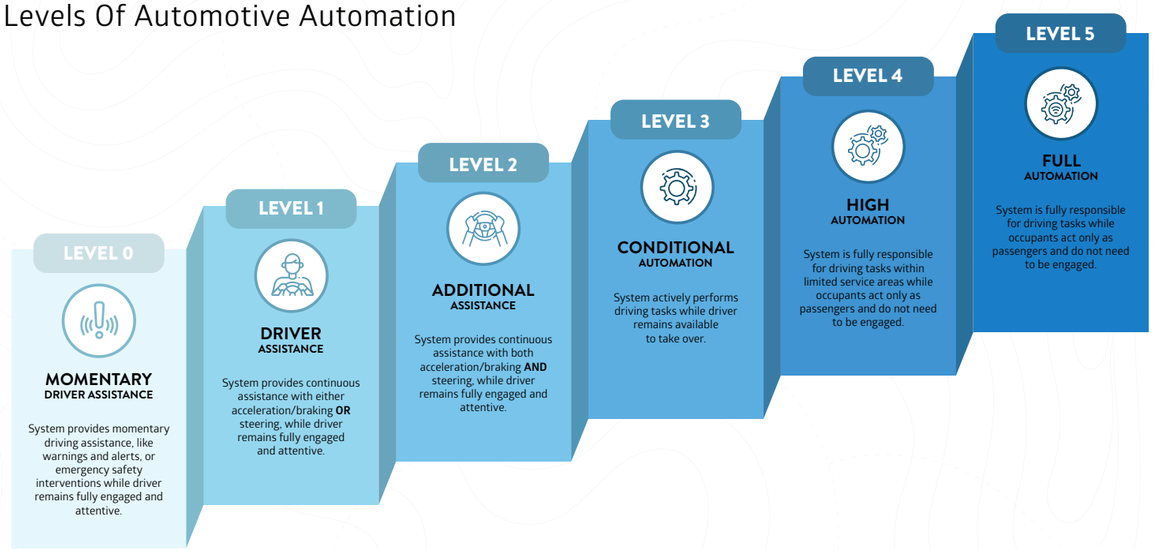
Cowen believes that autonomous aircraft will be in a trial period over the next decade as manufacturers work with regulators like the U.S. Federal Aviation Administration to develop rules and regulations for autonomous flight. The 2030s will be about developing aircraft. We believe the size of these aircraft will grow over time (from four passengers, to 19, to 30, and eventually 100) and from one pilot to zero pilots.

Hydrogen

Cowen believes that hydrogen powered vehicles will see the most success in heavy duty applications given range and weight advantages versus batteries, and faster refueling times. The maturation of hydrogen fuel cell technology and orders in heavy-duty/high horsepower engines, forklifts, and stationary power has accelerated investor interest. We are seeing strong momentum in the commercial trucking space given a similar total cost of ownership for operators looking to transition from diesel. Additionally, fuel cell material handling companies have demonstrated the value proposition of fuel cells for use in the forklift market. Customers such as Amazon, Walmart, and Home Depot and are pivoting to other applications.

In the U.S., the Inflation Reduction Act is the largest near-term driver of demand for the sector, enabling green hydrogen to be cost competitive with gray hydrogen (which is derived from natural gas and produced from fossil fuels) on qualifying projects through investment and production tax credits. Additionally, the Bipartisan Infrastructure Law in the

Levels Of Automotive Automation



Source: United States Department of Transportation, Cowen and Company

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Transportation OEMs & Technology

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United States includes $8.0 billion for regional clean hydrogen hubs to create jobs to expand the use of clean hydrogen in the industrial sector and beyond. The law also provides $1.0 billion for a clean hydrogen electrolysis program to reduce costs of hydrogen produced from clean electricity, and $500 million for clean hydrogen manufacturing and recycling Initiatives to support equipment manufacturing and strong domestic supply chains.

Semiconductors

The auto industry's success or failure in delivering on electrification and autonomy will hinge on its ability to produce vehicles that can efficiently utilize energy and vast amounts of data. As a result, semiconductors (both traditional and compound semis) will play an even more critical role in almost all functional areas of modern automobiles, particularly in the locus of innovation: electrification and intelligence/automation.

Semiconductors can solve some of the most pressing needs of auto OEMs. For example, Silicon carbide is a critical enabling technology in auto inverters that allows longer range and more efficient batteries. Accelerated global adoption of EVs is already driving increased demand for high-power, energy-efficient compound semiconductors, including silicon carbide (SiC) and Gallium Nitride (GaN) based components.

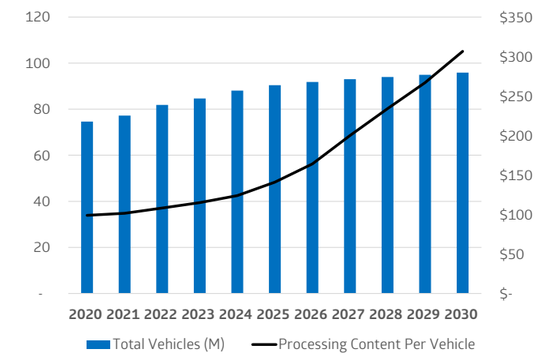
Cowen forecasts automotive semis revenue to more than double to $96 billion by the end of the decade, driven primarily by increased semiconductor content per vehicle. We forecast that total semiconductor content will increase from $108 per vehicle in 2022 to $307 per vehicle in 2030. Our forecast conservatively assumes nearly 45% of vehicles are still Level 0 (no automation) or Level 1 (hands on/shared control) in 2030, and that average annual selling prices decline 1-3% throughout the forecast period.

Policy

The transport sector is the fastest-growing contributor to climate change, accounting for 23% of global energy-related greenhouse gas emissions. Electric transport offers a solution for cutting millions of tons of greenhouse gas emissions per year, and curbing transport-related air and noise pollution. (It is noteworthy, however, that mining practices to obtain critical electric vehicle components such as lithium have come under increased scrutiny by ESG-focused investors.)

President Biden has set a goal of 50% of vehicles sold in 2030 being BEVs (battery electric vehicles), FCEVs (fuel cell electric vehicles), and PHEVs (plug-in hybrid electric vehicles). We believe the inflationary cost of batteries will linger for the next several years and will to lead to EV pricing above comparable ICE (internal combustion engine) vehicles at least through 2027. In the U.S., the $7,500 IRA tax credit is imperative to help narrow or close that gap for consumers. Policy will continue to have an important bearing on incentives, infrastructure development, and raw materials access.

Cowen Total Vehicle And Content Per Vehicle Forecast



Source: Cowen and Company

COWEN EVENTS

Cowen 15th Annual Global Transportation & Sustainable Mobility Conference
September 7-9. 2022

Cowen Next-Gen Fuel Summit: Renewable Diesel & SAF
June 16, 2022

Cowen 2nd Annual Sustainability & Energy Transition Summit
June 7-8, 2022

Cowen 50th Annual TMT Conference
June 1-2, 2022

Cowen 2nd Annual Mobility Disruption Conference
March 2-4, 2022

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Ongoing

Energy Transition Series
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Ongoing

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MOBILITY

THERAPEUTICS, TOOLS, & DIAGNOSTICS INNOVATION

COWEN RESEARCH THEMES 2023

"At the heart of many health care advances will be AI and synthetic biology – tools that are rapidly being adopted across biopharma to improve efficiency."

COWEN

In 2022, biopharma companies broke new ground in previously untreated diseases, advanced new targeted cancer agents into the clinic, and continued to show the potential of novel modalities. Simultaneously, diagnostic, artificial intelligence (AI), and synthetic biology tools continue to change the face of how and when therapies are used, discovered, and manufactured. Cowen predicts that 2023 will see a deluge of data, trial starts, and commercial milestones as companies, providers, and payors assess the potential of these breakthroughs and how best to use them.

Innovation in the biopharma sector often originates from small biotechs – preclinical to clinical development stage companies with large R&D budgets that are often unprofitable. Despite generally poor stock performance in 2022, innovation in the biotech industry has not slowed. For example, gene therapy technologies have progressed into second- and even third-generation products such as gene editing, base editing, and prime editing. RNA (ribonucleic acid)-based technologies are expanding into large diseases from their initial rare disease focus. Entirely new mechanisms such as psychedelics, protein degradation, and synthetic biology approaches are only just emerging. And in autoimmune diseases, a new class of agents that would remove pathogenic autoantibodies from circulation is starting to make its mark. Cowen believes that this class, known as FcRn inhibitors (based on the regions they bind to on antibodies), is poised to capture 10–15 indications and post >$10B in global sales.

Pharma companies continue to face calls to lower drug prices. In August, Congress passed the Inflation Reduction Act (IRA), which targets drug cost savings of $288 billion over 10 years. Cowen's analysis suggests that the impact of the IRA on pharma companies will be manageable, and our annual drug pricing survey of payers found that there is general uncertainty that the negotiation provision in the IRA will result in lower drug prices. In the meantime, new agents for Alzheimer's disease are on the radar for pharma companies in 2023 and innovative new diabetes and obesity drugs are starting to achieve success.

On the diagnostic front, Cowen has been tracking the emerging field of liquid biopsy – the ability to detect small traces of cancer in blood rather than relying on tissue samples – for nearly a decade. We find significant momentum within select segments of the liquid biopsy market with the use of minimal residual disease (MRD) monitoring to detect trace amounts of cancer DNA in patients with solid tumors after tumor removal or therapeutic intervention. With a projected market size of >$13 billion by 2027, there are multiple companies and products poised to capture share in the coming years.

At the heart of many health care advances will be AI and synthetic biology – tools that are rapidly being adopted across biopharma to improve efficiency. With >$60 billion invested since the start of 2021, there are multiple AI tool providers that offer differentiated platforms, as well as established and startup biotechs that are building an internal AI foundation from which to launch drug discovery and development efforts. Synthetic biology encompasses a wide range of applications including active living organisms that impart a biological benefit, such as cell and gene therapies, antimicrobial agents, or therapeutic antibodies. Much like AI, SynBio tools hold the potential to make R&D platforms competitive by enabling higher technical success with less infrastructure use. As R&D costs decline, companies can "fail early," test more prototypes in parallel, and more quickly iterate back to design through prototyping. While SynBio companies span myriad sectors, we've seen the greatest financing activity centered around biopharma, with 77 funding deals approaching $8 billion in 2021 alone.

WHAT WE'RE WATCHING

Targeted Oncology

The ability of scientists to finally elucidate inhibitors of KRAS (rat sarcoma virus – a prominently mutated protein in myriad cancers) after decades of research unleashed a wave of small molecule drugs in the clinic, with the KRAS G12C inhibitor Lumakras (sotorasib)

RAS Inhibitor Combination Approaches To Stave Off Or Tamp Down Resistance

	UPSTREAM			DOWNSTREAM		OTHER				
COMPANY	RTK	SHP2	SOS1	RAF	MEK	PI3K4	MTOR	CDK4/6	PD1/PD-L1	CHEMOTHERAPY
Amgen	✓	✓			✓		✓	✓	✓	✓
Lumakras (sotorasib, AMGN 501)	Afatinib (EGFR); Panitumumab (EGFR), Bevacizumab (VEGFR)	RMC-4630, TN0155			Trametinib		Everolimus	Palbociclib	AMG 404, Pembrolizumab, Atezolizumab	Carboplatin, Pemetraxed, Docetaxel
Mirati	✓	✓	✓					✓	✓	
Adagrasib	Cetuximab (EGFR), Afatinib (EGFR)	TN0155	BI 170963					Palbociclib	Pembrolizumab	
Roche	✓	✓							✓	
GDC-6036	Cetuximab (EGFR), Bevacizumab (EGFR), Erlotinib (EGFR)	GDC-1971							Atezolizumab	

Source: ClinicalTrials.gov, Cowen and Company

from Amgen approved in 2021, and adagrasib from Mirati anticipated by the end of 2022. While both will be available for second-line non-small cell lung cancer (NSCLC)—meaning patients with metastatic disease whose cancer has progressed after initial treatment—we view the bigger opportunities for both programs to lie in first-line metastatic NSCLC and to a lesser extent in gastrointestinal cancers like colorectal (particularly for adagrasib, which has shown differentiated efficacy relative to Lumakras). For adagrasib, we will be watching for combinations with first-line lung cancer standard of care Keytruda (pembrolizumab) and second-line metastatic colorectal standard of care cetuximab. For Lumakras, we are watching for an update for the monotherapy study in lung cancer patients who don't respond as well to Keytruda, as well as combination data with cancer immunotherapies in first-line NSCLC and in third-line CRC with Amgen's Vectibix (panitumumab).

Naturally, as these agents have progressed in clinical trials, resistance mutations against KRAS inhibition have developed, giving rise to combination strategies as well as alternative means to target KRAS. On the combination front, both Amgen and Mirati, as well as Roche (which has a KRAS inhibitor, GDC-6036, in Phase 1) are testing various combination approaches, with many seeking to tamp down other targets also located in the same pathway as RAS. The theory is that if RAS is turned back on by a mutation, the pathway could be shut down by also inhibiting a protein upstream or downstream to essentially turn off as many activation steps in the pathway as possible. Companies are also trying methods to shut down other potentially active pathways that may remain active even in the presence of RAS inhibition. The most anticipated combination data for programs in 2023 include: combinations of RAS inhibitors with chemotherapy, inhibitors of epidermal growth factor (EGFR), and programmed cell death ligand-1 (PD1/PD-L1) – all which are not in the RAS pathway but are part of standard-of-care regimens; as well as combinations with SHP2 and SOS, both of which lie upstream of RAS.

Additionally, several companies are testing an alternative means to block KRAS, which allows cancer cells to proliferate by cycling between their "on" and "off" states. Lumakras and adagrasib lock KRAS in its "off" state, while companies such as Revolution

THERAPEUTICS, TOOLS & DIAGNOSTICS

Medicines and Frontier Medicines are developing candidates that lock KRAS in its "on" state. Clinical data for Revolution's G12D KRAS-ON and multi-RAS inhibitors are expected in 2023.

Epigenetics

Epigenetics are reversible changes that regulate gene expression, often due to DNA modifications. These changes can occur via the addition of methyl groups to key proteins such as transcription factors – the proteins that are responsible for transcribing DNA into RNA. In oncology, methylation of tumor suppressor genes inactivates them, driving cancer cell growth. Protein arginine methyltransferases (PRMTs) are enzymes implicated in this aberrant methylation in some cancer types, with PRMT5 being a key factor in solid tumors, including glioblastoma multiforme (GBM), bladder, and pancreatic cancers. A key limitation among first-generation PRMT5 inhibitors was a lack of selectivity between tumor and healthy cells, resulting in toxicity at doses that showed lackluster efficacy.

Companies such as Amgen, Tango, and Mirati are developing more selective PRMT5 inhibitors that preferentially target a vulnerability specific to tumor cells – MTA (methylthiaoadenosine) – which accumulates in certain cancers. MTA-cooperative inhibitors essentially "glue" MTA to PRMT5, keeping it bound. This new generation of inhibitors selectively inhibits PRMT5 in MTAP-null tumor cells where MTA is accumulating, thereby preserving PRMT5 function in normal cells. This increased selectivity results in a potentially larger therapeutic window (e.g., the amount of active drug that can be given to elicit the greatest potential benefit with tolerable side effects). All three MTA cooperative candidates—AMG 193, MRTX1791, and TNG908—are in the clinic and could have data in 2023, starting with TNG908 with Phase 1 data in 1H23. These results will provide the first benchmark for evaluating the potential of MTA-cooperative inhibitors in MTAP-null solid tumors.

Psychedelics

Psychedelics, which encompass the universe of classic hallucinogens and agents that produce psychedelic-like effects, are emerging as a potential new treatment option for certain conditions. We believe the renewed interest in psychedelics, the growing body of clinical evidence, and signs of regulatory flexibility to bring psychedelics to patients present a significant investment opportunity. We saw multiple positive readouts for Phase 2 studies of psychedelic agents in 2022, and in 2023, some of these companies will be kicking off their pivotal Phase 3 studies to support registration. We will be watching the start of two Phase 3 trials for Compass's COMP-360 (crystalline formulation of psilocybin) for treatment-resistant depression (TRD) by YE22. Top-line data from the first trial are expected by YE24 and the other by mid-2025.

Additionally, GH-001, a formulation of 5-MeO-DMT administered via a proprietary inhalation approach, is expected to see a Phase 2b trial start in 4Q22/1Q23 to treat TRD, and a Phase 1 imaging study is planned in 1Q23. We are also watching for other trial starts of different 5-MeO-DMT formulations as well as top-line Phase 2a data for PCN-101 in TRD from Perception Neurosciences/atai.

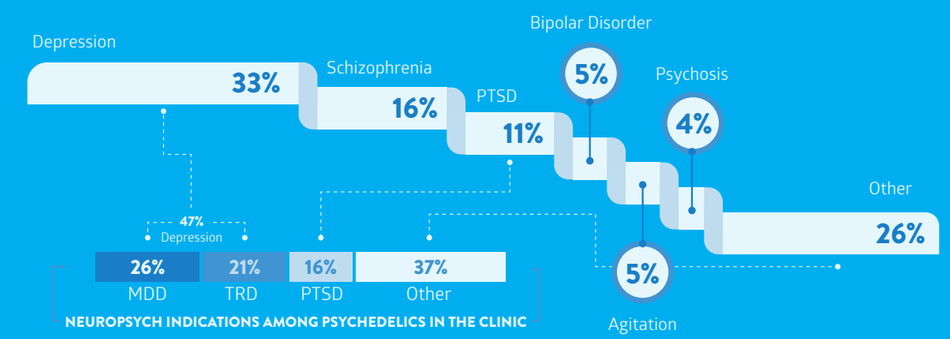
Targeted Protein Degradation (TPD)

TPD takes advantage of existing cellular machinery to tag problematic proteins for disposal. It offers several advantages over traditional small molecule drugs and could dramatically expand the target space to the roughly 85% of proteins implicated in disease biology that cannot be accessed with small molecule drugs. There are two classes of TPD molecules: heterobifunctional protein degraders and molecular glue degraders. The former is further along in the clinic. Arvinas pioneered the TPD space, with reported safety profiles to date for ARV-471 and bavdegalutamide that are consistent – if not improved – with those of existing and competitive therapies. Both agents are also able to achieve compelling levels of activity in highly refractory advanced cancer patients. A pivotal trial for ARV-471 in second-/third-line metastatic ER+/HER2- breast cancer is expected to start by year end, potentially positioning it to become the first FDA-approved heterobifunctional degrader should the trial succeed.

SNAPSHOT: MEDICAL INNOVATION IS EXPANDING TO MORE PATIENTS & MORE MODALITIES

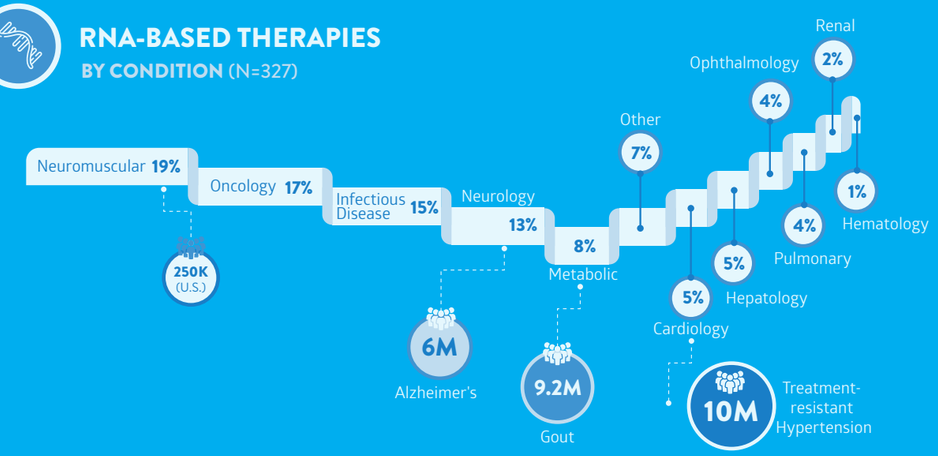
NEUROPSYCH THERAPEUTIC CANDIDATES

BY DISEASE (N=260)



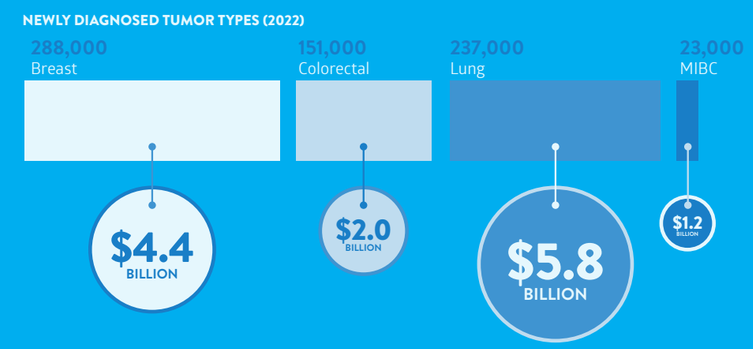
RNA-BASED THERAPIES

BY CONDITION (N=327)



MINIMAL RESIDUAL DISEASE

MONITORING IN SOLID TUMORS



Source: SEER Database, Cowen and Company

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Other companies developing heterobifunctional degraders include C4 Therapeutics, Kymera, Foghorn, and Nurix. All four companies anticipate early clinical data readouts over the next year, as well as a few trial starts and new candidates entering the clinic. Monte Rosa is the only molecular glue-focused public TPD company, using its AI-driven QuEEN platform. There are four candidates from Monte Rosa that we are watching over the next several months, including the company's lead molecular glue candidate MRT-2359, for which we anticipate Phase I dosing to start shortly. We also expect investigational new drug application (IND) submissions from three other declared programs targeting inflammatory diseases, oncology, and hematologic malignancies in the years to come.

MRD Monitoring

As new targeted oncology agents advance, diagnostic companies are making progress on blood-based assays to measure the earliest signs of cancer recurrence. MRD tests that rely on circulating tumor DNA (ctDNA) are gaining ground, with first-mover Natera garnering reimbursement decisions across multiple tumor types, including colorectal cancer, and immunotherapy response monitoring for its Signatera test. Signatera uses a tumor-informed approach, which means that it first relies on obtaining a sample of the patient's tumor from which it establishes a personalized panel of tumor markers. Signatera then screens the patient's blood sample against the panel to detect cancer recurrence at predefined intervals over the course of three to five years. Alternatively, Guardant Health's Reveal MRD test is tumor-agnostic, using an established panel of markers against which it screens the patient's blood over a similar period of time. The Guardant test has obtained Medicare reimbursement approval in colorectal cancer.

We are watching several milestones related to additional reimbursement coverage for the Signatera platform, including the first commercial payer coverage win for Signatera in 2023 as well as data readouts in CRC, breast, and bladder cancer, which are anticipated over the next few years. In our discussions, key opinion leaders in this field have been particularly bullish on the potential for serial MRD testing to monitor for cancer recurrence and treatment response in CRC, as well as certain high-risk breast cancers such as triple-negative breast cancer (TNBC) and bladder cancer.

For Guardant, over the next few years, we are awaiting multiple study readouts in CRC as well as a study in early-stage cancers. Over that time frame, we will also be watching for a Medicare coverage decision for Guardant Reveal in breast and/or lung cancer indications. We anticipate new entrants to the MRD space in 2023, including Personalis, Myriad, and Grail, and will be watching the uptake of Twist's low-cost MRD Rapid Custom 500 panel, which was launched in 2022. We anticipate potential adoption from academic/university hospital labs and reference labs in 1H23 as well as possible use of the panel in clinical utilities studies in late 2023 and beyond.

FDA guidance related to the use of ctDNA as a surrogate endpoint in clinical trials is on our radar. This presents upside to MRD use in clinical trials among biopharma companies seeking to expedite development of new cancer drugs. Any movement on the VALID Act during the "lame duck" session in Congress would also be meaningful for MRD and diagnostic companies broadly, as it would provide regulatory oversight of laboratory-developed diagnostic tests.

