

GLOBAL X MODEL PORTFOLIOS

INVESTING IN THEMATICS FROM A PM PERSPECTIVE

As of March 2022



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INTRODUCTION

Expectations for technology are constantly changing. Just a decade ago, accessing the internet via a mobile device was clunky at best. Today, the slightest amount of buffering of HD video draws intense annoyance from smartphone users. As innovation begets innovation, the COVID-19 pandemic accelerated the adoption and use of important technologies spurring even more advancement. While the pandemic encouraged a step up in use, we think of this overarching trend as the continued shift from [Innovation to Utility](#), where new technologies build on ideas that came before, turning the revolutionary into the day-to-day. As workplaces regain normalcy, the technological tools utilized during the pandemic look to have staying power, launching Americans into a “New Normal” of technology.

In this white paper, we seek to detail key themes shaping our world. This iteration of the report is focused exclusively on the Disruptive Themes category, but later this year we will be releasing our analysis into the People & Demographics and Physical Environment categories. This research and analyses support some of the thematic investing decisions made in the Global X ETF Model Portfolios. Used standalone or as satellite strategies, our thematic approach strives to position portfolios for the future. Global X’s suite of Model Portfolios contains three strategies that are exclusively focused on thematic equity, and an additional seven model portfolios that include thematic equity in the context of a broader asset allocation. Our portfolios are actively managed (not static) and will enter and exit themes over time. As such, not all themes available will be directly represented at a given time. For more information on Global X Model Portfolios, including allocations, please consult our [Advisor Login](#).

THEMATIC EQUITY ADOPTION

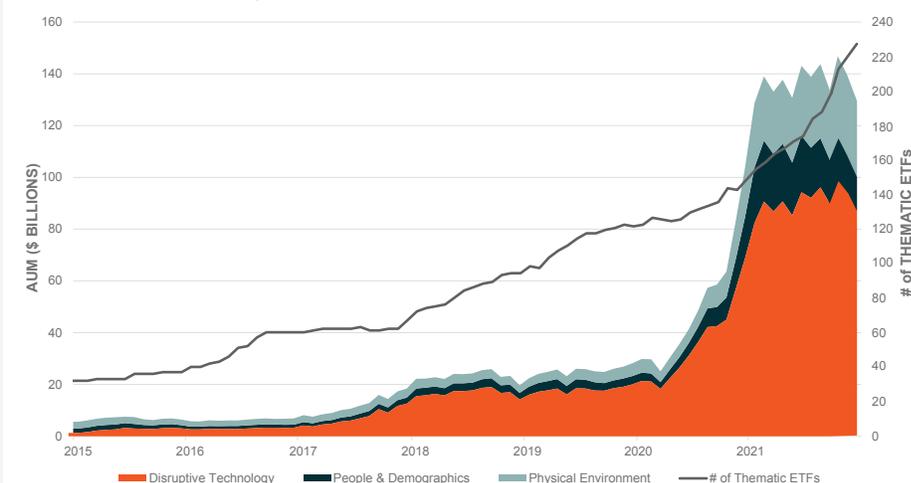
Interest in accessing thematic equity through ETF products increased significantly over the last few years. COVID-19 related lockdown restrictions and shifts in how society engages with technology drove a sharp increase in thematic adoption during 2020. While society is learning how to live with this virus as life is starting to return to normal, the technologies that enabled us to engage during the pandemic will be used as building blocks to the future.

“At the end of 2021, there were 229 thematic ETFs totaling **\$129.4B** in assets under management (AUM), down 3% from Q3 2021 but still **up 24%** from Q4 2020.¹”

¹ Global X Research as of 1/10/22

AUM OVER TIME

Source: Global X ETFs, Bloomberg Data as of 12/31/2021.



Note: AUM includes assets of funds closed until the last month of trading activity.