Alzheimer's Disease

A decision this year from the U.S. Centers for Medicare & Medicaid Services (CMS) restricted coverage of Biogen's Alzheimer's drug Aduhelm to clinical trial participants. Since that decision, Biogen and Eisai have reported positive Phase 3 data for lecanemab. Like Aduhelm, lecanemab targets amyloid-beta, the hallmark protein involved in Alzheimer's pathology. The top-line data from lecanemab's CLARITY-AD trial released by Biogen/Eisai show a statistically significant reduction in clinical decline on the trial's primary endpoint and also achieved all key secondary endpoints, marking a watershed moment for the Alzheimer's field. CLARITY-AD served as the first definitive proof that reducing beta amyloid can slow the progression of Alzheimer's disease. Clinicians at Cowen's October 2022 Therapeutics Conference believe that lecanemab will be meaningful to patients

and that the low rates of cerebral edema relative to Aduhelm provide a differentiated benefit for lecanemab.

Key milestones in 2023 include an FDA decision on accelerated approval as well as CMS's decision regarding reimbursement of lecanemab. Eisai plans to file the results of CLARITY-AD with regulators in the U.S., EU and Japan in 1Q23. CMS's previously published national coverage determination (NCD) stated that beta amyloid antibodies, approved due to direct evidence of clinical benefit, could receive coverage under comparative studies which may include registries. We believe lecanemab would meet the criteria for coverage so long as patients are enrolled in registries, a lower barrier to access than that for Aduhelm.

By the end of 2022, we expect a potential FDA accelerated approval decision for Lilly's donanemab. Donanemab met its primary endpoint in the Phase 2 TRAILBLAZER-ALZ study, and the company has completed the rolling submission for approval. The clinician panel at Cowen's Therapeutics Conference were optimistic that donanemab would be successful based on the already positive Phase 2 results.

Agitation (clinical restlessness or worry) in Alzheimer's is considered a significant unmet need, with 70-80% of Alzheimer's patients affected. Here, we could see data by year end for Axsome's AXS-05, which already reported positive Phase 2/3 results in 2020. Physicians on our Therapeutics Conference panel were optimistic the trial would be successful.

Diabetes And Obesity

We continue to view the diabetes and obesity markets as opportunities for growth. Lilly launched its new drug Mounjaro (tirzepatide) in 2022, which demonstrated robust efficacy in Type 2 diabetes, and key opinion leaders believe tirzepatide will be used as a first-line injectable in diabetes patients. At Cowen's 2022 Therapeutics Conference, KOLs claimed they had not encountered any problems with reimbursement for Mounjaro (this is likely aided by the commercial co-pay card, which covers up to 12 refills for patients with commercial insurance but no coverage for Mounjaro). These opinion leaders were also optimistic that Novo's Cagrisema could show comparable results to Mounjaro in its Phase 3 trials assuming the company replicates what was seen in Phase 2. Novo plans to start Phase 3 trials in obesity by the end of this year, and in diabetes in 2023.

Mounjaro has also demonstrated best-in-class weight loss (21% at the highest dose) in the SURMOUNT-1 clinical program, with regulatory filings planned post the successful completion of SURMOUNT-2 in April 2023. Clinicians at our Therapeutics Conference were excited about the efficacy of Mounjaro in obesity, and Lilly management sees significant opportunity in obesity given the success of Novo's Wegovy and Mounjaro's superior weight loss profile. By the end of this year, Amgen will release Phase 1 data for AMG 133, a novel antibody that may offer less frequent dosing than approved options.

RNA Therapies

We anticipate multiple new drug approvals for RNA therapeutics, with several expected to exceed $1 billion in annual revenue by 2030.

Key milestones for marketed RNA therapeutics include a likely FDA filing to expand the label of Alnylam's Patisiran to include a rare cardiovascular condition, as well as data for Alnylam's Amvuttra (vutrisiran) HELIOS-A extension study for biannual dosing to treat hATTR amyloidosis (a rare inherited condition that leads to a build-up of amyloid around organs). Alnylam has also pivoted its corporate R&D focus to larger indications, with programs in hypertension, Alzheimer's, gout, and non-alcoholic steatohepatitis (NASH). We expect top-line results from a Phase 1 trial in early-onset Alzheimer's in late 2022, and Phase 2 data from trials of zilebesiran in hypertension in mid-2023.

We anticipate Phase 2 data in 1H23 for another early RNA pioneer, Sarepta, with its next-generation Exondys agent: SRP-5051. The candidate is being evaluated in patients with Duchenne muscular dystrophy (DMD) who are amenable to exon 51 skipping, and uses Sarepta's proprietary peptide phosphorodiamidate morpholino oligomers (PPMO).

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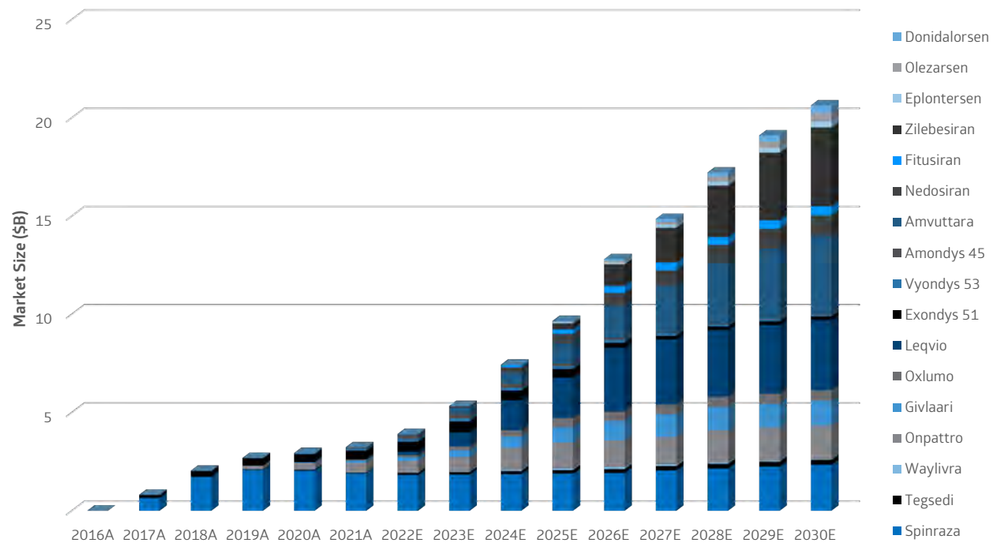
The PPMO technology is designed to increase tissue penetration compared to earlier-generation molecules. We are watching for trial starts and first-in-human data from emerging platforms, including data from Entrada's ENTR-601-44 to treat (DMD)-amenable to exon 44 skipping, and the submission of an IND for Entrada's myotonic dystrophy 1 (DM1) candidate, both anticipated in 2023. Avidity is also expected to have its third candidate in the clinic, AOC 1044 for exon 44-deleted DMD, by the end of this year, and we anticipate data from its antibody oligonucleotide conjugate (AOC) platform as early as year end. The AOC platform is designed to overcome some of the challenges that have beset first-generation RNA platforms, enabling tissue-specific delivery and a wider range of diseases to target.

Geographic Atrophy

We anticipate the availability of at least one new agent to treat geographic atrophy (GA) in Apellis's

Multiple RNA Drug Approvals Anticipated, Several With Expected >$1 Billion Yearly Revenue



Source: Cowen and Company

pegcetacoplan. GA is a large potential market for which nothing has been approved to date. Cowen's survey of retinal specialists and payers suggested that pegcetacoplan could be used by 29% of diagnosed GA patients within three years of launch. Our 2027 U.S. pegcetacoplan GA sales estimate of $1.4B assumes 10% penetration of diagnosed U.S. GA patients, implying that there could be meaningful upside should our consultants' predictions prove accurate.

Additionally, Iveric Bio's Zimura has achieved statistical significance in its second pivotal study in geographic atrophy (GATHER2), with a 1Q23 planned submission to the U.S. Food and Drug Administration. At Cowen's Therapeutics Conference, ophthalmologists on our panel were encouraged by Zimura's clean safety profile, citing a lack of inflammation, ischemic optic neuropathy, and endophthalmitis. They also believe that the market can easily support two products.

FcRns

The neonatal Fc receptor (FcRn) is a protein that is present in the placenta, where it transports maternal immunoglobulin G (IgG) to the growing fetus. First-in-class FcRn inhibitor Vyvgart from Argenxy is in its first full year on the market to treat myasthenia gravis (MG) and is thus far beating consensus sales estimates. We anticipate three Phase 3 readouts in 2023, including a rare but chronic autoimmune disorder in which the body's immune system attacks the myelin that insulates nerves (CIDP), as well as in pemphigus (PF) and immune thrombocytopenia (ITP), other autoimmune disorders in which the immune system attacks select healthy cells. There are several other FcRn inhibitors in the clinic with key data readouts anticipated in 2023, including Immunovant's batoclimab (Phase 2), followed by top-line results in myasthenia gravis and initial results in CIDP in 2024. We could also see Phase 3 data for JNJ's nipocalimab in MG by 2024 and a possible FDA approval of UCB's rozanolixizumab in MG in 2H23.

Synthetic Biology

The SynBio industry is rapidly unfolding, with current products impacting many end markets, akin to the early days of Internet and mobile computing adoption. Cowen anticipates 2023 funding for SynBio startups to be materially higher than in 2022 and nearer to the record $18B invested in 2021. We also expect to see more SynBio products in development pipelines and commercial launches across many industry verticals, including therapeutics, AgBio, industrials, food, beauty, textiles and apparel, and life science tools and diagnostics.

Artificial Intelligence

Where AI underpins company pipelines, we are watching Relay Therapeutics – a leading AI drug discovery company with a fully integrated platform known as Dynamo. Dynamo relies on AI, Anton supercomputer, proteomic modeling, molecular dynamic simulation, and numerous other in silico and wet lab capabilities to develop drugs for otherwise "undruggable" targets. RLY-4008, the only selective fibroblast growth factor receptor 2 (FGFR2) mutant inhibitor, has validated the platform by offering robust data in FGFR2 amplifications for cholangiocarcinoma (CCA). In 1H23, we expect the full dose escalation data for RLY-4008 in CCA, and in 2023, we expect early RLY-4008 data from non-CCA, solid tumor cohorts, as well as Phase 1 data for RLY-2608 for breast cancer. In 4Q23/1Q24, we expect initiation of Phase 1 trials for a novel CDK2 (cyclin-dependent kinase 2) inhibitor.

We will be watching for partnership wins at AI tool providers such as Absci and 23andMe to provide insight into how the broader biopharma community is embracing AI. Absci has built an "integrated drug creation platform" that leverages synthetic biology technologies, proprietary functional assays and data-driven deep learning computational models to discover next-generation biologic drug candidates and design optimized production cell lines in parallel. The company announced two validating partnerships in 2022. We will continue to monitor for future partnerships and how existing collaborations advance. 23andMe is a genetics-focused health care company that pioneered direct-to-consumer genetic testing, with roughly 80% of users also opting in to allow use of their data for research. The company has a collaboration with GSK that has resulted in the identification of 50+ new targets. The first therapeutic from the agreement, GSK-608, is in Phase 1 and Phase 2 oncology studies. The exclusivity term of the GSK partnership is expected to end in mid-2023, opening the door for collaborations with other pharma and biotech partners.

COWEN EVENTS

Cowen 25th Annual Therapeutics & MedTools Conference
October 11–12, 2022

Cowen 2nd Annual Novel Mechanisms In Neuropsychiatry Summit
September 19, 2022

Cowen RNA Therapeutics Summit
July 21, 2022

Cowen Tools/Dx Revolution
June 26–29, 2022

Cowen 7th Annual FutureHealth Conference
June 22–23, 2022

Cowen 3rd Annual Oncology Innovation Summit
June 2, 2022

Monkeypox Vaccines And Therapeutics Webinars With BAVA, CMRX, EBS And SIGA
May 25, 2022 and August 16, 2022

Cowen 42nd Annual Health Care Conference
March 7–9, 2022

Cowen 2nd Annual Genetic Medicines Summit
February 3, 2022

Hot Wheels
August 9–11, 2022

Cool Wheels
January 17–19, 2022

THERAPEUTICS, TOOLS & DIAGNOSTICS

TECHNOLOGY INNOVATION

COWEN RESEARCH THEMES 2023

"Cowen sees significant potential for disruptive growth and innovation in quantum computing, compound semis, customer data platforms, data-driven drug discovery, and web 3.0 payments solutions."

COWEN

For decades, "FAANG" stocks, representing shares of Facebook (Meta), Amazon, Apple, Netflix, and Google (Alphabet), played an outsized role in public markets and in the daily lives of billions of people. Many of these and similar companies have recently seen their business models come under stress, and governments seem increasingly poised to challenge their reach and impact, whether through legislation, regulation, or litigation. The U.S. House of Representatives, for example, increased the antitrust resources of the Department of Justice and Federal Trade Commission by as much as 40% in anticipation of bipartisan engagement with Big Tech.

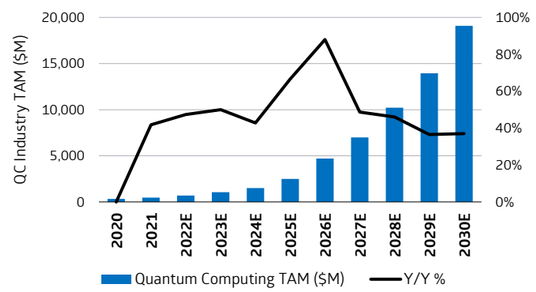
Cowen is anticipating a new wave of technology companies, in part arising from: growing security concerns amidst a changing geopolitical landscape; increased urgency to develop clean energy applications; shifts to demographics more apt to embrace virtual interactions and digital representations; and a heightened focus on delivery of personalized experiences while respecting consumer privacy. Examples include the potential of quantum computing, compound semiconductors, an evolving metaverse, and novel customer data platforms.

WHAT WE'RE WATCHING

Quantum Computing

Quantum computing, which began to be researched in earnest beginning in the 1980s, leverages the principles of quantum theory, which explains the behavior of energy and material on atomic and subatomic levels. The theory is that quantum bits (or "qubits") allow these subatomic particles to exist in more than one state at the same time and allow them to perform calculations that might otherwise take an enormous amount of time. The 2022 Nobel Prize in Physics was awarded to three scientists for work that has "laid the foundation for a new era in quantum technology," according to the Nobel Committee for Physics, which noted that "being able to manipulate and manage quantum states and all their layers of properties gives us access to tools with unexpected potential." As a starting point, the development of quantum computers, networks, and secure encrypted information transfer are in industry sights as development accelerates in earnest to uncover and commercialize applications that could stem from this science. Because of its potential cybersecurity applications, mastery of quantum technology is increasingly viewed as critical to sovereign security.

Quantum Computing Industry Total Addressable Market



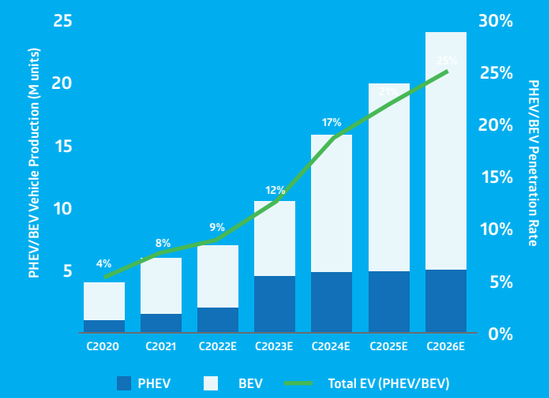
Source: Cowen and Company

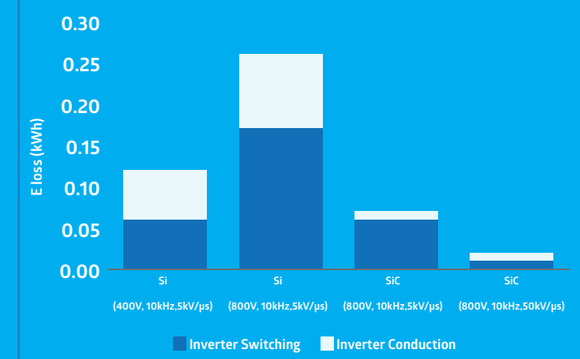
While still in its commercial infancy, Cowen expects quantum computing to grow at a 50% CAGR, from an estimated low base of $475 million in 2021 to about $2.5 billion in 2025, reaching a TAM of $19 billion by 2030. This is predicated on continued hardware infrastructure buildout, availability of enabling enterprise software products, and meaningful adoption of Quantum Computing as a Service (QCaaS) offerings.

We estimate hardware accounts for 60-70% of industry revenues today, given heavy R&D and capex spend, but we expect this ratio will decline to 50% by 2030. We believe superconducting quantum systems will drive much of the hardware value in light of their relatively high cost ($3-5 million each). The competitive landscape is rapidly expanding, with different quantum computing modalities in development, and there is no dominant technology at this juncture.

SNAPSHOT: MULTIPLE MARKETS REQUIRING HIGH-VOLTAGE SEMIS ARE INFLECTING

AUTOMOTIVE





#of BEVs (M of units)

SiC Inverter Attach Rate	$MM	16.7	17.7	18.7	19.7	20.7
	42.5%	$3,495	$3,698	$3,900	$4,102	$4,305
	45.0%	$3,677	$3,890	$4,103	$4,317	$4,530
	47.5%	$3,858	$4,082	$4,306	$4,531	$4,755
	50.0%	$4,039	$4,275	$4,510	$4,745	$4,980
	52.5%	$4,221	$4,467	$4,713	$4,959	$5,205
			Bear Case	Base Case	Bull Case	

- EVs will drive the lion's share of growth in SiC devices – Cowen's forecast calls for EV adoption growing from **8% in 2021 to ~25% in 2026**, and SiC inverter adoption growing from **30% to 47.5%**
- Importantly, we estimate this level of EV adoption drives SiC wafer demand well above third-party estimates of capacity alone
- SiC devices, particularly on 800V platforms, reduce energy loss significantly and drive system-level cost savings by reducing the need for larger, bulkier passives
- We forecast the **automotive SiC device market to be ~$4.3B**, but an additional 1M BEVs could add $200M+ to the TAM

OTHER MARKETS

EV CHARGING STATIONS
SiC to improve energy conversion efficiency, leading to faster charging

SOLAR POWER
SiC and GaN to be important in the PV inverter, converting AC power to DC power

WIND TURBINES
Using SiC in the inverter would drive material cost savings and power efficiency

AVIATION
SiC in propulsion systems could reduce aircraft weight and lower fuel burn by 1-3%

DATACENTER POWER
GaN's efficient, faster switching and smaller form factor bring benefits to power-hungry AI accelerators

5G INFRASTRUCTURE
GaN on SiC delivers high frequency performance at better power efficiency for M-MIMO

Source: Company Reports, Cowen and Company

Ion traps (electric or magnetic fields used to capture charged particles) are seeing increasing industry adoption, and the coming years could also see material progress in technologies focused on photonics and cold/neutral atoms.

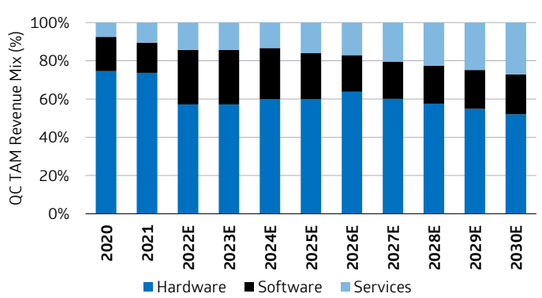
Compound Semiconductors

Efficient high-voltage power conversion and transmission are gating factors to clean energy adoption in multiple industries, including mobility, factory automation, and robotics. Cowen sees silicon-based power devices approaching the theoretical operating limits of power density as power demands continue to rise while combustible fossil fuels are de-emphasized. We believe wide bandgap compound semiconductors, Silicon Carbide (SiC) and Gallium Nitride (GaN), will help address the limitations of traditional power semiconductors, leveraging advantages in efficiency, size, and cost to capture and create value by accelerating use of myriad clean energy applications.

We expect the ongoing inflection in electric vehicle adoption alone to drive meaningful power semiconductor growth for at least the next decade. Current estimates indicate SiC usage can extend EV mileage ranges by 5-10%, and management commentary suggests net savings of $200-600 per EV through efficiencies in battery, space, and weight alongside reduced cooling requirements.

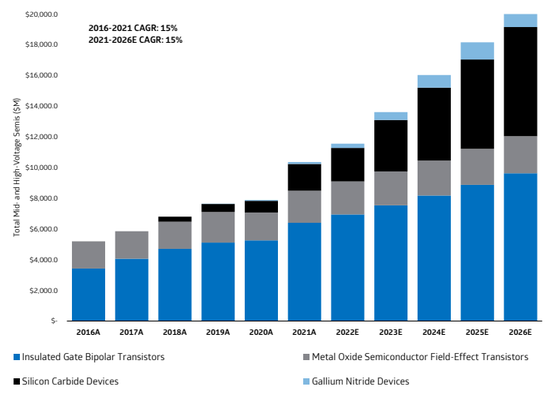
We project SiC materials and devices to generate revenues of $7.1 billion in 2026, advancing at a 34% CAGR, while GaN could drive revenues of $1.5 billion in 2026, growing at a 65% CAGR from a smaller base.

Quantum Computing TAM - Revenue Mix



Source: Cowen and Company

Mid- And High-Voltage Power Semis Are Forecasted To Grow At A 15% CAGR, On Pace With The Last 5 Years



Source: SIA, Yole Research, Cowen and Company

The Evolving Metaverse

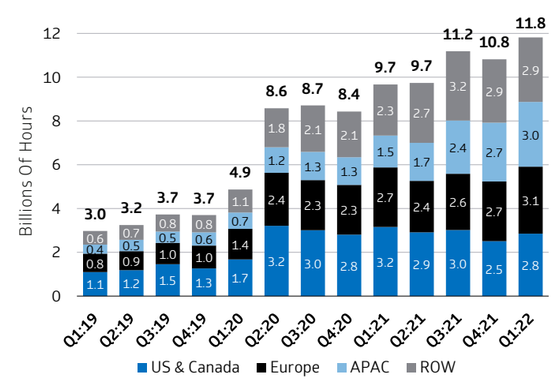
The "metaverse" refers to a virtual reality space in which users can interact with a computer-generated environment and other users. It is currently an area of keen media focus, company investment, and investor debate with many of today's leading technology giants and emerging upstarts identifying the metaverse as an area of future growth. This is perhaps best exemplified by Facebook's recent name change to Meta, with its controversial hopes of dominating a metaverse that the company claims will reach one billion people and "host hundreds of billions of dollars" in digital commerce over the next decade. Traditional media businesses are also considering the metaverse as a new platform for their IP, and retailers are intently exploring the metaverse as a potential new channel for sales of real and virtual goods.

Cowen believes the development of the metaverse represents a potentially important technology in commercial and societal terms, but we view realization of any meaningful manifestation of the metaverse as at least 10 years away.

User engagement on nascent platforms such as Roblox has shown undeniable growth on key metrics over the last three years. Roblox daily average users (DAUs) have grown 242% to nearly 60 million users, platform hours of engagement are up nearly 300% globally, and geographic reach now shows 75% of platform traffic emanating from outside North America. At the same time, certain of the critical attributes of the metaverse stand in conflict with entrenched business norms, and we believe resolution of these conflicts is one of several factors that will slow evolution of the metaverse, leading it to manifest further down the road than many companies and investors may imagine. For example, interoperability, a key pillar of any conception of the metaverse, is notoriously difficult and often undesirable for companies, who historically prefer to seek and maintain advantages with walled-off fiefdoms. It is tough to get companies to agree on a unified metaverse system when the advantages of owning such a system are so compellingly large. Illustrating this structural tension, we note that although a Metaverse Standards Forum was established earlier this year with participation from Microsoft and Meta, noticeably absent were metaverse proponents Apple, Google, and Roblox.

While the most obvious near-term use-cases in coming years are video games, where Meta competes through its Quest line of virtual reality (VR) gaming headsets, Meta has also set sights on a broad range of applications across social media, education, fitness, and business conferencing. Most recently, the company launched its Quest Pro VR headset, which targets professional users in the application of virtual workspaces.

Roblox Hours Of Engagement By Region



Source: Company reports and Cowen and Company

Roblox R&D And Infrastructure Trust & Safety Spend – Investing In The Metaverse; ($ Millions)

	FY18	FY19	FY20	FY21	FY22E
Research & Development	61.4	97.4	162.0	313.4	482.2
Infrastructure and Trust & Safety	102.5	154.6	256.8	421.2	584.8
Total	163.9	252.0	418.9	734.6	1,067.0
Y/Y Growth		53.8%	66.2%	75.4%	45.3%

Source: Company reports and Cowen and Company estimates

Meta management has emphasized that current hardware releases, such as the Quest 2 and Quest Pro headsets, are designed to bring users into the metaverse ecosystem rather than act as near-term profitability levers. For the first three quarters of 2022, Meta reported a $9.4 billion operating loss for its Facebook Reality Labs segment, which includes augmented and virtual reality related consumer hardware, software, and content. We estimate $21 billion+ in metaverse operating losses for 2023, significantly higher than the ~$15 billion loss run-rate coming out of 3Q22, moderating in 2025 as various metaverse applications come to fruition.

Customer Data Platforms

Customer Data Platforms (CDPs) are database-like systems that collect, process, and analyze vast amounts of unstructured data from digital customer interactions, representing the next evolution in the CRM (customer relationship management) marketing and customer engagement sector. These emerging platforms leverage artificial intelligence and machine learning to deliver real-time intelligence, rich personalization, and automation in a manner that also embraces consumer privacy expectations.

After years of incubation, we believe the CDP market is hitting a new inflection point. The COVID

TECHNOLOGY INNOVATION

> "We estimate an addressable market of over $65 billion when taking the broader ecosystem of marketing automation and product analytics into account."

pandemic was a major catalyst as consumers began interacting with businesses via digital channels at a much higher cadence. Last year's implementation of privacy protections, such as those requiring opt-ins for third-party cookies, are also a significant factor in motivating adoption.

We see the standalone market for CDP growing at a ~35% CAGR and expect it to reach ~$15 billion in 2026. Moreover, we estimate an addressable market of over $65 billion when taking the broader ecosystem of marketing automation and product analytics into account.

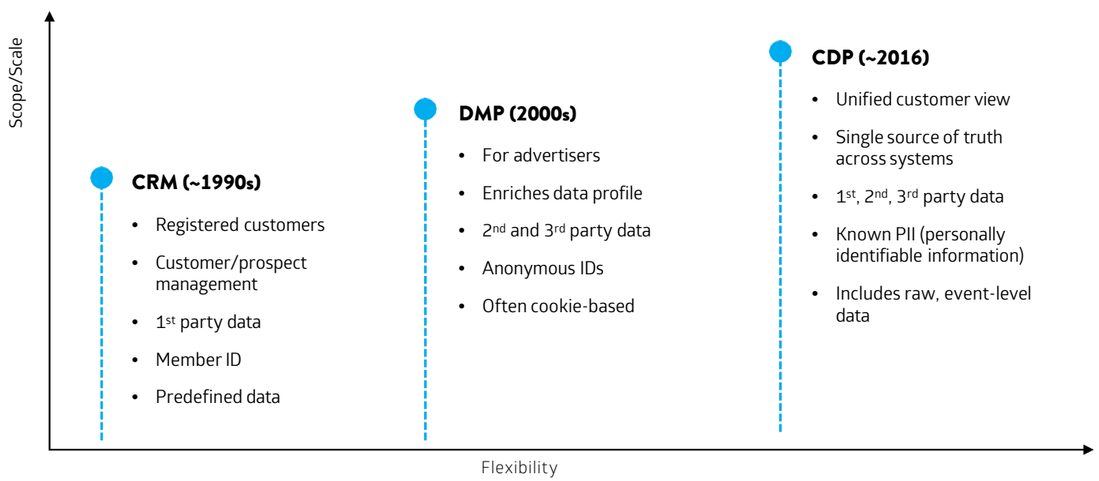
Data-Driven Drug Discovery

The biopharma industry has been investing in artificial intelligence technologies to aid target identification, drug design and clinical trial analytics efforts, and a March 2021 report issued by KPMG found that 82% of health care and life sciences executives sought more aggressive adoption of these technologies. CB Insights projects that health care AI venture funding will reach $9 billion this year. All the major biopharma companies have invested in emerging health care AI vendors.

Web 3.0

To date, blockchain architecture has limited crypto payments development. However, scaling solutions are developing and we view the Lightning Network and fiat-backed stablecoins as two underappreciated areas. Together we believe they hold the potential to position crypto as an increasingly viable rail in global payments. The addressable opportunity is significant as the global cross-border payments market will reach an estimated ~$156T in 2022 (5.1% 4-year CAGR) with total cross-border fee revenue of ~$290B, representing the fees and friction of the current cross-border payment system.

Invention Timelines Of CRMs, DMPs & CDPs



Source: Cowen and Company

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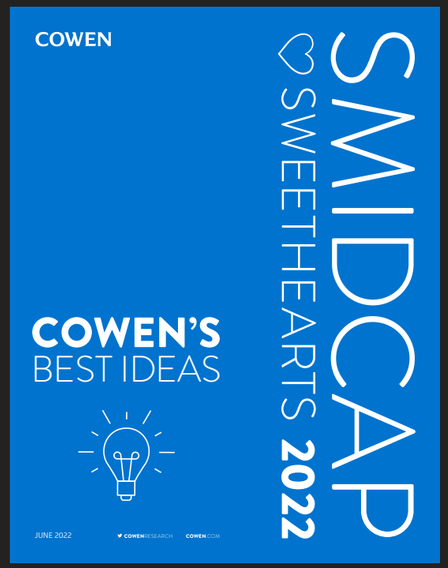
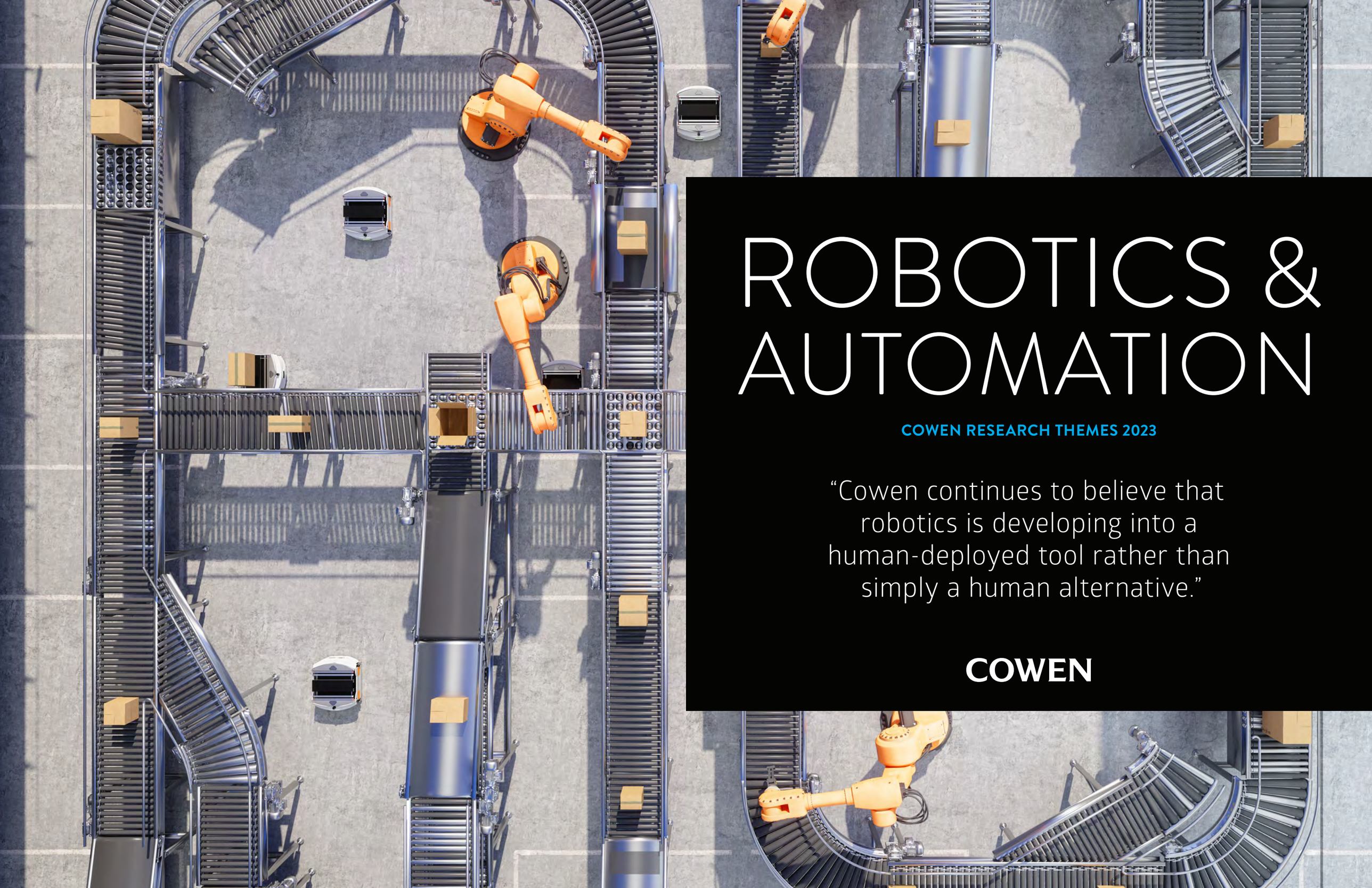
RELY ON COWEN'S BEST IDEAS THROUGHOUT THE YEAR





ROBOTICS & AUTOMATION

COWEN RESEARCH THEMES 2023

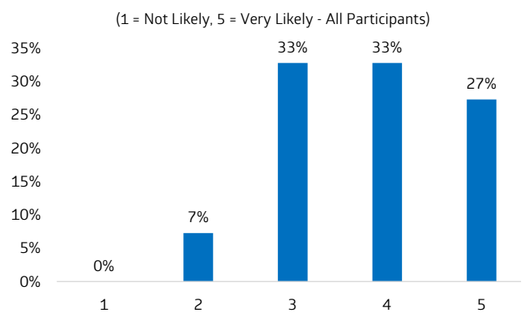
"Cowen continues to believe that robotics is developing into a human-deployed tool rather than simply a human alternative."

COWEN

Familiarity with robotics continues to increase, use cases broaden, and penetration deepens. Cyclical considerations matter. For example, logistics leaders such as Amazon are taking a breather after years of rapid expansion. However, solutions providers to the broader logistics ecosystem are in high demand, which indicates that the wider landscape is far behind the leaders and investing in closing the gap. Deployment decisions continue to evolve. Supporting growth has become more important, service-oriented models are now being accepted, and robotics are beginning to be thought of more holistically in terms of their impact on an entire organization.

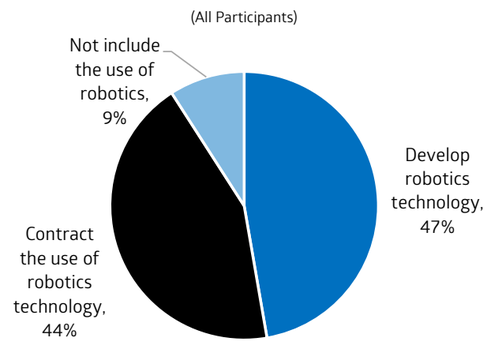
This shift coincides with a greater focus on ESG and sustainability. The practice of using robotics to meet climate goals has become increasingly pervasive, creating a potential long-term structural tailwind. Not only will robotic solutions providers have to fit within increasingly stringent supplier analyses (Scope 3 emissions, for example), but they will also have an opportunity to push customers' agendas forward as tools in the climate fight. History has shown that we are unlikely to dramatically alter consumption behavior (at least for now) to combat climate. We can, however, try to maximize output per unit of carbon, a concept Cowen explored earlier this year. In this emerging sector, Cowen continues to leverage its relationship with MassRobotics. In March,

How Likely Will Robotics & Automation Be Essential To Solving Key Climate Challenges?



Source: MassRobotics and Cowen and Company Robotic Survey, March 2022, n=55

In Order To Achieve Climate Change Objective, Your Company Will...



Source: MassRobotics and Cowen and Company Robotic Survey, March 2022, n=55

we partnered with MassRobotics to survey robot manufacturers and end users on how robotics can be used to address climate change targets. Of those surveyed, 91% indicated that they would develop or contract robotic technology to help achieve climate change targets. This compares to less than 50% who have deployed these solutions, suggestive of untapped growth potential. 75% of respondents expect current and potential future customers will discuss climate change as part of their relationship going forward.

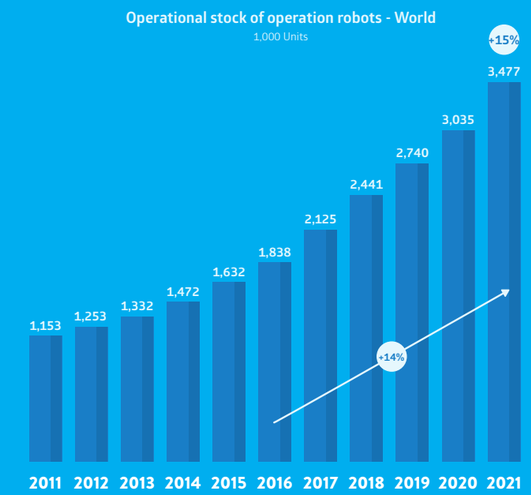
To understand how this relationship can work in practical terms, Cowen developed a model that can be used as a framework to understand how robotic solutions can impact climate discussions. Cowen estimated, for example, that using a single mobile robot solution within the fulfillment space and assuming penetration at 100% of the total addressable market would save, on average, 25% of UPS's 2020 carbon output and about 15% of Amazon's.

Exercises like these illustrate how the functional utility of robotics is expanding. Advances in sensing and dexterity have allowed humans and robots to work closer than ever before, a topic we explored in our research last year. Cowen continues to believe that robotics is developing into a human-deployed tool rather than simply a human alternative.

SNAPSHOT: MEGATRENDS ARE DRIVING ROBOTICS ADOPTION

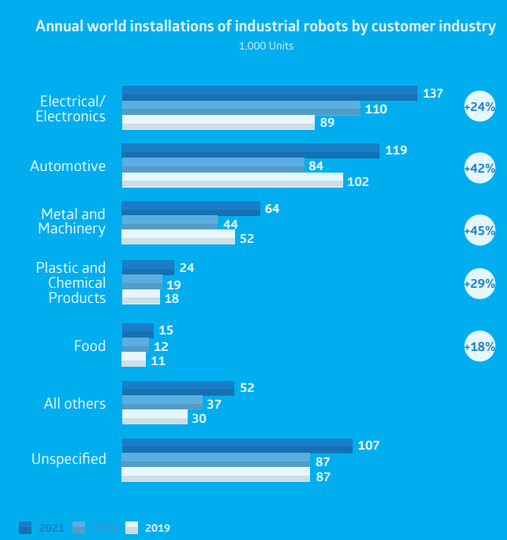
GROWTH TRAJECTORY OVERALL & BY INDUSTRY

3 millon industrial robots operating in factories around the world



Source: World Robotics 2022

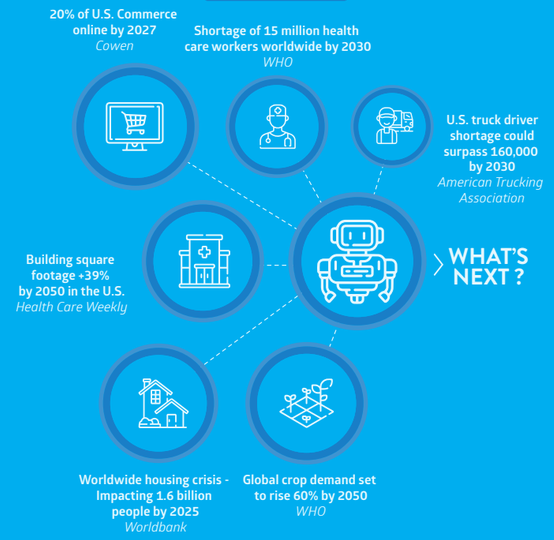
Electronics is a major customer of industrial robots



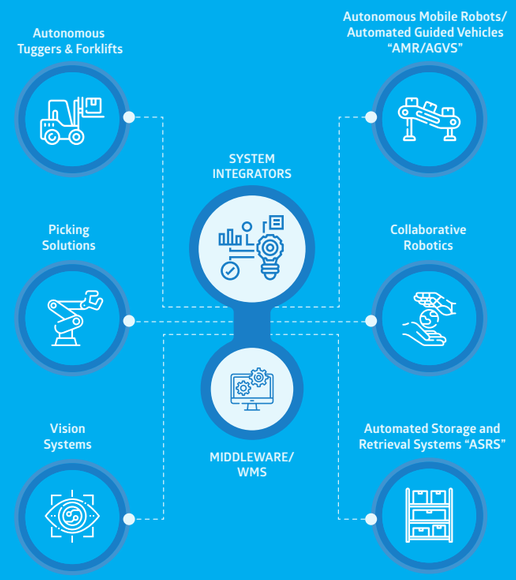
Source: International Federation of Robotics, Cowen and Company

LONG-TERM GROWTH TAILWINDS

Megatrends



ECOSYSTEM OVERVIEW



WHAT WE'RE WATCHING

Labor Trends

Persistent labor shortages have been a critical driver of robotics and automation adoption. Such shortages have only become more acute since COVID as approximately four million workers have left the labor force since the onset of the pandemic. By 2030, the number of people in the U.S. age 65+ will rise by approximately 17 million, up 30% since the last U.S. census count. Looking ahead, and notwithstanding the Fed's near-term policy aim of creating slack in the labor market, several factors suggest long-term structural labor market tightness. More specifically, Cowen believes that an aging population, lower birth rates, tighter immigration policy, and the push toward onshoring and regional supply chains are supportive of improving robotics and automation momentum.

Restaurant Automation

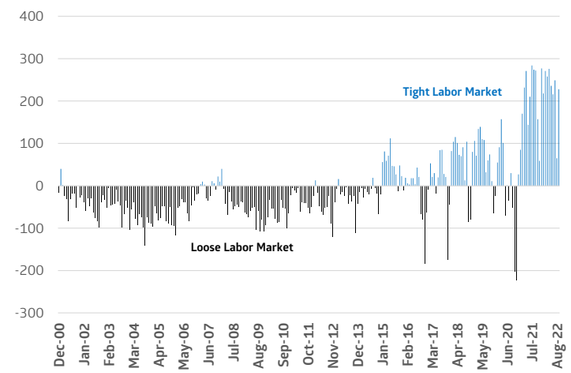
Cowen believes the adoption of robotics and automation technology in the restaurant industry is nearing a tipping point and that we will see broader industry adoption accelerate. Increased momentum is catalyzed by a tight labor market, emerging risks from unionization and California's FAST Act, improved functionality and pricing of new technologies, and post-COVID operator openness to digital adoption. Further, U.S. Federal legislation around immigration reform is unlikely, placing more of a need on automation.

Automation not only helps leverage labor and improve retention but also helps drive sales, with faster and more consistent service leading to higher throughput and the potential for a 10-15% sales lift through AI-driven suggestive upselling. Indeed, we believe that voice artificial intelligence, for phone-in orders and at the drive-thru, will scale faster than kitchen robotics given the ease of adopting software versus hardware.

Surgical Robotics

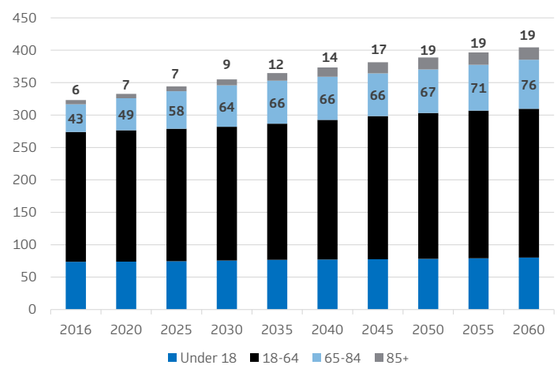
Despite advancements in robotic surgery technology, Cowen believes that the surgical robotics market remains significantly underpenetrated. Out of all the surgical procedures that could be addressed with current commercial robotic technologies, we estimate that only 3% are performed using robotic assistance. This highlights the limitations of current systems, including high-ticket capital equipment, expensive per-procedure disposable-instrumentation costs, and slower surgeons' workflows that can lead to procedural inefficiencies that drain valuable operating room time. We believe the market is set to change.

Warehouse And Transport Job Openings Minus Job Hires (Thousands)



Source: U.S. Bureau of Labor Statistics, Cowen and Company

Projected Age Groups Of The U.S. Population, 2016-2060 (Millions)



Source: U.S. Census Bureau, Cowen and Company

Next-generation platforms have taken learnings from incumbent robotic manufacturers and improved platform design to overcome these challenges. Next-generation robotic platforms combine advances in miniaturization, computer science and 3D visualization to produce a new category of intelligent yet more affordable robotic surgical systems.

We believe that future U.S. FDA (Food and Drug Administration) approvals for multiple surgical applications will unlock access, and that the general surgery robotics opportunity appears to be particularly ripe for disruption. Cowen expects advancements to drive greater robotic utilization among surgeons while also providing enhanced patient outcomes. In the general surgery market alone, next-generation robotic technology has the potential to address market opportunities approaching $150B. In the coming year, we will continue to track surgeon and administrator feedback, regulatory pathways, and indication expansion.

Retail

In retail, Cowen believes the value of automation is particularly high in online grocery, where businesses remain invested in finding strategic solutions to shore up their operational resiliency following the difficulties faced during the COVID pandemic.

The repetitive nature of online grocery fulfillment lends itself well to automated processes that are reliable and fast. For example, robotic technology company Autostore claims they can automate 90% of the grocery warehouse process, and that their picking robots can pick items seven times faster than humans.

Automation is also being used to address ESG and sustainability issues in retail, such as food waste, which, if assessed globally on an emissions basis, would equal the third largest emitting country. For example, online grocery robotics company Ocado leverages machine learning to monitor supply chain forecasts and adjust its orders with suppliers accordingly to minimize waste.

Robotic Process Automation (RPA) & Intelligent Automation (IA)

Cowen is bullish on the growth potential of RPA/IA, which we believe is in the early innings of secular growth momentum. An inflationary backdrop is

The Case For Broader Restaurant Automation Adoption

REVENUE GROWTH POTENTIAL

- Faster service, higher throughput
- AI-driven suggestive upselling (we estimate 10-15% ticket lift) and shared system-wide AI self-learning
- Supplemental labor
- Multiple language order processing (Spanish being important in the U.S.), already in place at ConverseNow, will likely become more prevalent

COST SAVINGS

- Longer-term potential to reduce labor costs
- Increased order reliability and consistency, which aides service times, reduces waste, and improves customer satisfaction
- Enhanced data access that can be used to improve restaurant operations

INCREASED PILOTING

- According to our roundtable, virtually every leading restaurant chain is exploring or testing voice AI for drive-thru and phone
- Once voice ordering becomes more mainstream at several large quick service restaurant chains, we would expect the remainder of the drive-thru industry to quickly adapt

OTHER BENEFITS & EFFICIENCIES

- Potential to remove less-desirable aspects of the job, improve morale, reduce turnover

BARRIERS TO ADOPTION HAVE DROPPED

- Post-COVID openness to digital adoption
- Improved technology & price points, quick payback periods

Source: Cowen and Company

ROBOTICS & AUTOMATION

> "Cowen's 2022 IT Services Spending Survey of enterprise software buyers highlighted strong growth potential for RPA software."

driving the need for greater cost efficiencies across organizations of all sizes. At the same time, a tight talent pool has helped spur automation demand. Process automation software is a key pillar of enterprise digital transformation initiatives, and the strategic prioritization of programs has been accelerated by COVID-19.

Automation software helps organizations automate business processes by utilizing software robots to assume human tasks and make them more reliable and efficient. Since the product is not confined to a single department or user base, RPA differs from most other enterprise software solutions. If properly planned, RPA can be utilized by a majority of knowledge workers within an organization. Additionally, automation platforms now offer low- or no-code capabilities, enabling users at all levels to quickly and easily create bespoke automation, data models, and apps for their businesses.

Looking ahead, we see significant growth potential in new AI-powered automation innovations. For example, advanced communications mining can extract unstructured content from various communications (e.g., emails, calls, chats, service tickets) and convert them into workable data used to train natural language processing (NLP) models. These models can enable no-touch routing, including answering common questions and handling requests automatically.

Cowen's 2022 IT Services Spending Survey of enterprise software buyers highlighted strong growth potential for RPA software. Of the buyers we surveyed, approximately half are still in the earliest stages of RPA usage or exploration, meaning significant growth opportunities exist. Expectations for spend confirm this, with 85% of buyers responding that they anticipate spending more on RPA over the next two to three years.