THEMATIC ADOPTION

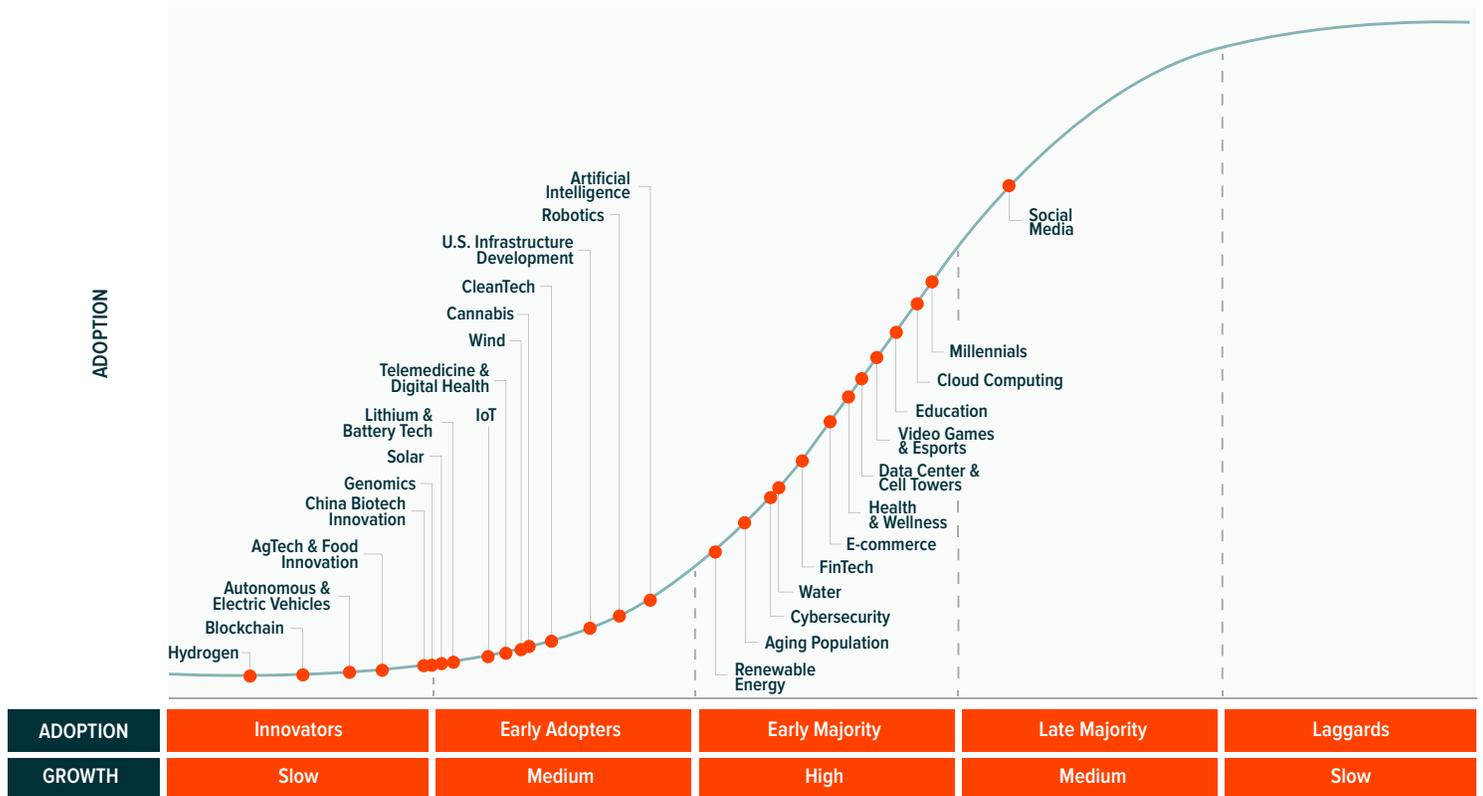
The adoption of new technologies typically follows an S-shaped pattern, with the rate of growth accelerating as the product gains mass acceptance, until eventual deceleration as the technology becomes pervasive (see chart). Our thematic strategies target themes in the Early Adaptors and Early Majority phases, and reduce exposure to themes as they advance into Late Majority territory.

The scalability of key technologies typically rises at higher levels of adoption, boosting revenue and potentially also profitability. While most themes experience gradual improvements in scale along the adoption curve, for themes that rely on interconnectivity, such as Social Media and to a lesser extent Video Games & Esports, monetization opportunities accelerate once the technology has high adoption levels and network effects make it is more difficult to switch to a different service.

In the disruptive technology category, we can currently trace majority of the structural changes to data and connectivity. As we transition to a digital future, this established new frontiers for interconnectivity.

THEMATIC ADOPTION

Source: EM Rogers, "Diffusion of Innovations", 1962, and Global X Research, 2020.