Businesses of all sizes are under pressure to seek out cost efficiencies to navigate persistent inflationary headwinds. RPA providers offer a suite of services that can unlock efficiencies to drive down costs and, in some areas, compensate for a tight labor market.

Defense

Numerous armed forces have ambitious plans to field fleets of unmanned and robotic systems. Some have already been put into use, while many of the most ambitious and ground-breaking programs remain under development.

One manifestation of these systems is a newer generation of drones called Collaborative Combat Aircraft – essentially unmanned wingmen for manned fighters. Ambitious and more capable ground and maritime drones and robotics have lagged (with some exceptions, of course). There are plans to purchase large fleets of systems, but for now, the focus is on building and experimenting with prototypes – both to improve the technology and understand how unmanned systems will be used in combat.

About four to five years ago, much of the U.S. Air Force's plans and concepts about future unmanned aerial vehicles (UAVs) became classified. We believe it's extremely likely that several kinds of next-gen UAVs are in development and likely flying.

The U.S. Army is experimenting with prototype "Robotic Combat Vehicles" that come in a variety of sizes. Field testing is underway to develop operations concepts and to set requirements for full-fledged acquisition programs, but those may not begin fielding until the mid- to late-2020s. Additionally, the Army is experimenting with various kinds of small- and medium-sized vertical takeoff and landing unmanned aircraft, including ones that are armed or lethal.

The U.S. Navy is experimenting with its first generation of unmanned ships and submarines that will operate independently for days or months on end and have ranges of thousands of miles. The Navy had

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ambitious plans to spend billions over the next five years to buy these craft, but it appears those plans have also been scaled back and systems may not be in the fleet until the late 20s.

Autonomous Mobility

Within the development of autonomous vehicles, Cowen sees autonomous fleets as the biggest opportunity in 2030 and beyond (versus individual ownership). Testing is underway (with some successful experiments completed), technology is being developed, and regulatory uncertainty persists. We believe that most of the technology exists to accomplish the mission of a fully autonomous vehicle, other than low-cost LiDAR solutions where solid-state development still needs to make inroads.

Cowen believes that in the mid-2020s, smaller (six to eight passenger) vehicles may be used in geofenced areas, such as college campuses. In the 2025 to 2030 timeframe, we expect small, pod-like hyper-local geofenced vehicles to emerge, with capabilities such as shuttling one to two passengers from mass transit hubs to their offices. We also see a great deal of promise in leveraging autonomy for heavy machinery and agriculture applications given the high cost of drivers and safety benefits.

We expect to see "level 4" autonomy emerge in trucking before consumer cars, i.e., exit to exit autonomy on the interstate with a driver still on-board and ready to take over the controls as needed.

Numerous companies have emerged that are looking to disrupt the $4 trillion global truck freight market, with an autonomous solution designed to address the "middle mile" in long haul freight applications. Just 10% of the trade corridors in the United States handle nearly 80% of all goods being moved. However, the addressable market is actually even more concentrated than that, as just 1% of the U.S.'s trade corridors move almost 40% of the nation's goods. This type of market is ideal for L4 autonomy, given goods are moved between fixed points on a regular basis.

Cowen believes there are strong safety, productivity, and workforce rationales for autonomous trucks, and in our proprietary survey of the carrier industry, we observed a developing trend among carriers to own autonomous technology outright as opposed to contracting autonomous capabilities through a third party.

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October 11-12, 2022

Cowen 7th Annual FutureHealth Conference
June 22-23, 2022

Cowen 50th Annual TMT Conference
June 1-2, 2022

Cowen 2nd Annual Mobility Disruption Conference
March 2-4, 2022

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November 21, 2022

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September 21, 2022

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February 15, 2022

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Ongoing

Physician Expert Webinar Series
Ongoing

ROBOTICS & AUTOMATION

DIGITAL ASSETS

COWEN RESEARCH THEMES 2023

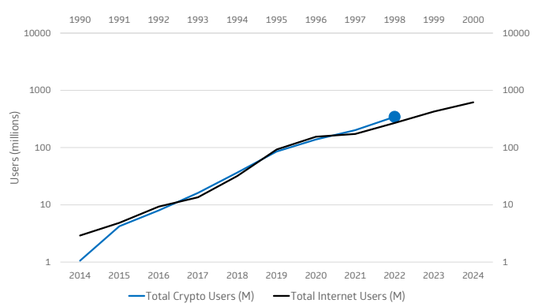
"In the U.S., we anticipate adoption of a wide-ranging regulatory paradigm similar to the governance model currently controlling the traditional products and services that crypto and digital disruptors are looking to replace."

COWEN

The full magnitude of losses caused by the November collapse of cryptocurrency exchange FTX will take time to be fully unraveled, but we view it as a crystallizing event with lasting impact, very likely catalyzing the beginnings of a regulatory framework in the U.S. to govern the use of cryptocurrency and digital assets. In the near term, we believe FTX's unraveling lays the groundwork for more aggressive U.S. Securities and Exchange Commission (SEC) enforcement actions in 2023 as efforts get underway for more comprehensive regulatory and legislative investor protections.

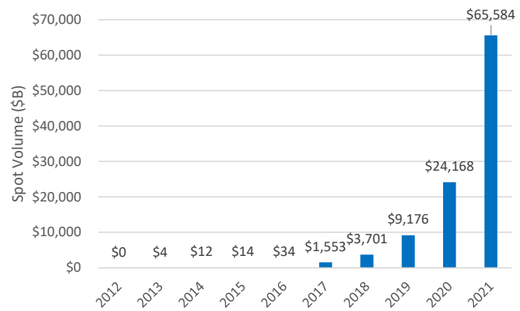
Cowen also believes cryptocurrency and digital assets are here to stay. Nearly 60% of global institutional investors surveyed by Fidelity were invested in digital assets in mid-2022, and more than 80% indicated that digital assets should be in investment portfolios. With public cryptocurrency market capitalization touching $1 trillion and nearly 30% of U.S. millennials actively using some form of cryptocurrency account, we believe we are entering a new chapter in the evolution of these asset classes and the businesses around them. At least in the U.S., we anticipate adoption of a wide-ranging regulatory paradigm similar to the governance model currently controlling the traditional products and services that crypto and digital disruptors are looking to displace, consistent with recent recommendations of the Financial Stability Board—the international body that monitors and makes recommendations about the global financial system.

Internet vs. Crypto Adoption



Source: The World Bank, Crypto.com, Cowen and Company

Annual Cryptocurrency Exchange Trading Spot Volume ($ billions)



Source: Nomics, Cowen and Company estimates

WHAT WE'RE WATCHING

Regulation

Against the backdrop of a "crypto winter," a host of U.S. regulators, including the SEC, Commodities Futures Trading Commission (CFTC), Financial Stability Oversight Council (FSOC) and bank regulators, along with Congress, have wrestled with the challenge of how best to instill and enforce basic risk controls to ensure crypto-related activities are appropriately protected and do not incur excessive leverage.

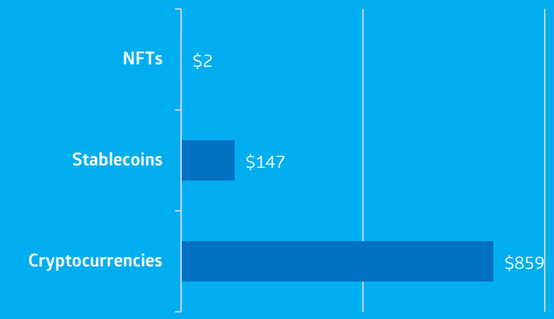
The collapse of FTX will catalyze widespread bipartisan demand for crypto regulation in 2023, bolstering SEC Chair Gensler's view that many tokens should be regulated as securities and that crypto trading platforms should be required to register as exchanges with the SEC. Fully decentralized tokens such as bitcoin (BTC) and Ether (ETH) would most likely be under the purview of the CFTC as these cryptocurrencies are largely viewed by U.S. regulators as commodities.

Some government representatives have called for breaking up "one-stop shop" crypto platforms, requiring that custody, trading, lending, and market making operate as distinct businesses that are separately capitalized, with strict requirements for

SNAPSHOT: DIGITAL ASSETS, SERVICES & PAYMENTS

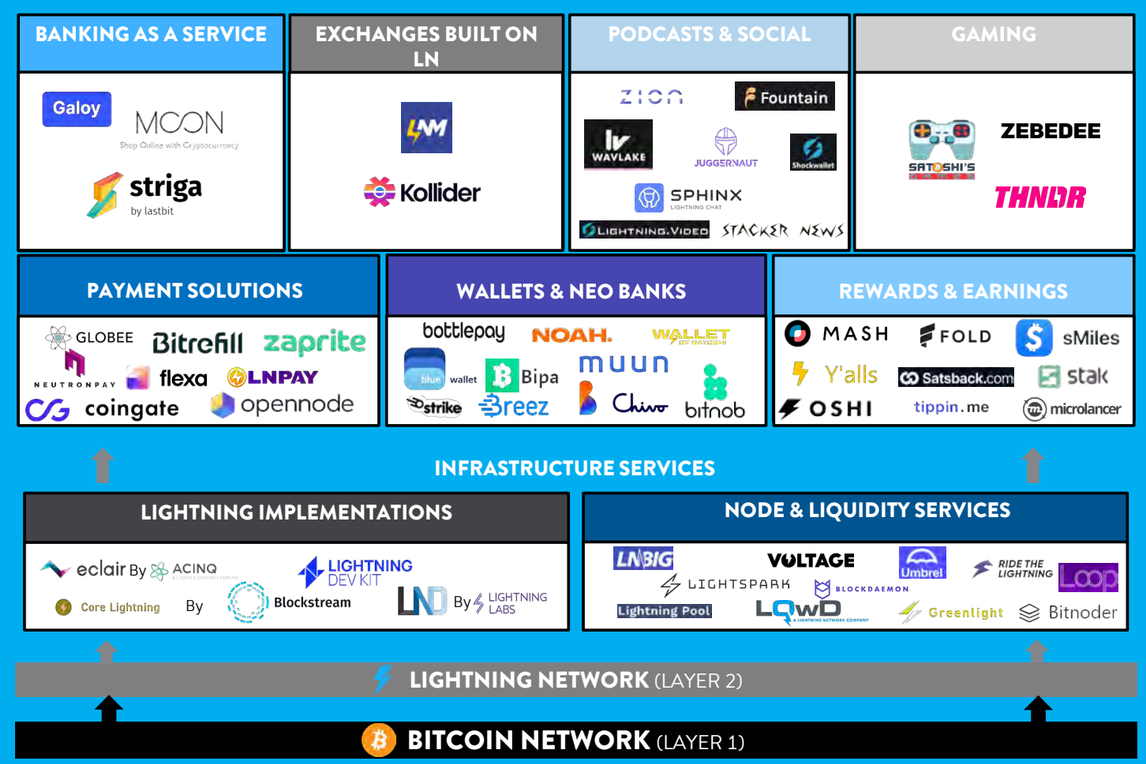
CRYPTO MARKET CAP OVER TIME ($ TRILLIONS)

MARKET CAP BY ASSET CATEGORY ($ BILLIONS)



Source: CoinMarketCap, Cowen and Company, 10/31/2022

APPS, PAYMENTS & FINANCIAL SERVICES



Source: Cowen and Company

"The collapse of FTX will catalyze widespread bipartisan demand for crypto regulation in 2023."

verification of assets, but it is too early to tell how this will play out. New regulation will need to address some of the differences between traditional and digital assets, including the instant settlement feature inherent in crypto, which differs from the "T+x" settlement frameworks associated with legacy securities.

We see SEC approval of a spot bitcoin ETF as unlikely in the near term given current sentiment among regulators, legislators, and consumers.

In keeping with the principle that new crypto and digital products should be regulated alongside the legacy products they aim to displace, we anticipate that use of crypto for payment settlement would be regulated by central bank and payment system oversight. Similarly, we expect that crypto products and services mimicking bank-like functions will be overseen by traditional bank regulators and subject to bank-like capital and liquidity requirements.

In the realm of payments and settlement, we believe the U.S. government intends to regulate crypto payments to ensure consumers have the same rights with crypto as they do with traditional payments, including being held harmless for unauthorized transactions. Crypto payment providers will need to demonstrate the ability to comply with these rules as well as with broader anti-money laundering and U.S. Bank Secrecy Act controls.

We also believe the U.S. Consumer Financial Protection Bureau (CFPB) will assert authority over crypto payments, including over wallets. This would mean crypto platforms that are hacked or that do not properly execute payments would face CFPB enforcement. We also believe the agency will consider whether crypto firms comply with fair lending laws.

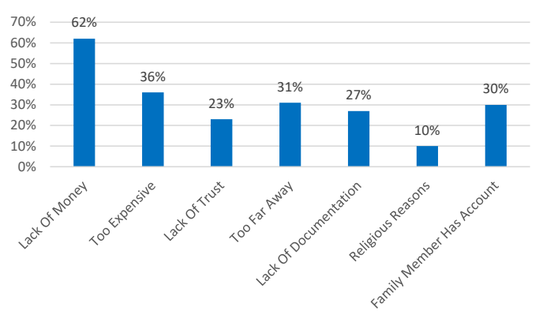
Evolving Use Cases In The Payments Ecosystem

We believe we are in the early innings of an emerging payments ecosystem that represents a productive and durable use-case for crypto in the near and long term, addressing consumer needs for payment transfer settlement solutions that are low cost, fast and accessible, particularly for the 1.4 billion adults (24%) who (per the World Bank Global Findex Database as of December 2021) do not hold any accounts with traditional financial institutions.

Crypto solutions carry the potential for instant settlement, compared with a range of 30 minutes to two or more days using traditional financial institution mechanics. Crypto transaction fees are expected to be dramatically lower, and especially so for person-to-person consumer transactions, which could ultimately cost a few cents versus $1 to $3.

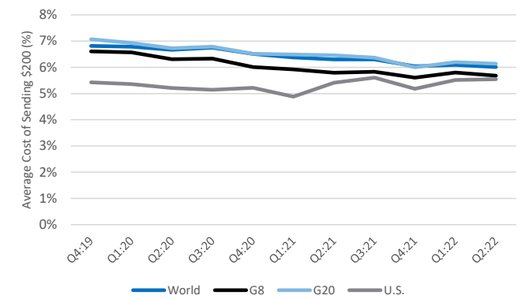
These attributes are particularly attractive to consumers in developing countries with rudimentary infrastructure and financial systems that are often expensive to access. The United Nations estimates that remittance payments represent a material source of income for 800 million people globally, with global remittance payments expected to reach over $800 billion by the end of 2022 and low- to middle-income countries involved in more than $600 billion of that activity.

Adults With No Account (%) Citing A Given Barrier As A Reason For Having No Financial Institution Account, 2021



Source: Global Findex Database 2021

Average Cost Of Sending A $200 Remittance Payment



Source: The World Bank, Remittance Prices Worldwide, Cowen and Company

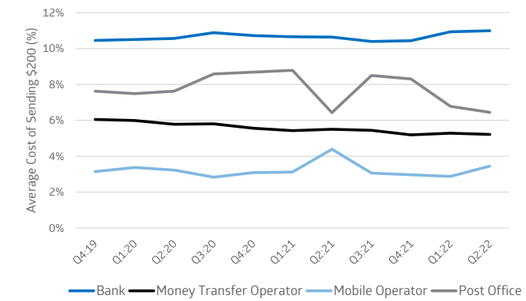
We estimate that average fees on global remittance payments will total nearly $50 billion in 2022, based on World Bank remittance price tracking, which suggests the global average cost of a $200 remittance payment over the first half of 2022 exceeded 6%, or $12.

Whether they are functioning as exchanges, payment rails or blockchain networks, we believe the crypto and digital asset platforms most advanced in their compliance infrastructures will be best positioned for success in the emerging digital payments ecosystem. We are watching Blockchain scaling solutions, such as Lightning Network, Bitcoin's layer-2 scaling solution, and Ethereum's post-merge upgrades, which aim to optimize for transaction throughput and reduced cost. We view fiat-backed stablecoins as another promising and underappreciated area for crypto payments development.

We are also monitoring the progress of existing companies and new entrants focused on making fiat-to-crypto on/off ramps more seamless and improving user/merchant interfaces, which we believe will be crucial for widespread adoption of cryptocurrencies as a form of payment.

For cryptocurrency exchange platform Coinbase, Cowen sees a $1 billion+ opportunity for high-margin USD Coin (USDC) reserve interest income.

Average Cost Of Sending A $200 Remittance Per Remittance Service



Source: The World Bank, Remittance Prices Worldwide, Cowen and Company

In light of this opportunity, the dominant players across multiple payment verticals are expressing commitment to making crypto a daily payment method, including among consumer wallet issuers (e.g., CashApp, Revolut, and Nu), payment networks (e.g., Visa and Mastercard), and merchant acquirers (e.g., Block, Adyen, and Cloudwalk).

Tellingly, Visa and Mastercard, two of the most mature companies in the payments industry, are developing robust crypto divisions and strategies, offering services such as digital asset security, enabling digital asset ownership, offering crypto credit cards, onboarding Non Fungible Tokens (NFTs) to payments networks, enabling digital currency cash-outs in fiat currencies, providing settlement in digital currencies such as stablecoin, and exploring potential partnerships around Central Bank Digital Currencies (CBDCs).

The crypto industry, whether in the form of legacy or emerging operators, may ultimately need to compete against governments in some instances. The U.S. Federal Reserve, for example, has been working for years on a digital dollar, which, although not close to launching, could one day threaten stablecoin and

"We believe we are in the early innings of an emerging payments ecosystem."

DIGITAL ASSETS

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Ongoing

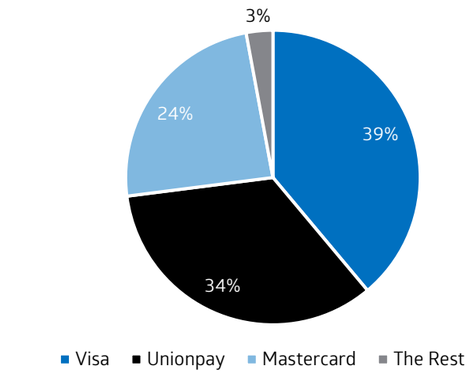
Crypto Quarterly Update Call Series
Ongoing

Crypto Policy Developments Call Series
Ongoing

cryptocurrency-based payment rails given that digital dollars would be backed by the full faith and credit of the United States.

Nearer term, the Federal Reserve may as soon as 2Q23 launch the biggest upgrade to the U.S. payments system in a generation when it activates the FedNow instant payment network. This will allow money to move between bank accounts in just a few seconds, offering many of the same instant settlement benefits of crypto payments, albeit without the ability to make cross-border transfers or service anyone outside the system of traditional banking institutions and accounts.

Market Share Of Purchase Transactions In 2021



Source: Nilson Report, Cowen and Company

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FUTURE OF HEALTH CARE DELIVERY

COWEN RESEARCH THEMES 2023

"Cowen believes health care will evolve away from the traditional fee-for-service payment model to a model that focuses on value and population health."

COWEN

The manner in which Americans pay for, interact with, and evaluate health care choices is undergoing a significant shift. We expect these changes to persist as payers and providers become more focused on value-based care models (driving consolidation); pharmacies expand their reach connecting consumers, drug developers, and providers; and wellness continues to accelerate, expanding the market for digital health providers.

Cowen continues to forecast an evolution of health care away from the traditional fee-for-service payment model to a model that focuses on value and population health. Value-based, capitated care (i.e., a health care system in which a medical provider is given a set fee per patient regardless of treatment required) continues to evolve as Medicare increases its emphasis on shifting from volume to value. In a VBC capitated model, the risk shifts from the payor to the provider, wherein the provider receives incentive payments for the quality of care they give to patients. The growing health care entitlement budget has the U.S. Centers for Medicare and Medicaid Services (CMS) focused on reining in spending, and VBC is viewed as a central feature of bringing down costs while improving care. As a result, CMS, under the current Administration, has set a goal of transitioning all of

> "A wave of consolidation is sweeping through the space as companies with deep pockets actively acquire primary care and home health practices or clinics."

its Medicare population – about 63 million people in total –to VBC arrangements by 2030, with a focus on primary care.

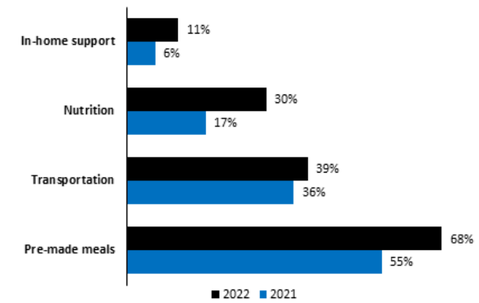
Early 2022 saw a large correction in VBC stocks. As a result, a wave of consolidation is sweeping through the space as companies with deep pockets actively acquire primary care and home health practices or clinics. These acquisitions extend these companies' ability to provide integrated, coordinated care, a key tenet of successful VBC models.

As VBC drives consolidation, consumerization is also sweeping through the U.S. health care delivery model. Payers catering to the $800B+ Medicare population are branding their primary care offerings for seniors, offering transportation, home care, and benefits that align with social determinants of health ("SDoH"),

Value-Based Care Drives Consolidation

Source: Cowen and Company

Services Provided By Medicare Advantage Programs, 2022 vs. 2021



Source: Avalere, Cowen and Company

such as healthy meals. An analysis of 2021 and 2022 Medicare Advantage plans by Avalere Health found that 68% of plans offered pre-made meals in 2022 (+24% from 2021), and 39% offered transportation (+8%), In addition, 30% offered nutritional education/ counseling (+76%), and 11% offered in-home support (+83%). These offerings not only play into the coordinated care aspects of VBC, but are becoming necessary for plans to attract and retain beneficiaries by catering more to individual consumer needs.

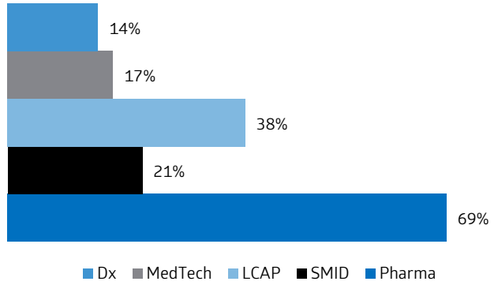
The pharmacy business model is also undergoing a shift, as major retail chains seek to build out their health care offerings, catering to consumer needs by providing primary care, and serving as a conduit for clinical research. Consumer preferences for more local, immediate care, coupled with an interest in tapping the $800 billion Medicare VBC market, are driving this trend.

Major retail pharmacy chains are recognizing the unique position they occupy in the health care ecosystem with the ability to serve as a local facilitator or intermediary for clinical research. Retail pharmacies CVS and Walgreens have both launched initiatives to use their primary care-equipped pharmacies as clinical research depots for another innovation that is quickly gaining traction – decentralized clinical trials (DCTs).

DCTs seek to shift clinical research away from traditional brick-and-mortar study sites, which are often located at major academic medical centers. Instead, DCTs rely on more virtual platforms to check in on and monitor patients who are being treated with investigational agents. When those evaluations must include physical assessments with physicians and/or nurses, retail pharmacies can serve as a local option. Given the large and often dispersed geographic footprint of pharmacies, they also offer the potential to recruit a more diverse and representative patient population that can't often be captured by traditional clinical study sites (e.g., access to rural and underserved urban areas) – a key ESG priority of biopharma and medtech companies. Cowen has found that biopharma companies see DCTs as a key component of their efforts to improve clinical trial diversity. In our 2022 proprietary survey of covered companies, 30% said that they were planning to or are actively using DCTs as a means to improve trial diversity, including 69% of pharma companies and 38% of large-cap biotechs.

Perhaps the largest sign of the growing role of consumers in health care is the emergence of a new category – wellness – driven by digital health innovations at scale. Following two years of disruption from the COVID pandemic, consumers have become more comfortable with the notion of improving their well-being through personalized technology. In Cowen's estimation, the consumerization of health

DCT Use As A Proportion Of Sector Respondents

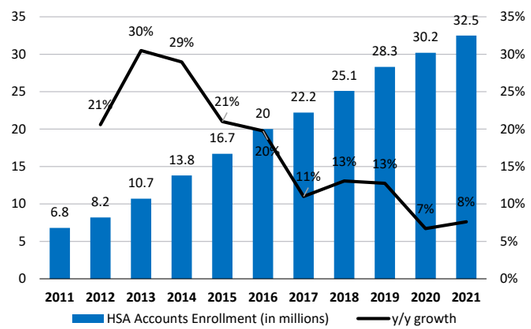


Source: Cowen and Company April-May 2022 ESG Trial Diversity Survey

care and wellness is creating a new $700 billion+ addressable market. An additional driver of this trend is the increase in high-deductible health plans as well as the growth of health savings account (HSA) plans, which enable the use of pre-tax income to be spent on health care, dental and vision care. HSAs increase individuals' spending power, while high-deductible plans incentivize consumers to focus on preventative care and wellness.

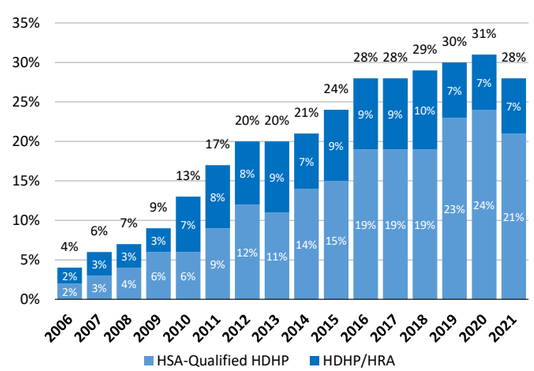
Our data find that, post-COVID, fewer younger patients are visiting primary care physicians and are instead using telemedicine. Interest in digital engagement is evidenced by Amazon's proposed $3.9 billion acquisition of One Medical, which combines in-person care with digital health and virtual care services, making it easier for patients to schedule appointments, renew prescriptions, access up-to-date health records, and advance health outcomes.
The health care industry is also experiencing the proliferation of consumerization through home prescription delivery, at-home testing and diagnostics, and digital technologies.

Number Of HSA Savings Accounts



Source: Devenir Group, 2021 Year-End Devenir HSA Research Report, Cowen and Company

Percent Of Covered Workers Enrolled In HDHP/HRA Or HSA-Qualified HDHP Plans



Source: KFF Employer Health Benefits Survey, 2018-2021, Cowen and Company

WHAT WE'RE WATCHING

Value-Based Care (VBC)

We expect our consolidation thesis to continue to play out after this year's VBC stock correction. Health plans such as UnitedHealth, CVS, and Humana are investing billions of dollars in VBC, and we expect this will continue, with the aim of increasing their physician bases. Companies already focused on VBC and are likely looking to consolidate include Humana (which has invested in VBC companies Cano Health and Oak Street Health), UnitedHealth, Walgreens Boots (which invested $5.2 billion in VillageMD), and Anthem/Elevance (which operates CareMore clinics and has a stake in Privia's management services organization).

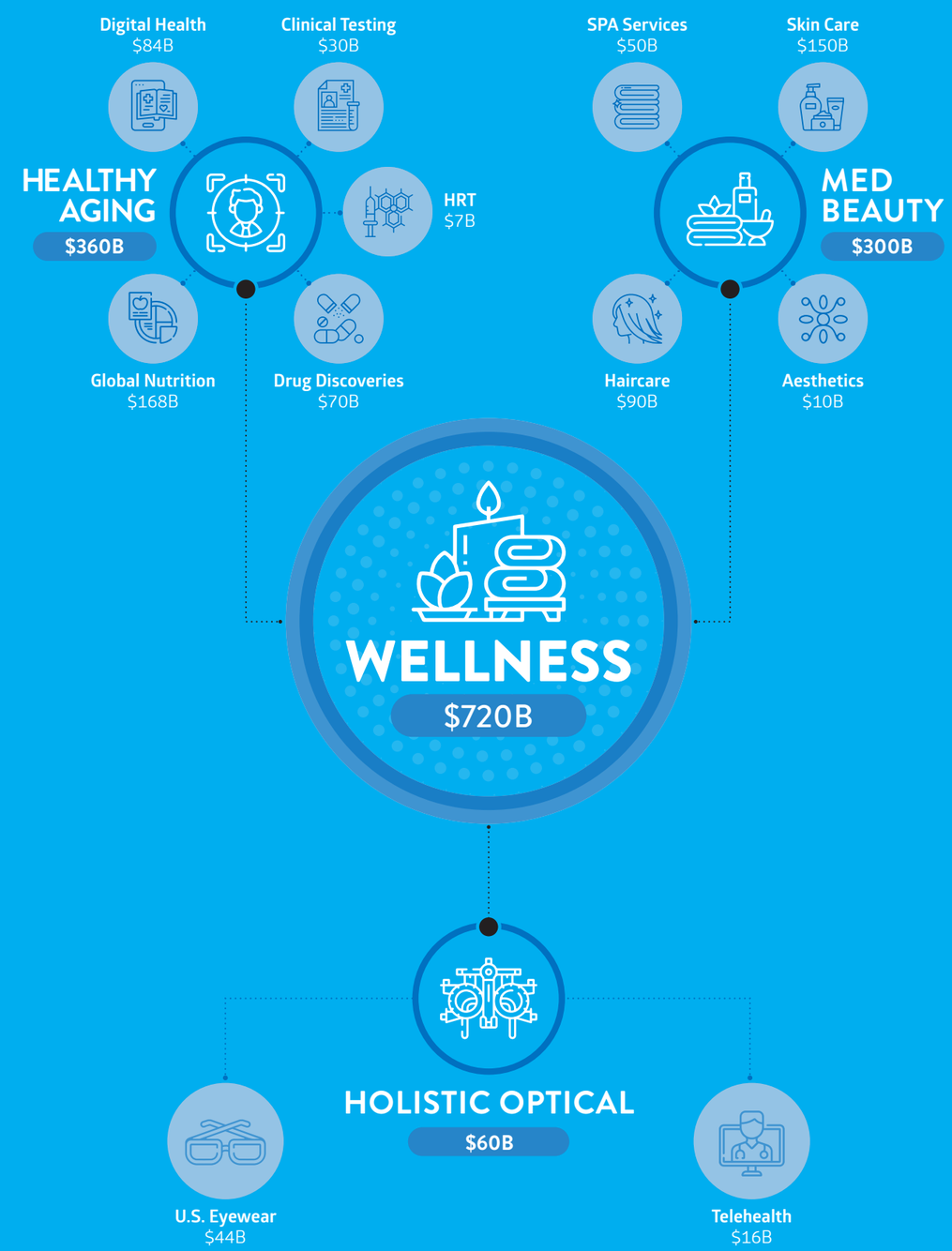
Hospital Volumes And Underwriting

The underlying shift in site of care is being driven in part by consumers, but there remains a post-pandemic weakness in hospital volumes and some uncertainty among payers as to whether this is a "new normal." This weakness, coupled with labor shortages at hospitals, leaves uncertainty with respect to the next underwriting cycle for payers. Prior to 2000, it was fairly common for premiums to increase ~11% per year. Since then, we have seen them stabilize in the low- to mid-single digits, and they are estimated to rise 6-7% in 2023. But continued labor issues could pressure payers, resulting in even larger premium increases.

The Evolving Pharmacy Business Model

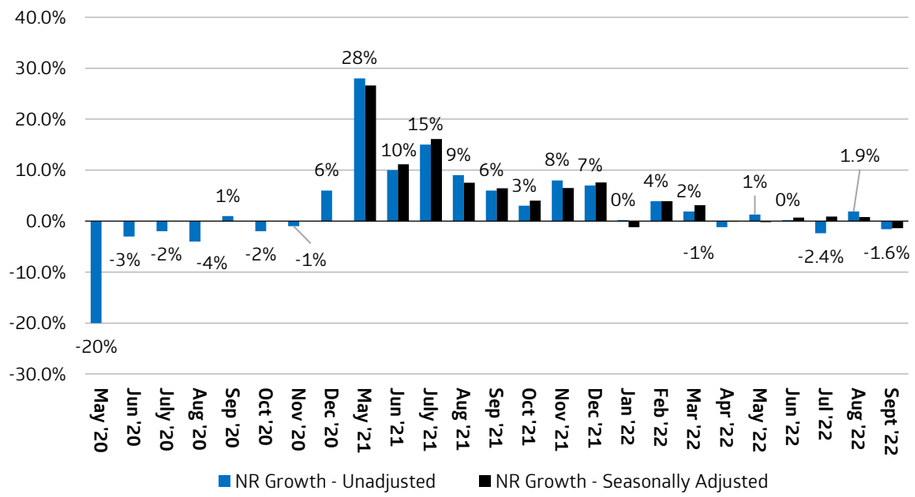
Major pharmacy chains Walgreens, CVS, and WalMart's Health & Wellness Division have moved to

SNAPSHOT: WELLNESS ECOSYSTEM REPRESENTS $700 BILLION+ ADDRESSABLE MARKET



Source: Cowen and Company estimates

Hospital Net Revenue Growth (year-over-year %)



Source: Cowen and Company Hospital Survey, August 2022

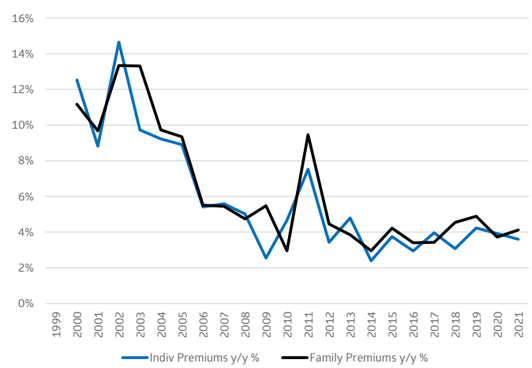
expand into clinical research. A benefit highlighted by these companies is an ability to recruit a more representative population by enrolling otherwise overlooked groups who may not typically seek care at an academic medical center, or individuals who live in more rural communities. In 2023, we will be watching for collaborations between these pharmacies and other entities involved in clinical research, including traditional contract research organizations (CROs) as well as biopharma companies.

We will also be watching for evidence that these sites can successfully enroll underserved populations. Our ESG research has found that simply putting enrollment sites in areas with a denser minority population does not often solve for recruiting a more representative patient population. These sites will likely have to undertake a multi-pronged approach that incorporates diverse site selection matched to disease demographics, outreach to patients and KOLs, and external education efforts to inform racial and ethnic minorities of the importance of clinical trials.

Clinical Trials Enterprise

While decentralized trials that seek to bring clinical research to patients where they live were quickly embraced out of necessity during the COVID pandemic to ensure business continuity in the drug industry, we will be watching the adoption of these new platforms and tools over the next few years to understand how and where companies decide to deploy DCTs going forward. Key metrics we will be watching for include partner renewals from DCT providers such as Science 37, as well as FDA approval of one of the first products developed via a DCT, which we anticipate in 2023 or 2024. Additionally, how established CROs respond

Commercial Health Insurance - Net Premium Growth



Source: Kaiser Family Foundation (KFF), Cowen and Company

ANALYSTS: FUTURE OF HEALTH CARE DELIVERY

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to the implementation of DCTs will be an important indication of the potential benefit these platforms can provide to conduct trials more efficiently and ensure fewer patient dropouts and less missing data.

Digital Health

There are multiple milestones within the digital health sector that we are watching in 2023 and beyond. Owlet has filed for FDA 510(k) approval for its Dream Sock, and we see the potential for the company to expand into the commercial health care arena if FDA approves the application.

Cue Health is also in a position to benefit from the consumerization shift. The company sells its lab-quality diagnostic tests through online and offline retail channels, providing consumers access to testing via its Cue Readers. Cue Health's Integrated Care Platform is designed to deliver a superior user experience in any setting, while its health app allows consumers access to their medical data immediately, empowering them to make better health care decisions. While COVID-19 tests have made up the majority of the company's revenue, we will be watching for results from clinical studies of its respiratory syncytial virus (RSV) test. RSV typically affects newborn infants, and an at-home test option could help to quickly detect RSV infection earlier in its course, expediting treatment to avoid adverse outcomes. The company is also starting to test its platform to detect chlamydia/gonorrhea. We will be watching for continued growth of Cue's direct-to-consumer offering of the Cue Reader, test volume pull-through, and the generation of non-COVID revenues as early as 1Q23.

DTC genetic testing pioneer 23andMe is also well positioned to benefit from the consumerization of health care and clinical research. The company's database of 13.1 million+ genotypes with 4 billion+ phenotypic data points provides a rich resource of insights for drug discovery and clinical research applications. 23andMe already has a significant partnership with GSK, a loyal and large customer base, and 50+ drug development programs. We will be watching for the successful advancement of those

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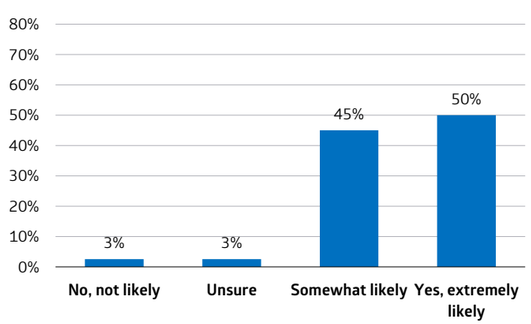
Digital Health Key Themes For 2022
January 27, 2022

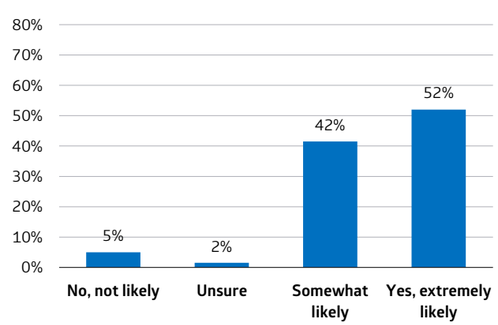
Cowen Hospital Survey
Monthly

Willingness To Prescribe PDT Product(s), Blinded



Source: Cowen and Company Physician Digital Therapeutics Survey

Willingness To Prescribe PDT Product(s), Unblinded



Source: Cowen and Company Physician Digital Therapeutics Survey

candidates in the clinic. Additionally, after July 2023, 23andMe will be permitted to establish new drug discovery collaborations and partnerships for its exhaustive database beyond the GSK deal.

Prescription Digital Therapeutics

We are monitoring the uptake of digital therapeutics solutions. Akili is still early in the launch of its autism prescription digital therapeutic EndeavorRx, which could change the treatment paradigm in this disorder. Pear Therapeutics was the first to launch a digital therapeutic with its reSET and reSET-O treatments for substance abuse disorder, and Somryst to treat insomnia. The company has had challenges in gaining reimbursement and uptake. We will continue to watch for increased adoption and uptake. Cowen's January 2022 survey of physicians found that they were overwhelmingly likely to prescribe prescription digital therapeutics for a range of indications, including substance abuse disorder.

We will also be watching for CMS's Transitional Coverage for Emerging Technologies (TCET) rule that would provide a new, voluntary coverage pathway for breakthrough medical devices and could benefit some prescription digital therapeutics. The new program would build on Medicare's Coverage with Evidence Development Pathway and could involve early evidence reviews and initiation of Medicare's coverage process prior to obtaining FDA clearance or approval.

COWEN EVENTS

Cowen 25th Annual Therapeutics & MedTools Conference
October 11-12, 2022

Cowen 7th Annual FutureHealth Conference
June 22-23, 2022

Post-Pandemic Health Policy Outlook
April 26, 2022

Cowen 42nd Annual Health Care Conference
March 7-9, 2022

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May 26, 2022

Hospital Call Series
Ongoing

CHNG/UNH Expert Call Series
Ongoing

Washington Weekly: Reconciliation & Drug Pricing/Health Care
Ongoing

Cowen Physician Expert Call Series
Ongoing

Cowen Medical Devices/LS Tools & Diagnostics Conference Call Series
Ongoing

FUTURE OF HEALTH CARE DELIVERY

ESG

COWEN RESEARCH THEMES 2023

"Over the next year, we believe that a confluence of investor pressure and regulatory actions will push ESG-oriented asset managers to better define, integrate, and defend their investment processes."

COWEN

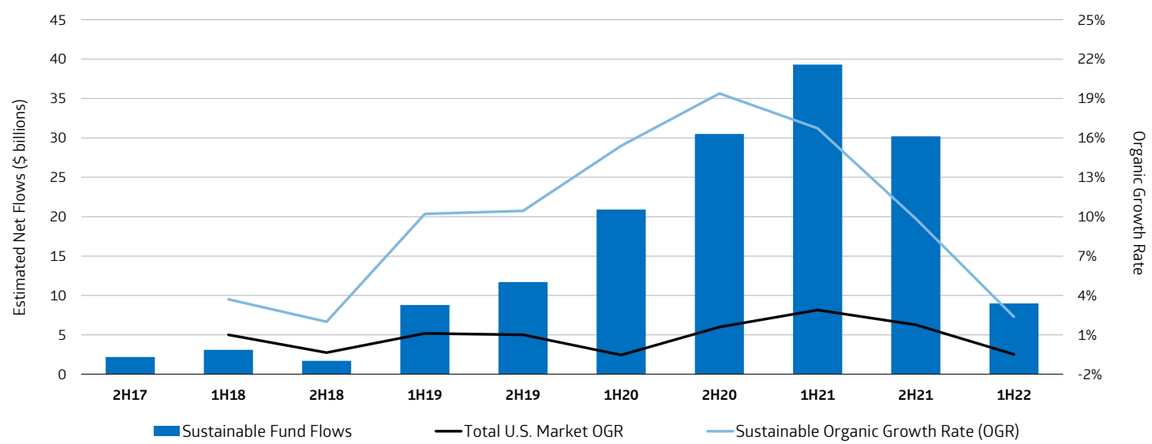
In 2022, financial market turmoil, pockets of investor skepticism over perceived "greenwashing" (i.e., funds touting themselves as "green" or "ESG friendly" without sufficient founding), and the increased politicization of ESG led to diminished flows into sustainable funds and weaker returns for most ESG funds on a year-over-year basis. The U.S. sustainable funds market grew 2.5% in the first half of 2022—better than the total market but a big slowdown from the previous year, according to Morningstar data. A tough market for technology and health care shares—a key component of many ESG portfolios—and tailwinds for fossil fuel stocks worked against most funds in the space. This mixed performance demonstrated the weakness of certain ESG indices and strategies that screen out entire economic sectors or skew heavily toward growth-oriented stocks focused on reducing emissions footprints. Going forward, we see greater focus on a wider range of ESG considerations and the factors material to driving long-term value.

Despite the challenges of 2022, ESG adoption by global investors continues to grow. A confluence of circumstances including Russia's invasion of Ukraine, supply chain disruption, consumer price inflation, growing worker activism, and loud left-versus-right political debates over ESG kept it prominently in the spotlight. The U.S. Inflation Reduction Act passed in July, which earmarked $369 billion for climate and alternative energy spending, demonstrated U.S. commitment to the energy transition, and opened the door to achieving major "E" pillar (environmental) progress in the transportation and power sectors.

At Cowen, we see ESG as an investment framework that helps measure and assess investment risks and opportunities. While ESG metrics are mostly non-financial in nature, they are central to properly valuing a company's long-term earnings potential. To do this, we combine the ESG policy expertise of our Washington Research Group with industry- and firm-level analysis by our team of over 60 equity analysts. For each stock we cover, we calculate an ESG score and identify the relevant material ESG issues for that company, and how it stacks up against peers.

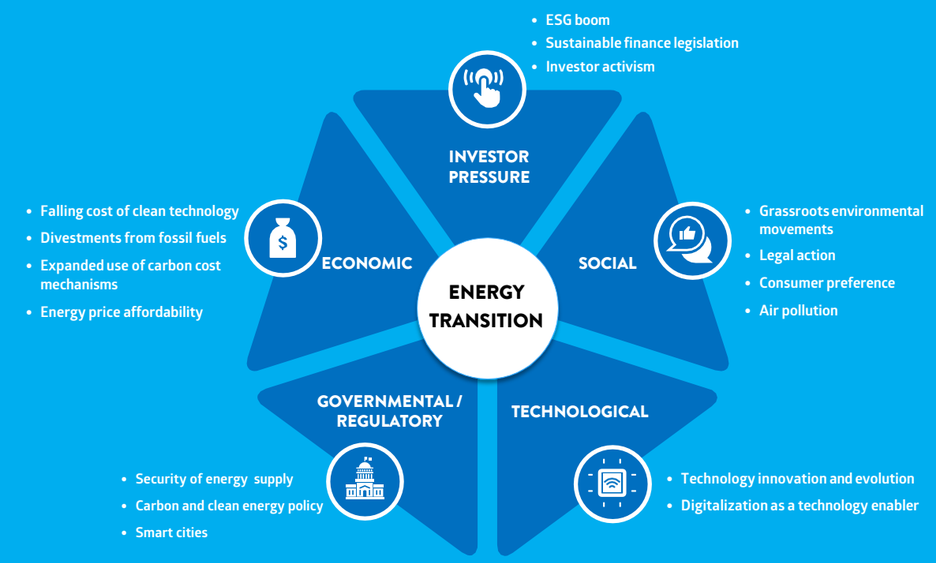
ESG is clearly a focus of investor attention. In 2022, Cowen's ESG research was some of our most popular, and ranged from work on alternative energy to a study of diversity in clinical drug trials. We expect interest in ESG-driven analysis to rise as regulators such as the U.S. Securities and Exchange Commission move toward mandating standardized corporate ESG disclosure, and investors put increased pressure on companies to put more focus on environmental, social

U.S. Fund Flows: Sustainable vs. Total Market



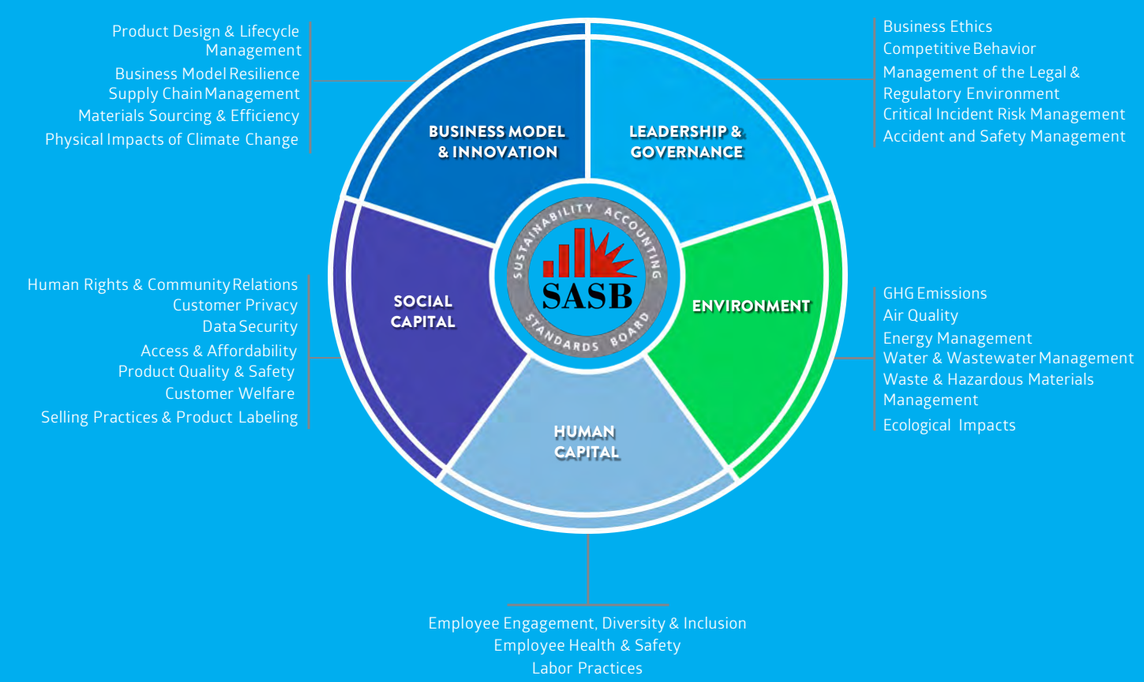
Source: Morningstar Direct, as of 30 Jun, 2022, Cowen and Company

SNAPSHOT: KEY FACTORS ACCELERATING THE DE-CARBONIZED ENERGY TRANSITION



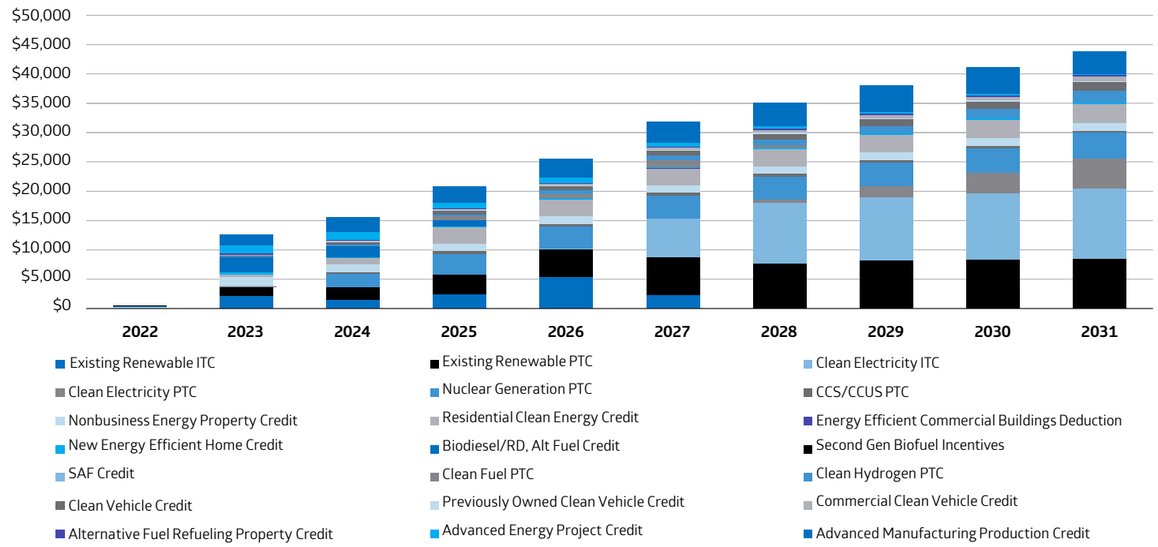
Source: Cowen and Company

ILLUSTRATIVE SASB ESG FACTORS



Source: SASB, Cowen and Company

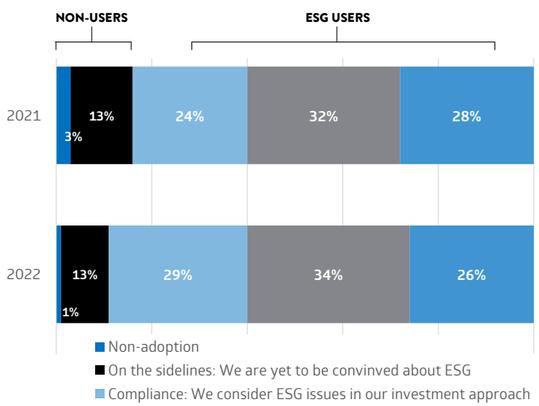
Projected IRA Climate/Energy Tax Credit Outlays ($ in millions)



Source: U.S. Congress, Cowen and Company

and governance issues. We also anticipate that ESG investing will grow in acceptance as it becomes better defined and as funds more clearly explain the extent to which ESG considerations govern their investment practices.