Data points along the adoption curve utilize the Global X ETF tickers to represent each theme. This is an indication of thematic adoption within society. This analysis is as of October 2021 and is subject to change. The curve does not in any way reflect past or future performance of the ETFs.

THEMATIC CLASSIFICATIONS

Global X Research has developed a holistic Thematic Classification System, designed to help investors better understand, track, and analyze the evolving thematic landscape. Focused on identifying powerful themes and organizing them by common traits and drivers, the system consists of four layers of classifications: Categories, Mega-Themes, Themes and Sub-Themes, with each layer becoming increasingly granular in its focus.

As of publication, the classification system is comprised of 3 categories, 11 mega-themes, and 42 themes. The number of each is expected to change over time as the thematic landscape evolves. The table provides an overview of the Global X Thematic Classification System and our takeaways from each mega theme.



Category	Mega Theme & Key Takeaway		Theme	
DISRUPTIVE TECHNOLOGY	The Infrastructure of the Digital World	Big Data Big Data's cloud computing and cybersecurity technologies integrate exceptionally well from a portfolio perspective, as the data-dense cloud necessitates ongoing cybersecurity spending and investment.	Machine / Deep Learning	
			Cybersecurity	
			Quantum Computing	
		Connectivity If AI is a system's brains, the Internet of Things (IoT) acts as the digital nervous system. Connectivity enables real-time and remote monitoring of autonomous systems.	Cloud / Edge Computing	
			Digital Infrastructure	
			5G / Next Gen Networking	
	UPCOMING			
	How it Relates to the Physical World	Robotics The adoption of robotic and AI tools combined with internet of things (IoT)-based sensors and massive scale cloud computing is sparking the Fourth Industrial Revolution, increasing the efficiency and effectiveness of factory-based production.	AI / Automation	
			3D Printing	
		Mobility We expect the Mobility theme to be boosted by the integration of robotics & AI and internet of things (IoT) technologies that will result in the proliferation of connected, autonomous EVs.	Drones	
			Autonomous Vehicles	
	How it Relates to the Digital World	Digital Experiences Improved connectivity opens a world of possibilities for enhanced online engagement. The future is likely to be more interactive with improved cloud computing increasing the potential for video game streaming and increased blurring of physical and digital worlds.	Electric Vehicles	
AR / VR				
Video Games				
Social Media				
FinTech We expect continued innovations in mobile payments, online banking, and alternative lending platforms to bring financial services to previously unbanked and underserved populations.		Streaming		
		Mobile Payments		
		Peer-to-Peer Lending		
		Crowd Funding		
PEOPLE & DEMOGRAPHICS	New Consumer	Blockchain		
		Millennials & Gen Z		
		Emerging Market Consumers		
		Urbanization		
		E-commerce		
		Education		
		Sharing / Gig Economy		
		Safety & Security		
		Cannabis		
		Sports Betting		
	Professional Sports			
	Health	Healthcare Innovation		
		Aging Population		
		Health & Wellness		
Emerging Market Healthcare				
Alternative Medicine	Alternative Medicine			
	Climate Change			
	CleanTech			
	Clean & Renewable Energy			
PHYSICAL ENVIRONMENT	Disruptive Materials	Resource Scarcity		
		Disruptive Materials		
		Infrastructure Development		
PHYSICAL ENVIRONMENT	Infrastructure Development	Infrastructure Development		



Infrastructure of the Digital World

We can currently trace majority of the structural changes to data and connectivity. A handful of key themes are foundational, providing the technological backbone for the digital future. Given interconnectivity between technologies and themes, these foundational themes link to both the physical and digital world.

KEY MEGA THEMES:

- Big Data
- Connectivity



BIG DATA (CLOUD COMPUTING & CYBERSECURITY)

Perhaps no investment theme has been more important to the business world since the COVID-19 outbreak than Big Data. As workplaces went remote, access to key documents, applications, and computing resources made cloud computing essential. We expect the global economy to shift further into the cloud over time, though connectivity can be both a blessing and a curse, as readily accessible files can become an easy target for malicious actors. Fortifying cybersecurity measures are therefore necessary investments to protect remote treasure troves of sensitive data.