ESG Adoption Has Increased To 89% from 84%



Source: Capital Group, Cowen and Company

WHAT WE'RE WATCHING

Energy Transition And Security

Mitigating climate change remains the major focus of ESG investing. Companies are increasingly expected to explain their strategies for using (or producing) renewable energy and are facing pressure to quantify business exposure to climate-related risks and the carbon footprint of their operations and supply chain.

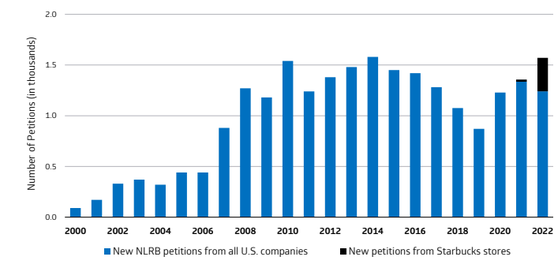
The drive toward renewable sources of power has taken on new urgency given stress on energy markets. The EU remains committed to a strict, renewable-focused plan backstopped with LNG (liquified natural gas), although Russian sanctions have complicated these efforts. The U.S. is undertaking a slower, gas-enabled transition. Developing economies will rely largely on whatever their cheapest source of energy is, be that coal, oil, or renewables like solar.

Investor and industry debate around sustainable power has also changed. Pre-COVID, the discussion of alternatives centered on getting to grid parity – the point at which alternative energy costs undercut those of conventionally sourced power. Because of higher oil and gas prices, we've arrived there sooner than expected. In 2021, 60% of global solar and wind installations were economically viable without subsidies, according to Cowen analysts. That number will continue to rise as the cost profile of alternatives improves, even with inflation.

The Inflation Reduction Act (IRA) represents the largest Federal-level climate and energy legislation in U.S. history, and provides the potential for the U.S. to cut emissions by over 40% by 2030.

Aside from renewable energy stocks, opportunities lie in energy resiliency, storage, and infrastructure. The U.S., for example, will need to modernize its power grid to support the energy transition envisioned by the IRA. We see benefits for developers of electric transmission, pipelines, and renewable generation infrastructure. In particular, Cowen is monitoring public-private partnerships that move the transition needle. We expect financing to flow into the hydrogen economy and hard-to-abate sectors like heavy infrastructure.

New Union Petitions Have Risen Since COVID Began

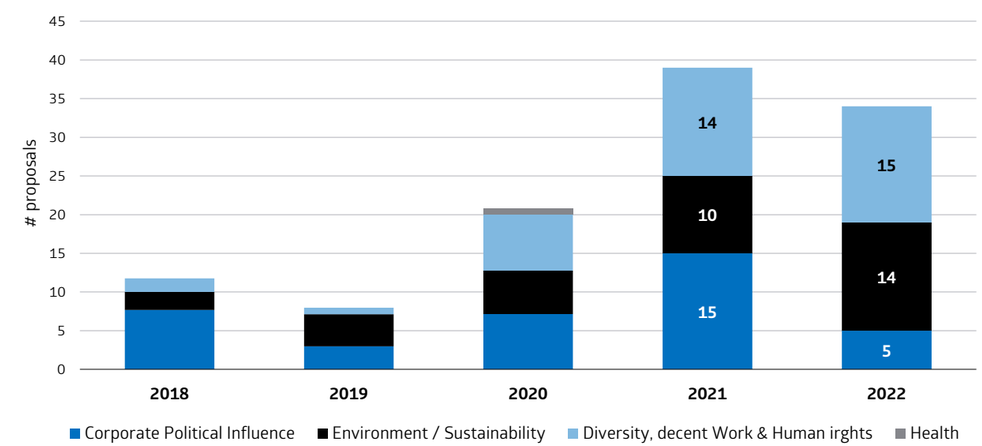


Source: Bloomberg News analysis of National Labor Relations Board filings
Note: Totals for 2022 are through July 31

Supply Chains & Government Oversight

Companies are under increasing pressure to be transparent about where products come from, who makes them, and how. For example, investors want assurance that a company's carbon emissions or problematic labor practices aren't simply being driven into other countries where standards are potentially lower. While subject to criticisms such as difficulties with data collection and measurement, calculation methodologies, and materiality standards, the U.S. and EU have proposed significant overhauls of

Number Of ESG Proposals Receiving Majority Votes By Shareholders



Source: Sustainable Investments Institute (Si2), as of July 1, 2022, Cowen and Company

ANALYSTS: ESG

Jeffrey Osborne
Sustainability & Mobility Technology

Brian Holland
Sustainable Food & Healthy Living

Jason Gabelman
Next-Generation Fuels & Energy

Gabe Daoud, Jr.
Battery Technology & EV Charging

Oliver Chen, CFA
Retailing – Broadlines, Department Stores & Specialty Stores

John Miller
Washington Research Group - ESG, Energy & Sustainability Policy

Joseph Giordano, CFA
Diversified Industrials, Automation & Robotics

Marc Bianchi, CFA
Industrial Gas & Equipment, Nuclear, and Energy

David Deckelbaum, CFA
Next-Generation Materials & Energy

John Kernan, CFA
Retail & Consumer Brands

disclosure rules which would require many companies to disclose so-called "Scope 3" data, i.e., data on indirect emissions that occur in the supply chain of the reporting company, including both upstream and downstream emissions. Regardless of the outcome of these proposed disclosure requirements, we expect investors to increasingly demand ESG accountability from corporations.

Macro Stress

Macro factors will continue to pressure corporations on the Social and Governance front. Persistent inflation has led to demands for higher wages and highlighted questions about the affordability of food, fuel, and housing. Worker activism is rising. The U.S. National Labor Relations Board found that union election petitions rose 58% year on year in the first nine months of 2022, exceeding the total number of filings for 2021. Unfair labor practice charges rose 16% in the same period. We have also witnessed the emergence of grassroots unionization efforts that shun traditional organized labor and focus on micro, region-specific issues.

Pressure on corporations to take values-based positions and stand up against racial, demographic, and economic inequities continues to mount. Activist shareholders have successfully called for civil rights audits of companies and gender and race pay gap reporting. A mid-2022 report by Proxy Preview, which monitors data on ESG shareholder resolutions, noted a nearly 60% increase in votes favoring disclosure and action on ESG shareholder resolutions versus the same period the year prior.

Fund Nomenclature

The nascent nature of ESG investing has resulted in some lack of clarity regarding how investment funds may advertise their ESG or sustainability focus, including confusion regarding what may qualify as an Article 8 (funds that promote "E" or "S" characteristics but do not have them as the overarching objective) or Article 9 (funds that specifically have sustainable goals as their objective) fund under the EU's sustainable finance disclosure regulation (SFDR) schema. Over the next year, we believe that a confluence of investor pressure and regulatory actions will push ESG-oriented asset managers to better define, integrate, and defend their investment processes. Funds will need to provide clear parameters around the intent of their strategies and the metrics they use to assess companies' ESG progress. ESG factors will increasingly contribute directly to security selection and weighting.

Generational Shifts

Gen Z and Millennial consumers' spending and investment influence are set to grow and ESG & sustainability are more important to them relative to older consumers. Based on Cowen's Gen Z & Millennial survey, 79% of Gen Z consumers and 74% of Millennial consumers consider sustainability and social impact either "important" or "very important" when purchasing a brand. Gen Z and Millennials should grow to 70% of the population by 2028 vs. 60% today and they will inherit an estimated $60 trillion of wealth by 2042.

COWEN EVENTS

Cowen Global Transportation & Sustainable Mobility Conference
September 7-9, 2022

Cowen Next-Gen Fuel Summit: Renewable Diesel & SAF
June 16, 2022

Cowen WRG Washington Climate/Energy Policy Day
June 13, 2022

Cowen Sustainability & Energy Transition Summit
June 7-8, 2022

Cowen & Bloomberg Intelligence: ESG and Energy-Transition Webinar Series
Ongoing Conference Call Series

Cowen ESG: Today Shapes Tomorrow Webinar Series
Ongoing Conference Call Series

Cowen Navigating The ESG Path Series
Ongoing Conference Call Series

Energy Transition Series
Ongoing Conference Call Series

Mobility Disruption Series
Ongoing Conference Call Series

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Download the new brochure that highlights Cowen Research's ESG philosophy, areas of coverage, dedicated products, events, and people, and our ESG scoring methodology.

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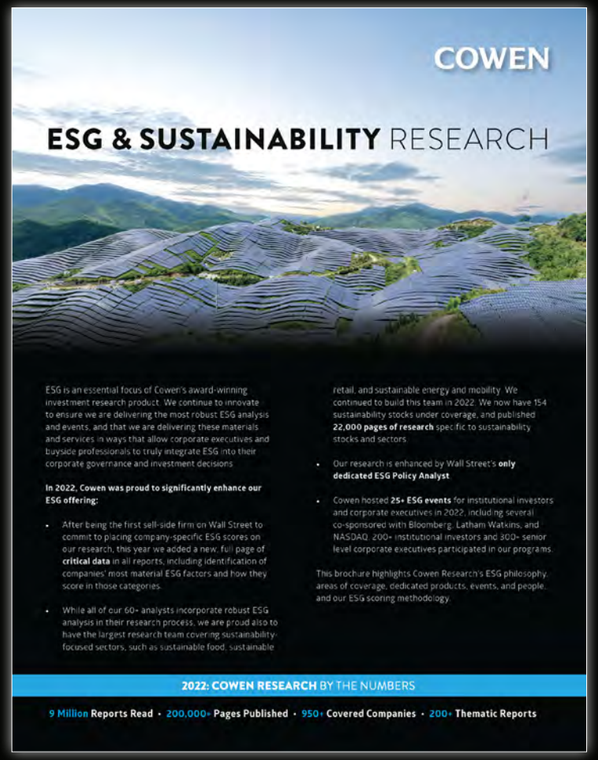
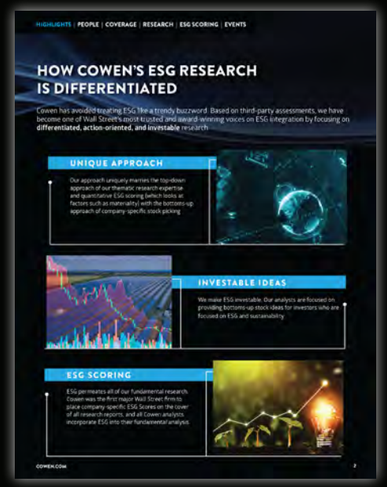
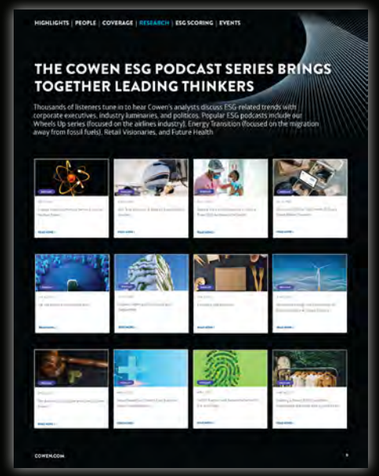






FUTURE OF PUBLIC HEALTH

COWEN RESEARCH THEMES 2023

"The future of public health will see private and public entities engaged in a coordinated, robust approach to limiting disease spread, and providing essential benefits and resources to employees."

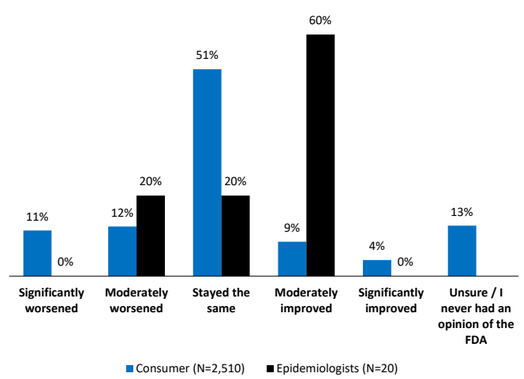
COWEN

The COVID-19 pandemic changed the way public health crises will be managed in the future – hopefully for the better. The future of public health will see private and public entities engaged in a coordinated, robust approach to limiting disease spread, and providing essential benefits and resources to employees. But this transition will require action across multiple sectors, and at all levels of government. 2023 should see new policies and enabling technologies evolve to better help address future public health crises.

At the U.S. federal level, public perception of successes were found mainly with the FDA and the DOD. The FDA acted quickly to authorize tests, therapeutics, and vaccines, and the DOD assisted in an early response to major cities, shuttled necessary PPE from overseas to hospitals in the U.S., and later stood up vaccination centers and delivered tests.

In the height of the pandemic, the private health care sector harnessed its intellectual prowess, manufacturing capabilities, and significant scientific resources to reprioritize programs, redistribute manufacturing capacity, and collaborate at a scale not seen before. These efforts resulted in the rapid development of two COVID-19 vaccines authorized for emergency use in the U.S. within 12 months of the virus being detected and less than 11 months after the sequence became available. While vaccine development before the COVID pandemic typically took years, in the last two and a half years, the FDA authorized four COVID-19 vaccines with an average development timeline from human trials to authorization of 13 months, including several that employed novel mRNA technology.

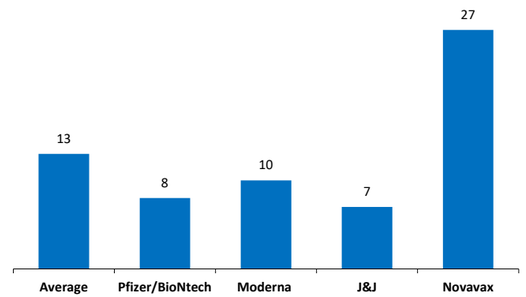
Since The Start Of The Pandemic, My Opinion Of The FDA Has...



Source: Cowen Proprietary Consumer Survey, July 2022; Cowen Proprietary Epidemiologists Survey, August 2022

Novel Vaccines Produced In Record Time

Months From First Patient Enrolled Until EUA Granted

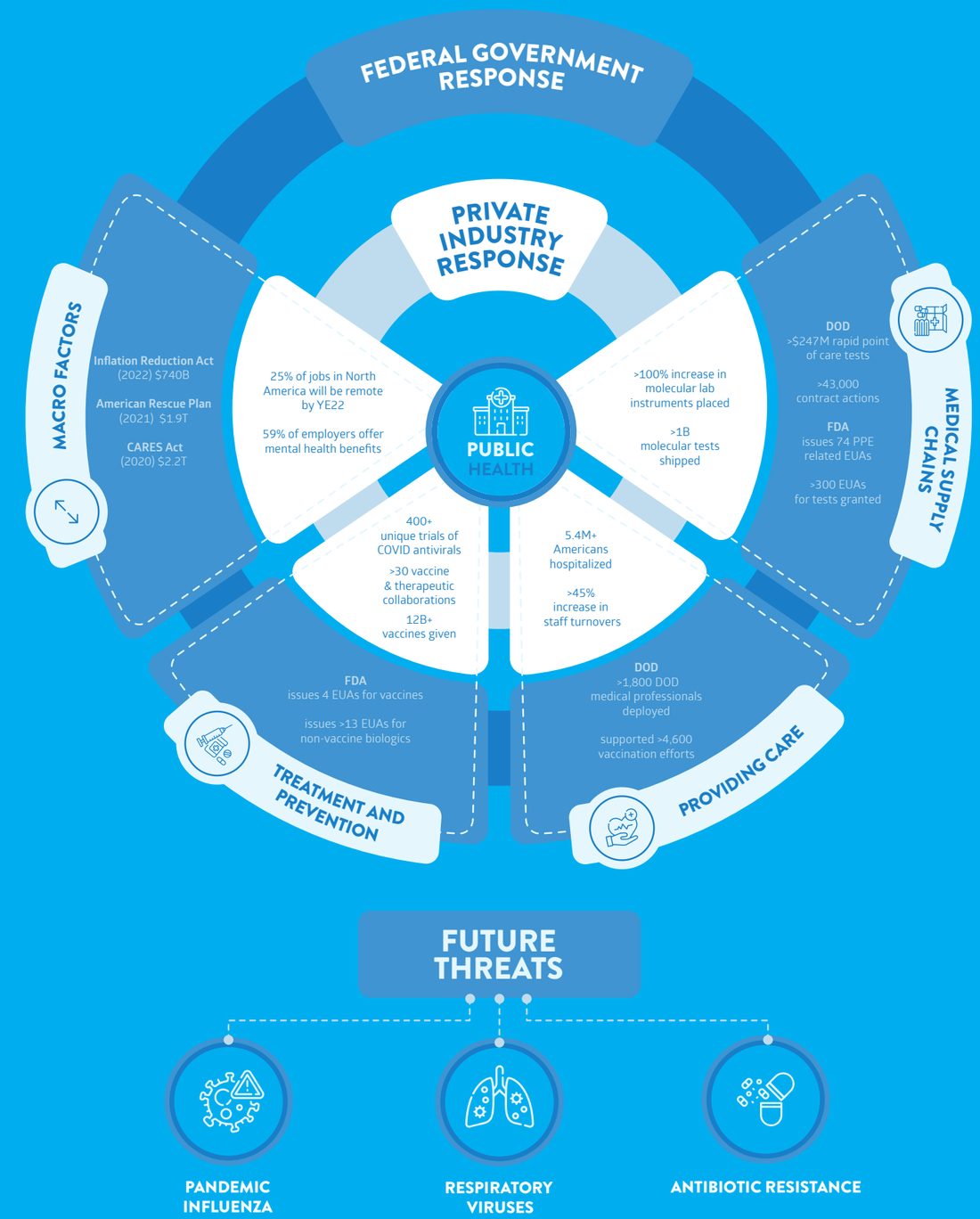


Source: Cowen, FDA, Company websites

The intention of all vaccines is to expose the human body to a foreign antigen that will induce an immune response that is sufficient to protect from future infection. Whether a vaccine includes a weakened form of the virus itself, fragments of key proteins, or the genetic material needed to create key proteins, this robust immune response is the goal. mRNA vaccine technology contains the "instructions" in the form of messenger RNA (mRNA) which the body will produce and then form antibodies against. The success of mRNA vaccines during COVID-19 changed the face of response for future pandemics.

There are several advantages to mRNA vaccines, but with respect to pandemic preparedness, two are most critical: Rapid development from target selection to product candidate (weeks or months vs. years for other modalities) and rapid scale-up of product due to a relatively generic manufacturing process that doesn't have to be reconfigured or adjusted based on the exact product being made.

SNAPSHOT: PUBLIC HEALTH RESPONSE SHARED ACROSS PRIVATE & PUBLIC ENTITIES



Source: FDA, DOD, AdvaMed, PhRMA, LinkedIn, Harris Poll, Cowen and Company

Ultimately, Cowen believes the ability to rapidly develop mRNA vaccines for nearly any viral target should enable future preparedness for any significant mutations/variants to SARS-CoV-2 (as we have seen with Delta, Omicron, and others), for the next pandemic, and for other infectious diseases for which there is no vaccine (or where current vaccines are not very effective).

During the pandemic, we also saw unprecedented collaboration among biopharma and medical products companies, and cooperation across sectors. Cowen counted more than 26 partnerships to assist with manufacturing various vaccines and antibody therapeutics.

As COVID spread globally, the private sector assumed a larger role in protecting the population by offering remote work capabilities and other measures to ensure workplace safety. Many private enterprises emerged from the pandemic with a higher public perception of trustworthiness than the government. For example, in March, the Edelman Trust Barometer poll found that ~77% of Americans trusted their employers, with non-profits coming in second, more than the government.

Since the height of the pandemic, many corporations have continued to offer remote work options (which in many cases has increased the number of total worker hours) and have increased mental health service offerings (59% of employers offered such offerings in 2022, up from 52% in 2021, according to a Harris Poll survey). In a tight labor market, these work options are likely to persist.

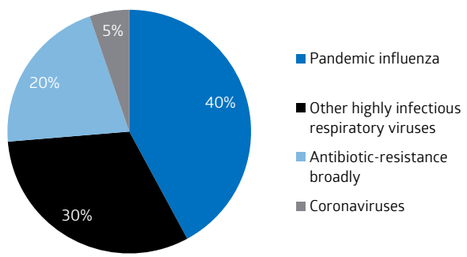
WHAT WE'RE WATCHING

In 2023 and beyond we anticipate progress on several public health fronts, including at the federal level, where they seek to restructure agencies such as the CDC while elevating other offices (and potentially creating more agencies) in an effort to improve the government's pandemic response.

Biden Administration Biodefense Strategy

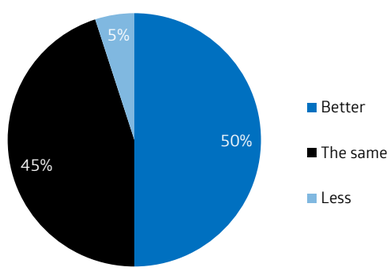
In October, the administration revealed its National Biodefense Strategy and Implementation Plan, in which it gave FDA a supporting role and outlined ambitious goals for the future. The plan envisions investing in domestic vaccine infrastructure to be able to "develop vaccines within 100 days; manufacture enough vaccine for the population of the United States within 130 days; and work with international partners to develop sufficient vaccine supply for high-risk global populations within 200 days." The plan sets similarly ambitious goals for therapeutics: Invest in capacity to be able to "accelerate therapeutic development and validation to repurpose existing drugs within 90 days or develop novel therapeutics within 180 days." These development goals are associated with a request for $88.2 billion of mandatory funding in the President's FY23 proposed budget that would provide $16-17 billion per year, over five years, largely to the United States Department of Health and Human Services (HHS), the U.S. State Department, and USAID.

What Is The Pathogen Of Greatest Concern?



Cowen and Company Proprietary Epidemiologists Survey August 2022 (N=20)

How Prepared Do You Feel We Are For The Next Pandemic?