KEY TAKEAWAYS

- COVID-19 related pressure boosted the Big Data theme as it increased cloud utilization faster than previous estimates. Now an estimated 92% of enterprises use multiple cloud services, employing 2.6 public and 2.7 private clouds on average.¹
- Cybersecurity spending is expected to increase significantly with the global economy going digital. Ninety-six percent of organizations increased their cybersecurity spending in 2020, according to a recent survey. And 91% increased their cybersecurity budgets in 2021.²
- Big Data's cloud computing and cybersecurity technologies integrate exceptionally well from a portfolio perspective, as the data-dense cloud necessitates ongoing cybersecurity spending and investment.

WHY CLOUD COMPUTING AND CYBERSECURITY ARE SUCH POWERFUL FORCES

Cloud computing offers proven efficiencies that modernize business practices.

Of all the investment themes that we track, the Cloud Computing theme likely accelerated the most due to COVID-19 because it became essential to business continuity. In a survey by computer software company Flexera, 29% of respondents said that they increased their cloud usage significantly more than expected during the pandemic, while 61% made slight increases due to pandemic-related operational changes.³ Today, an estimated 92% of enterprises use multiple cloud services, employing 2.6 public and 2.7 private clouds on average.⁴

With growing demand attributed to lower operating costs, better collaboration, increased flexibility, and improved turnaround times for server expansion, the largest enterprises by revenue accounted for 51% of the cloud market in 2020.⁵ These firms were not new to the cloud, having used it to build applications or host corporate infrastructure. The next push looks to modernize core business applications and processes. Technology conglomerate Cisco expects 94% of all corporate workflows to run through some form of cloud infrastructure by 2021, as servers dedicated to individual tasks quickly become relics.⁶

The next stage of the cloud's evolution looks to be omni-cloud solutions that stitch together multiple platforms and services to create more integrated data sharing and access. Managed multi-cloud environments should help assuage security, cost, and governance issues, the top concerns of enterprise cloud decision-makers.⁷

Currently, supply chain constraints, including the ongoing semiconductor shortage, are a challenge. But we believe the shortage can enhance the Cloud Computing theme. Under more normal conditions, corporations have a choice. They can build out their own personalized data centers, spending the time, resources, and expertise to customize servers. Or they can contract a cloud provider that offers a more general but rapid turnkey

solution. Currently, high costs and long lead times due to supply constraints disincentivize personalized server builds, forcing organizations into the cloud to avoid the risk of delays.⁸

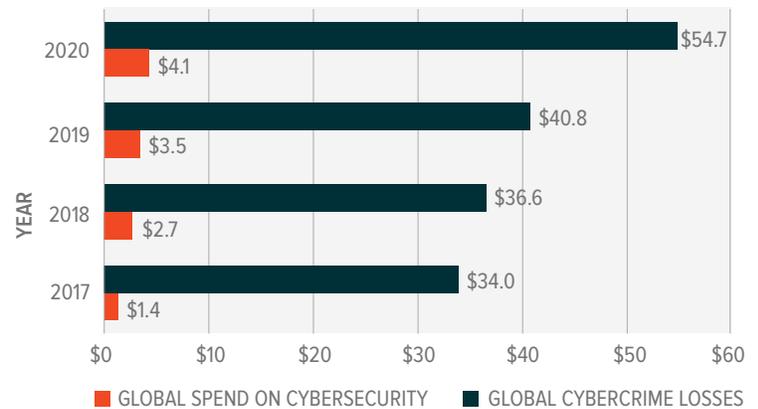
As the value of data increases, it requires more protections.

Cloud computing data centers aggregate and concentrate valuable data and processing power, increasing the speed and effectiveness of computing tasks. But that digitization makes protecting this valuable and sensitive data essential. The World Economic Forum marked cyberattacks as the 7th global risk by likelihood and 8th by impact in 2020.⁹ It's estimated that global cybercrime costs will grow by 15% per year to \$10.5 trillion annually by 2025.¹⁰

In 2020, ransomware attacks increased by 62% globally and 158% in North America compared to 2019.¹¹ These malicious attacks have real consequences for business, infrastructure, and end users beyond lost data and operational disruptions. According to FBI data, economic losses from more than 791,790 reported cybercrime incidents in 2020 exceeded \$4.1 billion.¹² The effects of a successful breach, financial and otherwise, can be felt for years after the actual threat ends. As much as 22% of negative effects occur in the second year after the event, and another 11% surface in the third year.¹³

CYBER ATTACKS CONTINUE TO CAUSE DAMAGE EVEN AS SPENDING INCREASES DRAMATICALLY

Source: IC3, March 2021, Canalys, January 2021.