Cowen and Company Proprietary Epidemiologists Survey August 2022 (N=20)

DOD's Biodefense Posture Review

In addition to the Biden Administration's Biodefense Strategy, the U.S. Department of Defense is currently undergoing its first-ever posture review of its biodefense efforts. With this review anticipated to wrap by the end of 2022, we will be watching to see what, if any, major changes are made.

CDC Restructuring

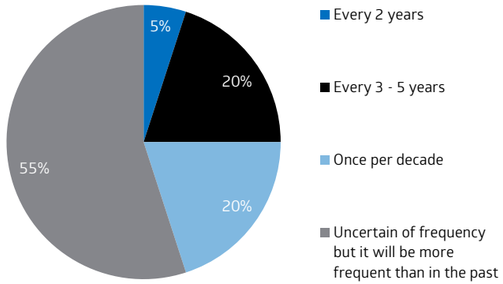
In response to criticism during the pandemic, in August 2022, the U.S. Centers for Disease Control and Prevention (CDC) announced a restructuring to help it better respond to future public health crises. The CDC lost significant ground in its reputation among Americans and epidemiologists, according to Cowen's July and August 2022 surveys. Key systemic challenges within the agency, including inconsistent data requirements and an overly academic mentality, hamstrung its response to the pandemic, as well as other public health crises such as the monkeypox outbreak in June 2022. The reorganization will need to include an overhaul that standardizes data collection and shifts to a more pragmatic and rapid-response mentality.

Additionally, as the November mid-term elections change the face of Congress, we could continue to see pressure to make the CDC director a confirmed position – a priority among Republican lawmakers. The PREVENT Pandemics Act in the Senate would seek to make the CDC director a Senate-confirmed position. We believe the chances of that portion of the bill surviving are above 50% and expect action on the bill in the lame duck or in 1H23.

Antibiotic Resistance

Cowen's August 2022 survey of epidemiologists found that the consensus view is that a pandemic the severity of COVID-19 is unlikely in the next decade. However, the frequency of infectious disease outbreaks is increasing, with concern over antimicrobial resistance a top concern. Anti-microbial resistance is borne out of infections treated with antibiotics that are not effective against a certain bacterial infection or poor antibiotic stewardship. During COVID-19, there was an increase in antibiotic resistance, further escalating a growing public health crisis.

At What Frequency Should We Expect To Experience An Outbreak Of Any Scale In The Future?

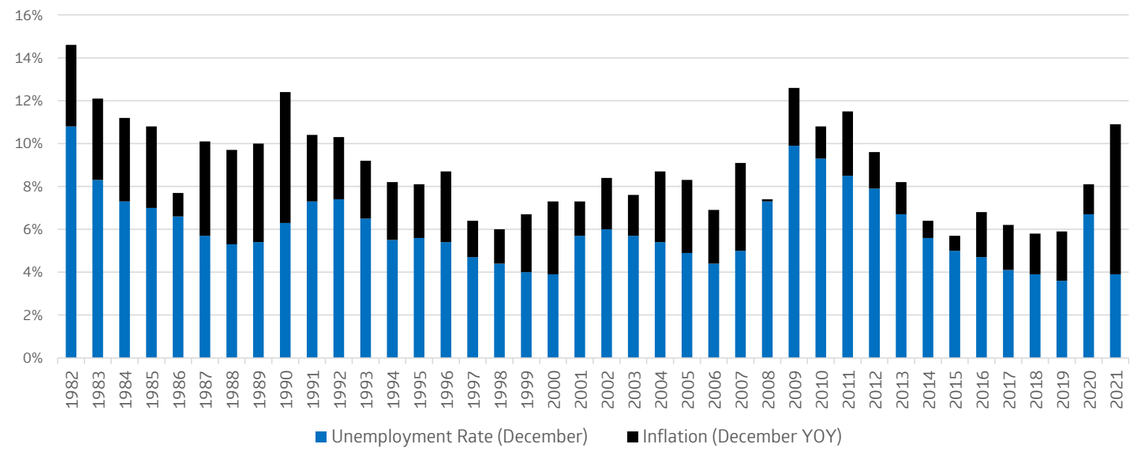


Cowen and Company Proprietary Epidemiologists Survey August 2022 (N=20)

After over five years of progress at reducing deaths from antimicrobial resistance, there was a "significant increase in antimicrobial use, difficulty following infection prevention and control guidance, and a resulting increase in health care-associated antimicrobial resistant infections in U.S. hospitals," the CDC determined in a July 2022 report. Hospital infections and death both increased at least 15% during the first year of the pandemic, the agency found.

Cowen will continue to track the progress of antimicrobial resistance, as well as the pipeline of novel antibiotics in the clinic. However, development of these newer agents requires a shift in the commercial model. Novel antibiotics are often the

Historical Annual Unemployment & Inflation (1982-2021)



Source: Bureau of Labor Statistics and Cowen and Company

last line of defense used by doctors in treating an infection and thus sales volumes are often too low to justify the R&D costs to develop them in the first place. While policies in the U.S. to change the payment model for antibiotics have stagnated, the U.K. is testing a subscription-based model as a "pull" incentive for biopharma companies. In June 2022, the U.K. announced that Shionogi and Pfizer would receive a maximum of $13 million per year for the next decade from the U.K.'s National Health Service for two new antibiotic products. In a subscription payment model, the companies are paid a fixed sum for the antimicrobials based on a health technology assessment of their value to the United Kingdom National Health Service (NHS), not the volumes used. The drugs include Shionogi's cefiderocol and Pfizer's ceftazidime-avibactam.

Macro Policy Fallout From COVID-19 Relief Bills

The legislative response that pushed $2 trillion in U.S. federal dollars to many American individuals and businesses during the pandemic was successful in aiding economic recovery. However, some legislators saw lengthening unemployment benefits, stimulus checks, and Paycheck Protection Program (PPP) dollars as potentially causing more harm than good in that they could have lasting impacts on inflation, the deficit, and unemployment levels.

Other Public Health Crises Created By COVID-19

The pandemic upended traditional health care. Many surgeries were delayed or cancelled, well-child visits were put off, annual health exams were cancelled, and a growing increase in vaccine hesitation ensued. Additionally, the health impacts of COVID-19, including lung scarring and residual infection, identified a new, potentially chronic condition – "Long COVID." With these issues highlighted as key concerns among epidemiologists in our August 2022 survey, we will be watching their evolution and implications for biopharma and medtech companies.

The Progress Of mRNA Vaccines

Moderna and Pfizer/BioNTech ushered in a new era of vaccine preparedness with the successful development and manufacturing scale-up of their COVID-19 mRNA vaccines. As both companies move their platforms into seasonal influenza vaccines, COVID-19 boosters, and other infectious pathogens of concern, we will be watching to see if the associated vaccines are as successful in terms of efficacy as well as safety/tolerance and uptake. Moderna is developing a vaccine for nipah virus, and BioNTech is developing vaccines for malaria and TB. Both are also developing vaccines for influenza.

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Cowen 25th Annual Therapeutics & MedTools Conference
October 11-12, 2022

Cowen RNA Therapeutics Summit
July 31, 2022

Cowen Tools/Dx Revolution
June 26-29, 2022

Cowen 7th Annual FutureHealth Conference
June 22-23, 2022

Monkeypox Vaccines And Therapeutics Webinars With BAVA, CMRX, EBS And SIGA
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Biden Biodefense Strategy Sets Ambitious Goals For Future Vaccines, Therapies
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Monkeypox Outbreak Grows, Key Concern Is The Virus Becomes Endemic In The West
August 17, 2022

Monkeypox Update: Cases Continue To Rise, WHO To Hold A Meeting On July 21st
July 20, 2022

Monkeypox Outbreak Likely To Be Well Contained With Existing Vaccines/Drugs
May 25, 2022

FDA Accelerated Approval Reforms Included In Budget; Action Possible This Year
March 29, 2022

HHS Supply Chain Report Calls For Contingency Plans On Biotech Products
February 25, 2022

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FUTURE OF WAR

COWEN RESEARCH THEMES 2023

"There are new modes of threat, including risks to cyber and biosecurity that are determining the planes on which future wars will be fought."

COWEN

Russia's escalation of its war on Ukraine on February 24, 2022 was the largest act of aggression in Europe since World War II and a startling demonstration of deepening global security dilemmas that shattered decades of geopolitical status quo. Two decades after the 9/11 attacks and resulting war on terror, new conflicts are forcing the West to shift its diplomatic, economic, technology, and military strategies. The U.S.-China relationship is, by many measures, at its worst state in years, with China's military having grown to the point where it is a potential threat to U.S. dominance. Questions abound as to whether (or when) President Xi Jinping might invade Taiwan. Nuclear defense strategy is being re-examined given threats by Putin to use nuclear weapons in the war with Ukraine, and proliferation by rogue states like North Korea and Iran.

This coincides with a technology-driven arms race that will dramatically shift the way we fight wars in the future, driving an upswing in U.S. and European defense spending. Cowen expects at least a 10% increase in the U.S. defense budget in FY 2023, equating to around $50 billion. U.S. Department of Defense spending on research & development is surging to its highest level in 70 years in a push to develop next-generation weapons like hypersonic missiles and find battlefield uses for commercial technology, such as drones. There are new modes of threat, including risks to cyber and biosecurity that are determining the planes on which future wars will be fought.

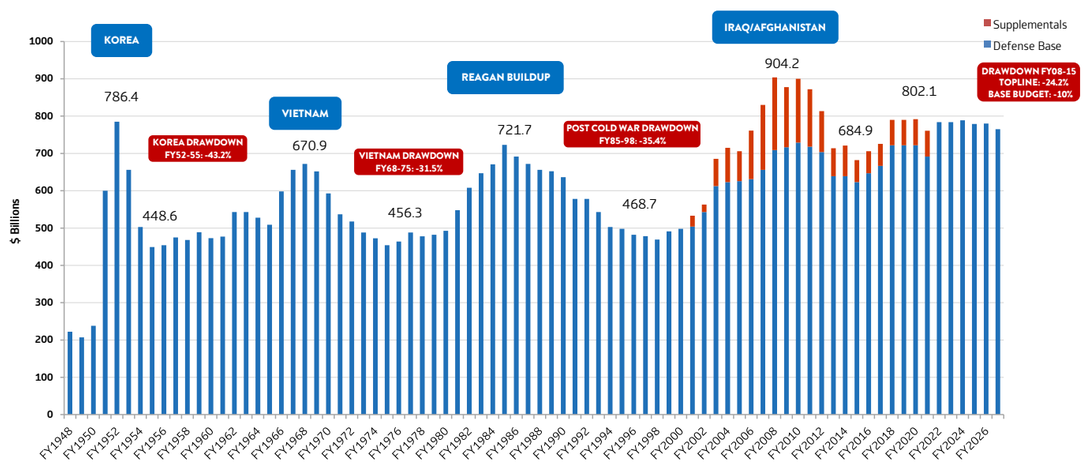
Below we detail areas we will be watching closely in 2023: Russia/Ukraine, China/Taiwan, the Middle East, cybersecurity, next-generation technology (i.e., space, hypersonics, biodefense, and unmanned robotics), and technology policy. Cowen's expertise in aerospace & defense, software, semiconductors, and cybersecurity, and the geopolitical insights from our Washington Research Group, help investors navigate these dynamics.

WHAT WE'RE WATCHING

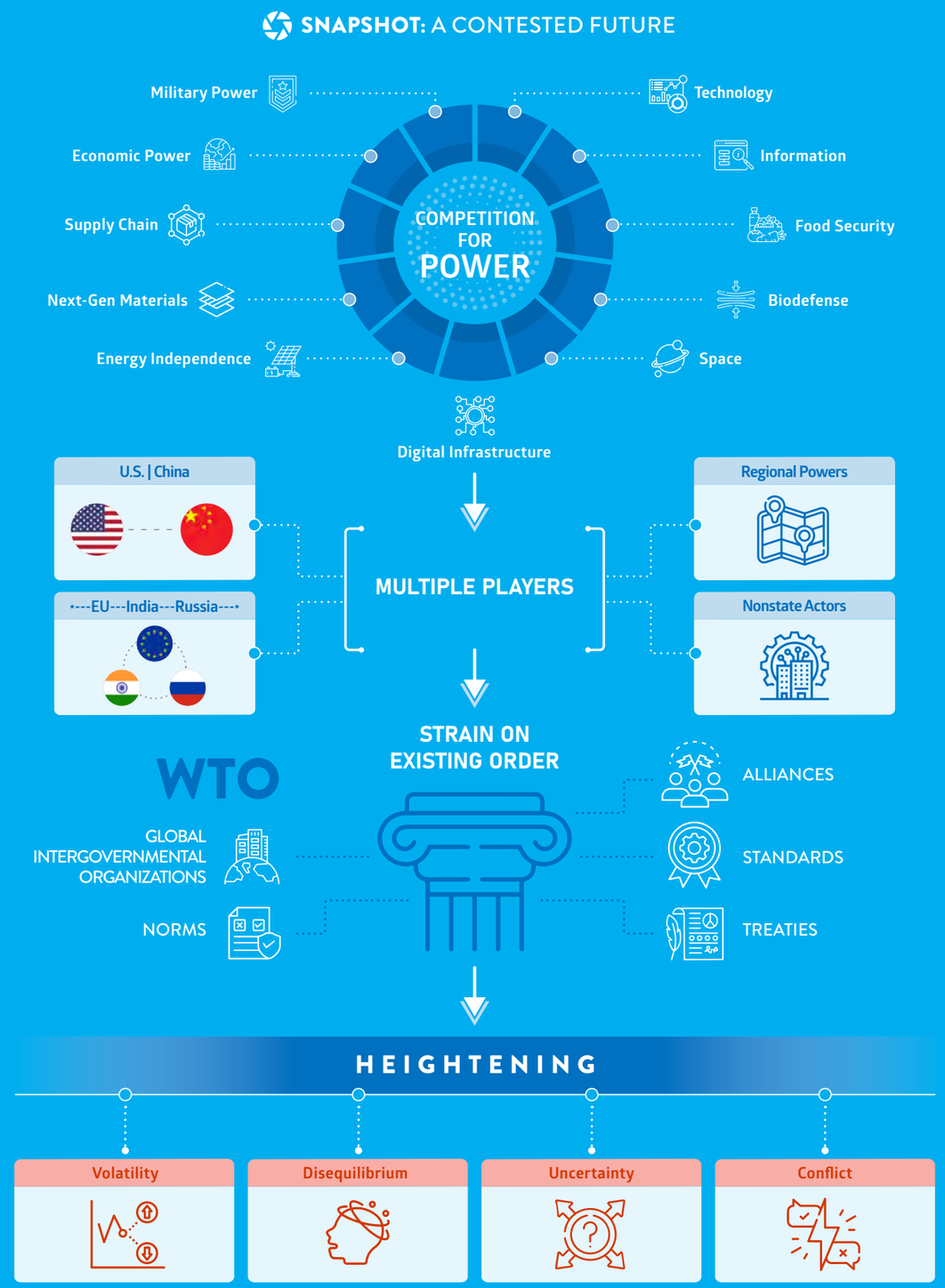
Russia/Ukraine

Russia's war against Ukraine has once again reminded the world that despite decades of technological advancement since the last major ground war, nation-versus-nation combat remains bloody and costly. Both sides have lost many people and resources, and the world has suffered economic losses in the form

DoD Budget Authority Spending Cycles



Defense Spending - Constant FY23 Dollars
Source: The Punaro Group, Cowen and Company



Source: Office of the Director of National Intelligence, Cowen and Company

"The most pressing issue in U.S.-China relations is China's relationship with Taiwan and the potential for military conflict, particularly should events outlined in the PRC's anti-secession law occur, such as Taiwan declaring de jure independence."

of higher energy prices, food shortages, and supply chain disruptions. The conflict has forced a rapid recalculation of alliances, pulling even longstanding neutral nations into its orbit. It has forced the U.S. to return its attention to Europe, a region where it had been reducing its military footprint, and to review overall military doctrine to incorporate lessons from Russia's ground war failures and the impact of unmanned armaments such as drones.

Indeed, Ukraine's ability to withstand the onslaught by a military as powerful (as least theoretically, or in terms of spending) as Russia's has provoked a rethink of many long-held assumptions. For example, if Ukrainian forces can destroy a Russian tank by dropping grenades from a homemade drone, what does that mean for a tank-heavy army like that of the U.S.? Many observers assumed Russia would have won quickly and easily, yet it did not.

This has culminated in a view of future warfare that in many ways is similar to wars of the past. Global alliances matter. Offense is harder than defense. Air supremacy is key to controlling the ground. Heavy weaponry is crucial, and the more the better.

Russia's greatest lever in this fight may be its control over energy resources in Europe. As cold sets in, will leaders who have condemned Russia be able to maintain their stance when their citizens are suffering from food and fuel shortages and economic pressures? The answer to that question will reveal much about geopolitical resolve and the role it will play in future conflicts.

China/Taiwan

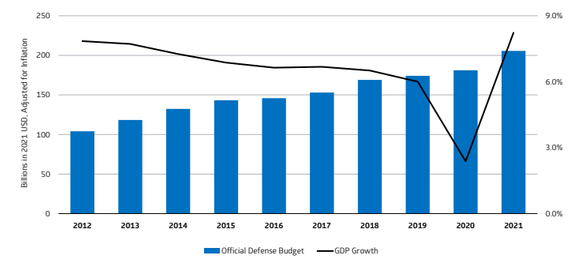
Over the past 30 years, China has evolved into an integrated and technologically advanced military force. It has put the full strength of its industrial and technological base behind its defense effort by funneling money into private sector initiatives aimed at generating military advances.

The latest U.S. assessment of China's military strategy highlights some remarkable facts. China's defense budget has doubled over the past 10 years, growing around 7% annually. China is on track to have at least 1,000 nuclear warheads by 2030, exceeding projections the U.S. made two years ago. China's navy is now the largest in the world with 355 ships, expected to grow to 420 by 2025 and 460 by 2030. China has fielded its first hypersonic missile and bolstered its space-based operations (both space-based assets and the ability to destroy other satellites).

U.S.-China relations have grown more tense due to Russia's invasion of Ukraine and continued economic statecraft. The most pressing issue in U.S.-China relations is China's relationship with Taiwan and the potential for military conflict, particularly should events outlined in the PRC's anti-secession law occur, such as Taiwan declaring de jure independence. The PRC's "One-China" principle states that Taiwan and mainland China are both part of China. China has declared a desire for "peaceful reunification," but has not ruled out the use of force. At October's Chinese Communist Party's 20th national congress, Chinese President Xi repeatedly stated his opposition to Taiwan independence, stating that "resolving the Taiwan question and realizing China's complete reunification is, for the Party, a historic mission and an unshakable commitment."

"Beijing seeks to reshape the international order to better align with its authoritarian system and national interests," the U.S. Department of Defense wrote in its annual assessment. It went on to forecast that if China's military stays on its current growth path, by 2027, it will be capable of successfully conducting forced reunification with Taiwan.

China's Official Defense Budget, 2012-2021



Source: Office of the Secretary of Defense, Cowen and Company

Protecting Taiwan's current status may come down to the U.S.'s ability to develop technologies to combat a PRC incursion. It will also depend on Taiwan's ability to defend itself if need be — an area where it may learn lessons from Ukraine. Regional alliances like The Quad, consisting of the U.S., Japan, India and Australia, will also be important, along with technology-led efforts like bringing nuclear submarine and long-range strike capabilities to Australia.

Cowen believes that China's relationship with the West will continue to be tense. The question is whether China can become a strong enough military and economic superpower to gain sway with neighbors such as the Philippines, India, Indonesia, or others. In doing so, China could minimize the U.S. presence in Asia and potentially compel Taiwan to negotiate on Beijing's terms.

The Middle East

Iran is a central figure in the potential for armed conflict in the Middle East. The United States and Iran severed diplomatic relations back in April 1980. More recently, relations worsened under the Trump Administration with the U.S. withdrawal from the Joint Comprehensive Plan of Action (JCPOA). What has followed is a series of events, further ratcheting up tensions: Iran's reversible breaches of its obligations under the nuclear deal (i.e., exceeding limits on its stockpile level of enriched uranium); Iran's suspension of the Additional Protocol with the International Atomic Energy Agency; a series of focused Iranian attacks against oil interests, including a Saudi Arabian oil facility; an attack on a U.S. drone; the U.S. authorization of a drone strike that killed Iran's top military leader, General Qassem Soleimani; and the imposition of trade sanctions against Iran. Recent efforts to restore the JCPOA have not been successful. A nuclear-armed Iran would pose a threat to the United States and Middle East region. It remains to be seen how U.S. and regional policies of deterrence and containment will unfold.

Cybersecurity

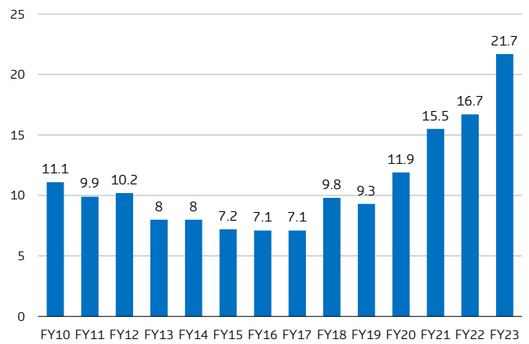
Cyber is another key front in contemporary warfare. The Russia-Ukraine war brought this into stark relief with the cyber attacks launched by each country on the opponent's mission-critical infrastructure at the outset of the conflict. Meanwhile, Chinese hacking activities toward the U.S. have shown no signs of slowing. In one striking example, in May 2022, privately held Cybereason uncovered a sophisticated and difficult-to-detect long-term hacking campaign against the U.S. that had been previously unnoticed.

Cowen believes that wars of the future will be as much about the power of information as they are about lethal firepower. The potential of quantum computers to break security codes could have severe consequences and is a significant factor we are monitoring. A 2021 report by the U.S. National Intelligence Council's Strategic Futures Group predicts that connectivity will be key for future militaries in that the advantage will go to the side that can most efficiently collect, analyze, and communicate data—or, conversely, to the side that can most swiftly disrupt or disable an opponent's ability to do the same. Private sector tech players will be crucial. In one sign of what's to come, Microsoft was awarded a contract worth potentially up to $22 billion by the U.S. Army

"Cowen believes that wars of the future will be as much about the power of information as they are about lethal firepower."

FUTURE OF WAR

DoD Space-Based Systems Annual Budget Request ($ billions)



Source: DoD

to produce "mixed-reality" headsets. We expect this trend to continue, especially with the CHIPS act and other incentives to homegrow U.S. technology.

New Frontiers

Mounting geopolitical tensions are reflected in an equally tense next-generation arms race that is driving defense budgets higher in a cycle of technological innovations and counters among rivals.

Cowen believes that space will be one of the fastest growing areas of defense spending. The DoD requested almost $22 billion for space systems for FY23, a significant increase from $17 billion in FY22. China's space program is second only to the U.S. in number of operational satellites, and it is continuing to launch satellites with a range of advanced capabilities including intelligence, surveillance and reconnaissance; high-data rate advanced communications satellites; precision navigation and timing; new weather and oceanographic satellites; and space-based anti-satellite weapons.

Hypersonic missiles are an important factor in space-based defense. A U.S. Congressional Research Service report indicated that Russia fielded its first hypersonic weapons in December 2019, and that some experts believe that China fielded hypersonic weapons as early as 2020. Hypersonic missiles travel at five times the speed of sound (about one mile per second) and maneuver with precision directly toward a target (in contrast to a ballistic system, which sends a missile up and back down to earth in a parabolic arc). The U.S., which has invested billions of dollars in ballistic missile

DoD's Shift To National Defense Strategy Is The Biggest Change In 40 Years

LESS ALIGNED		MORE ALIGNED	
GROUND FORCES	• Smaller, lighter USMC Pacific-focused • Smaller, tank-heavy Army European-focused	NUCLEAR TRIAD	• Columbia, B-21, GBSD are growing • Smaller programs face some risk (TLAM-N)
LEGACY AIRCRAFT	• Retire less capable aircraft • Retire expensive to maintain aircraft	SPACE	• Significant spending in Classified • Disruption from comm'l/nontraditional
MANNED NAVAL	• Survivability of 'big decks' debate may be over • New platforms – SSN & DDG – expensive	MISSILE DEFENSE	• Core programs being updated • FMS still very strong: Europe, Asia, MENA
STATIC C4I	• Current systems vulnerable to attack • Cannot operate in 'denied' environments	NDS WEAPONS	• Hypersonics, directed energy and new weps • DoD restocking and increasing inventory
TRADITIONAL PRESENCE	• Shift forces from MENA to INDOPACOM • Shift forces from Germany to E. Europe • Burden-sharing Korea/Japan	UNMANNED & ROBOTIC	• Next-gen aircraft in development • Ground & Maritime next frontiers but delayed • Disruptions and tradeoffs to manned
4th ESTATE INFRASTRUCTURE	• Reduce DoD headcount and infrastructure for back-office and support functions. • Shift money to R&D and procurement	HIGH-TECH ENABLERS	• Mixed bag of new tech: 5G, AI, etc. • C4I & Data links: JADC2

Source: Cowen and Company

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defense, is rushing to assemble effective defenses against hypersonics. Space-based sensors, direct energy defenses and other systems being developed by the U.S. Space Force and the DoD's Missile Defense Agency in conjunction with corporations such as Raytheon and Northrup Grumman will become critical to defending against this new threat. In 2022, the U.S. Air Force successfully test-fired its own hypersonic weapons.

Biodefense

The U.S. National Biodefense Strategy, updated in October 2022, outlines what the country is doing to protect itself from a biological threat, whether natural, accidental or deliberate. The crux of the plan involves rebuilding U.S. biomanufacturing capabilities to support rapid delivery of vaccines and therapeutics in the event of an emergency. It also includes specific goals for developing novel antivirals and "pathogen agnostic" therapies that can be stockpiled in advance of a threat. The goals in the plan are associated with a request for $88 billion of mandatory funding in the President's FY23 proposed budget.

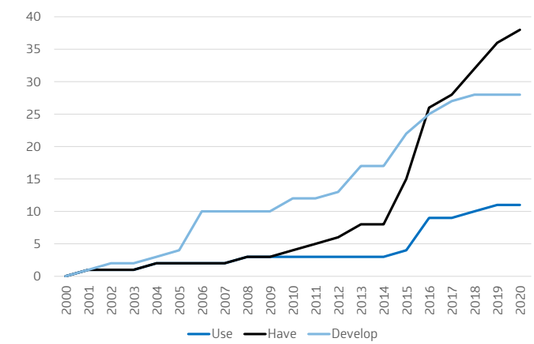
Unmanned and Robotic

Ukraine's effective use of aerial and maritime drones are proof points of unmanned technologies' military potential. The U.S. Navy sees maritime drones as a key part of its strategy to leverage next-generation technologies against U.S. adversaries. Unmanned Underwater Vehicles (UUVs) enable the creation of an underwater intelligence, surveillance, and reconnaissance network that mirrors U.S. aerial and land-based networks. According to a 2016 DoD report entitled "Autonomous Undersea Vehicle Requirement for 2025," submarine based UUVs will be used to extend the host submarines' effective range and to carry out missions considered too dangerous for crewed vehicles. Other unmanned technologies could also come into play for different applications, including eVTOL (electric vertical take-off & landing) vehicles, which could replace the HMMWV ("Humvees") for gear and personnel transport.

Technology Policy

Technology itself has become a key weapon in the fight for economic and military dominance, with China and the U.S. attempting to control each other's access to crucial technology and complex supply chains such as semiconductors. We believe the trade war always masked the larger tech war, which is in the early stages with more change ahead.

Number Of Countries That Have Developed, Acquired, And Used Armed Drones Over Time



Source: New America, Cowen and Company

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August 17, 2022

Cowen Semi-Annual DC Day: TMT Policy
May 2, 2022

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CANNABIS

COWEN RESEARCH THEMES 2023

"Cowen believes the industry can weather its growing pains through continued expansion into new adult-use markets, consolidation, and incremental regulatory relief."

COWEN

Q&A

The cannabis market has undergone significant transformation since Cowen became the first Wall Street equity research firm to cover the space in 2016. Adult use has increased, support for U.S. legalization has expanded, and despite federal wrangling, individual states with large metropolitan areas have continued to legalize and commercialize cannabis.

There remains a significant opportunity to transition a large illicit market that is currently 2x larger than the legal market. Cowen believes in the industry's long-term potential and projects the legal cannabis industry will grow to $42 billion by 2026 from $26 billion in 2022.

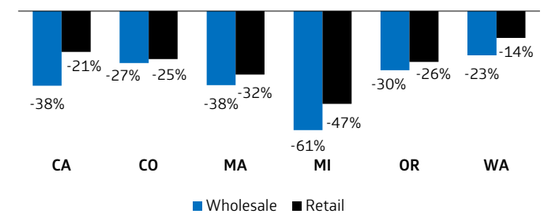
Federal legalization, which would dramatically improve the operating environment for U.S. cannabis businesses, remains at a standstill. State legalization, a slow process that has created a patchwork of isolated markets with unique dynamics, has continued to march forward. Prices, dependent on state-level supply and demand, have fallen dramatically due to operator scaling efforts in anticipation of state-level adult use legalization and market expansion through social equity licenses. Encouragingly for the industry, lower prices are driving volume growth as it narrows the price gap to the illicit market.

Cowen believes the industry can weather its growing pains through continued expansion into new adult-use markets, consolidation, and incremental regulatory relief. We discuss the roadmap for cannabis with Cowen's three top experts on the sector.

Q. Vivien, give us an update on your outlook and thoughts on growth of the U.S. legal cannabis market over the next five years.

A. ***Vivien Azer, Cowen Cannabis, Tobacco & Beverages Analyst:*** We continue to believe that legal U.S. cannabis sales, without federal legalization, can grow at a double-digit CAGR, driven by incremental state-level change, like the pending commercialization in New York State. We expect price deflation could persist for another year. When earlier states legalized, deflationary cycles generally lasted 18-24 months, at which point we witnessed a reduction in cultivation capacity drive stabilization in wholesale pricing.

Cannabis Prices Are Under Pressure



Source: Cannabis Benchmarks, Headset, and Cowen and Company

Q. How did the November 2022 mid-term elections in the U.S. turn out for the cannabis industry?

A. The "green wave" hit a wall. There were five ballot initiatives in the election that proposed adult use cannabis. Only two passed: Maryland and Missouri. But there are some interesting details beneath that headline. Maryland generated over $500 million of medical use cannabis sales in 2021, suggesting it will be a large recreational-use market and one that is germane to leading multi-state operators (MSOs). Missouri, a smaller market, was still a key win for cannabis advocates given it is a "deep red" state not well penetrated by the leading MSOs. And even in the three states that voted no—Arkansas, North Dakota and South Dakota—support for legal cannabis was over 40% in every case. That suggests a growing social acceptance happening even in more conservative states.

Q. Tell us about post-COVID consumer behavior in terms of cannabis. Do you expect continued migration from illicit to legal channels?

A. COVID drove notable increases in cannabis purchases, consistent with what we saw in alcohol and tobacco. Like those other categories, we are seeing a normalization in growth rates off those elevated levels. But the incremental sales seen during the pandemic have not reversed. For instance, California's legal market sales in 3Q22 were still 67% higher than 3Q19. Meanwhile, states where cannabis has been legal longer are also retaining those sales, with Oregon up 10% over 2019 levels, and Washington up 8%. Price deflation in legal cannabis is a very helpful mechanism in disrupting the illicit market, as is incremental state-level legalization.

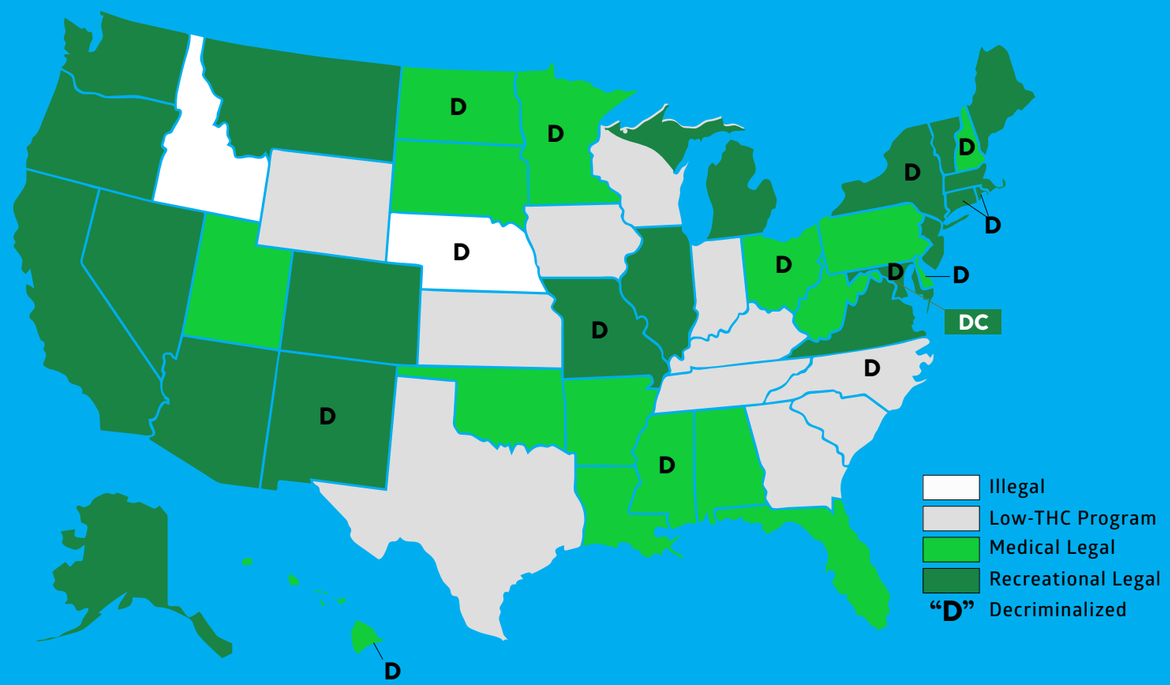
Q. What strategies are MSOs using to deal with current challenges of price declines and the lack of federal legalization?

A. To insulate margins against price deflation, most of the MSOs are prioritizing sales through their own retail network, where they can capture the most margin. Vertical integration has been a key theme. We are also seeing companies discuss more prudent capex deployment. With equity prices depressed, and the cost of capital rising with interest rates, M&A is more difficult to pursue right now. That said, we would expect continued consolidation over time as margin pressure from price deflation will make it more challenging for smaller operators.

Vivien Azer
Cowen Cannabis, Tobacco & Beverages Analyst

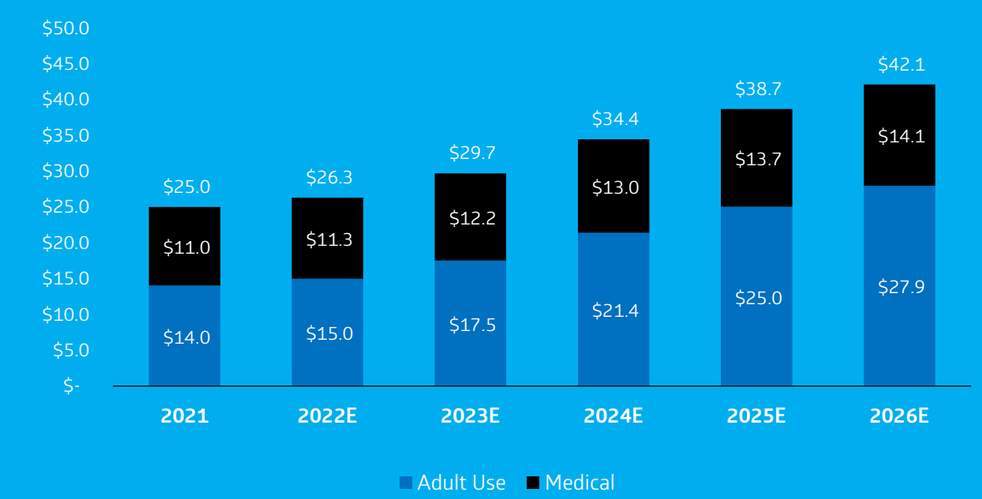
Vivien Azer is Cowen's senior research analyst specializing in cannabis. She was the first senior Wall Street analyst to cover this emerging area, and under her leadership Cowen has built up a coverage universe of key players in the space. Her work, which also encompasses research on beverages and tobacco, has earned her industry accolades, including a spot on Institutional Investor's All-America Research Team on several occasions. In 2022, Vivien was selected as one of the most influential names in cannabis on Forbes' "The Cannabis 42.0" list. She was also named to MJBiz Daily's list of "20 Women to Watch in 2019" and selected by Business Insider as a "Rising Star of Marijuana Investing." Vivien holds a BA from the College of William and Mary and an MBA from NYU's Stern School of Business.

BY THE NUMBERS: CURRENT STATE OF U.S. CANNABIS LEGALIZATION



Source: U.S. Census Bureau, State Data, Company Reports, and Cowen and Company

FORECASTED U.S. LEGAL CANNABIS TAM



Source: State Reports, Cowen and Company

Q. How does the current macroeconomic outlook potentially affect the industry (inflation, rising rates, tight capital, recession fears, supply chain issues)?

A. Broad consumer inflation is weighing on consumer spending on cannabis, and driving smaller basket sizes, but this is being offset by higher traffic. Price deflation in wholesale flower pricing is helpful to the consumer as it drives continued affordability.

Q. Are you bullish on Europe as a new frontier for legal cannabis?

A. Medium to long term, yes, but what we've learned is that cannabis regulatory change almost always takes longer (and sometimes much longer) than people expect.

Q. What about the Canadian market?

A. The Canadian market continues to grow, though price deflation persists. It also remains the case that often smaller operators have more success in capturing market share, relative to the larger incumbents, as they prove to be more nimble.

Q. A big focus for the U.S. industry is the SAFE Banking Act, which would allow legal cannabis businesses to tap into traditional banking services that are currently unavailable to them. Setting aside the timing of passage, let's talk about the implications this legislation would have for the industry. How would greater and cheaper access to banks affect the cannabis industry?

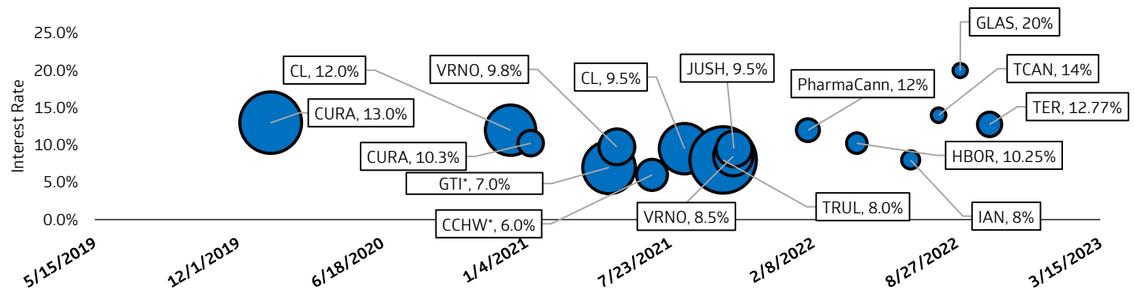
A. We expect that with the passage of SAFE, the cost of capital for MSOs could theoretically come down 100-300 bps, though we don't think major banking institutions will begin working with the cannabis industry, so cost of capital would likely remain elevated. Crucially, however, SAFE would allow for the use of credit cards for legal cannabis purchases, making purchasing easier for consumers and possibly having a modest benefit to overall basket size.

Historical Commentary From REITs On Passage Of SAFE Banking Act

MORTGAGE REITS		SALE-LEASEBACK PROVIDERS	
AFC gamma (ADVANCED FLOWER CAPITAL)	CHICAGOATLANTIC REAL ESTATE FINANCE	INNOVATIVE Industrial Properties	NewLake CAPITAL PARTNERS
1Q22: "..still believe that it's going to pass on lame-duck without capital market's support, which actually is the perfect storm for AFCG and the other lenders. **You're going to get additional institutions that can invest in us, but not necessarily the widespread banks and other lenders that can lend to the industry."**	**2Q22:** **"I think we'll lower our cost of capital. It will bring more capital into the market.** I think we've built a phenomenal brand, and we will be the beneficiaries of that growth."	**2Q22**: "Whatever SAFE Banking looks like, even if it's in a stripped-down version, it will be a benefit to the industry as a whole. And **that would give operators other options for capital, certainly given banking access**... Also, certainly, that would give us access to capital and different options for raising debt, which we think would certainly lower our cost of capital. So we look at it definitely as a net plus. ...We've always thought that, yes, maybe, again, depending what version of SAFE comes out, **there may be a little more competition**... So there's still going to be, **I think, a lot of the big national banks stay on the sidelines** because it's still a Schedule I substance. So if it happens, when it happens, we look forward to it and we think it will be a net plus for us."	**3Q21:** "We're actually excited for legalization. It's a net benefit for our business and allow me to explain. Number one, upon SAFE Banking passing or, ultimately federal legalization, improves the cash flow, profitability and risk profile of our in-place tenant base. And that improves the value of our assets or increases the value of the assets that we own today. Each one of these legislative steps also ushers in another boost to the industry in terms of acceptance and, more importantly, growth. And as we know, the centerpiece for growth for all of these businesses is rooted around real estate, locations to grow, manufacture, process, distribute, but also to sell."

Source: Cowen and Company

Evolution of Cannabis Debt Costs of Capital



Source: Company Reports and Cowen and Company

A. ***Jaret Seiberg, Cowen Washington Research Group Analyst:*** There is also symbolic significance to this measure, in that it would be the most significant cannabis measure that Congress has enacted. If passed, it would tell us that it is possible to find 60 votes in the Senate for other cannabis bills, even if legalization is not immediately on the table.

Q. Jaret, talk about the state of Capitol Hill's attitude regarding Federal legalization of cannabis. How far have we come, and how far do you think we can go in the coming years?

Jaret Seiberg

Cowen Washington Research Group

Jaret Seiberg is the financial services and housing policy analyst in Cowen's Washington Research Group, which has been routinely recognized by Institutional Investor as one of the top macro policy teams on Wall Street. He began covering financial policy in the early 1990s as a journalist, including roles as deputy Washington bureau chief for American Banker and as the Washington bureau chief for The Daily Deal. His bailiwick at Cowen includes issues related to cannabis, commercial banks, housing, payments, investment banking, M&A, taxes, the CFPB, cryptocurrency, and Capitol Hill.

A. Few issues have seen as dramatic a change in their political fortunes as cannabis. Even five years ago the politically safe position was to oppose legalization. Today, it is to favor legalization. That is why we believe cannabis legalization is possible. To us, it is not a question of if it happens, but when it happens. As we have long argued, policy changes as big as legalization take time. This was never going to be a two- or three-year battle. Washington doesn't change that fast.

Q. Vivien, how would federal legalization change the game for MSOs and other cannabis businesses?

A. ***Vivien Azer, Cowen Cannabis, Tobacco & Beverages Analyst:*** Federal legalization would allow for capital markets access, and the elimination of 280E, a section of the Internal Revenue Code that prohibits taxpayers who traffic in controlled substances (like cannabis) from deducting typical business expenses. It essentially taxes companies on gross profit and results in companies sometimes paying as much in income tax as they're generating in pre-tax income. Federal legalization would allow for a national wholesale network. There would be concern around further price deflation with this, but at the same time it would allow for far more efficient production, especially for value-added products like beverages that have complicated supply chains requiring scale.

Q. Jaret, is there a way for cannabis to be rescheduled from a Schedule 1 controlled substance so that 280E would no longer be a burden on operators?

> "Thomas argued that the federal government is no longer trying to govern cannabis because it is intentionally not enforcing existing laws against it."

A. ***Jaret Seiberg, Cowen Washington Research Group Analyst:*** Changing how cannabis is scheduled is a complex process that can be subject to legal challenges. It is not something that the president can do via executive order. It requires peer-reviewed research that can be replicated, which can be tough when dealing with a plant rather than a chemical compound. This is why we believe it will be years before the federal government is able to change how cannabis is scheduled. You also need a president in office at the time who supports the change.

This also ties into the punitive 280E tax treatment. Congress enacted 280E to prevent cannabis companies from taking normal business deductions from their taxes. Yet it also appreciated that the law could change over time. It is why Congress said 280E only applies if cannabis is a Schedule 1 or 2 drug. If it falls to Schedule 3 or lower, 280E no longer applies. The problem, as we noted earlier, is that it could take well beyond the 2024 election to change how cannabis is scheduled. It could even extend past the 2028 election. This is why the focus has been on getting Congress to remove it, which could be done if Congress legalizes cannabis or if it changes the tax law. Had Democrats emerged from the mid-term elections with wide margins in both chambers of Congress, then legislative action might have been possible. That didn't happen, which is why we don't see legislation to legalize or repeal 280E as likely over the next few years.

Q. What do you believe is the most likely path to federal legalization?

A. The courts may be the fastest path to legalization and removal of 280E. There is something called the

Eric Assaraf

Cowen Washington Research Group

Eric Assaraf covers health care and medical technology policy for Cowen's Washington Research Group, which has been routinely recognized by Institutional Investor among the top macro policy teams. His particular focus is on Medicare coverage and reimbursement issues, and he also closely watches state-level developments related to cannabis legalization. Mr. Assaraf received a bachelor's degree in communication and an MBA from the University of Maryland at College Park.

nullification theory that U.S. Supreme Court Justice Clarence Thomas discussed last year in a dissenting opinion. This is a bit complex, but it centers on the federalist system in in the United States in which the states have authority over anything the federal government does not specifically seek to govern. Thomas argued that the federal government is no longer trying to govern cannabis because it is intentionally not enforcing existing laws against it. He contends this means that the federal government has relinquished its right to govern cannabis, which means each state can decide if the drug is legal. We expect to see this legal argument in every cannabis case that makes it to an appeals court. If the courts agree, then cannabis would no longer be scheduled. And if it is not scheduled, then 280E does not apply. This would also take a few years to play out, but it might be faster than waiting for congressional or administrative changes to how cannabis is scheduled.

Q. Eric, talk about 2022 from your perspective looking at cannabis on a state-by-state level. What trends did you notice?

A. ***Eric Assaraf, Cowen Washington Research Group Analyst:*** While cannabis ballot initiatives went two for five in the mid-term elections, state-based legalization efforts will continue to shift toward "red states" as

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the number of pickup opportunities for the industry in "blue states" has narrowed. This is an important trend to watch, as legalization in conservative states could improve the political calculus on the federal level in the U.S. Legalization in conservative states puts pressure on Republican senators to support cannabis policies. We've seen it happen. For example, Steve Daines of Montana went from being an opponent to the co-sponsor of the SAFE Banking Act.

Q. What states are you watching most closely in 2023?

A. There's likely to be a lot of attention on Pennsylvania. States to watch in 2023 include Minnesota, Oklahoma, Ohio, and Delaware for adult-use, and Kansas and North Carolina for medical use. Ohio, given its population of around 12 million, is probably the most important from a market perspective.

Q. Vivien, what's investor sentiment like right now and what are some potential catalysts that might get institutional investors excited about the sector?

A. ***Vivien Azer, Cowen Cannabis, Tobacco & Beverages Analyst:*** Institutional investors did serious work on cannabis in 2018 and 2020 when there seemed to be tangible catalysts. Today they are showing less inclination to try to predict catalysts. The industry needs better access to capital including the ability to list on major U.S. stock exchanges. Until then, any re-rating of the stocks will likely be driven by transitory enthusiasm from retail investors. Institutional investors have become quite savvy when it comes to seeing through positive headlines that have limited tangible benefits to liquidity and access to capital.

Q. Is there a pathway for up-listing of cannabis stocks to U.S. markets soon?

A. ***Jaret Seiberg, Cowen Washington Research Group Analyst:*** It is difficult to see Congress giving the securities exchanges political cover to list cannabis companies. That means it will be up to the exchanges to change their own policies and permit listings. We see no evidence that the exchanges are likely to pivot, which is consistent with their cautious approach to listings of cannabis companies.

Q. Jaret, what other hurdles might the industry overcome in 2023 and beyond?

A. Interstate commerce is one possibility. We believe that is inevitable once there is legalization, but it doesn't have to wait that long. In theory, adjoining states could enter compacts that allow state-legal cannabis to move across their borders. But the reality is that states where it costs more to grow cannabis will not want to be inundated with cannabis from states with lower costs. Such exports could cause the loss of agricultural jobs in these higher-cost states, which would run contrary to the economic development theme that forms the foundation for many legalization efforts.

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