According to solutions provider Insight CDCT (Cloud + Data Center Transformation), 96% of surveyed organizations increased their cybersecurity spending in 2020, and 91% expanded their cybersecurity budgets in 2021. However, current solutions largely focus on closing immediate security gaps and addressing the easiest-to-deploy options first, not the most concerning threats, including state-sponsored corporate espionage, attacks on critical infrastructure, and disinformation campaigns.¹⁴ For example, the Solar Winds hack discovered in December 2020 is believed to be the work of the Russian Foreign Intelligence Service. About 100 companies and a dozen government agencies were compromised, including the U.S. Treasury, Justice, and Energy departments, and the Pentagon.¹⁵

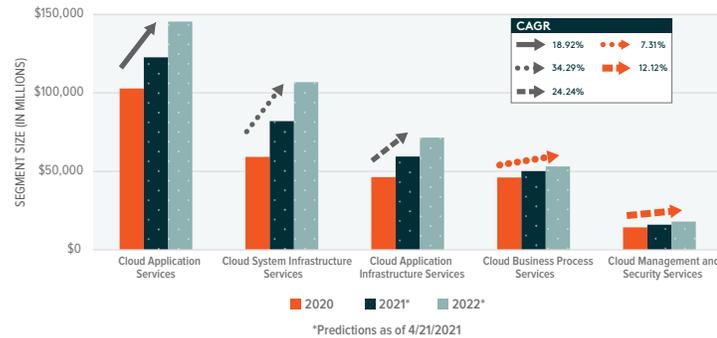
The increased sophistication of state-sponsored cyber threats requires equally sophisticated state responses. The Biden administration recently issued a new mandate for federal agencies to patch cybersecurity vulnerabilities in government software. This mandate covers about 200 known security flaws, making it one of the most widespread initiatives of its kind.¹⁶ Additionally, the House passed the Small Business Administration (SBA) Cyber Awareness Act, requiring small businesses to notify Congress of cybersecurity breaches. A second component includes the Small Business Development Center Cyber Training Act for cybersecurity counseling certification programs.



VISUALIZING THE MARKET OPPORTUNITY

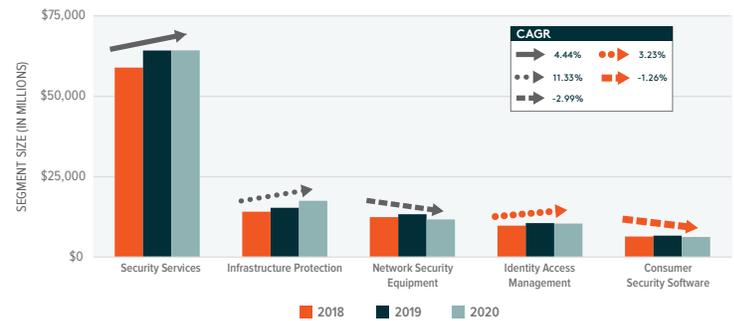
GLOBAL CLOUD COMPUTING SPENDING BY LARGEST SEGMENT

Source: Gartner data as of 4/21/2021.



GLOBAL CYBERSECURITY SPENDING BY LARGEST SEGMENT

Source: Embroker data as of 11/2/2021.



RISKS TO THE BIG DATA THEME

Supply chain disruptions could affect development of critical cloud infrastructure.

A concern for Big Data and the broader technology space is the supply chain constraints limiting the availability of certain types of semiconductors. This shortage has nuanced effects on the Cloud Competing theme as increased demand from end users is offset by capacity growth restrictions. Data center development is necessary for the continued expansion of service offerings and staying competitive in an industry with regular hardware advancements and data demand increases.

Shortages aren't affecting every type of semiconductor. High-margin microchips, such as the server-level central processing units (CPUs) and graphics processing units (GPUs) that make up the backbone of data centers, are generally available. But other necessary components like power supplies and network switches face lead times in the 40–60 week range, more than double the pre-pandemic norm.^{17,18} Semiconductor foundry capacity is growing at 1–3% per year, but that growth is outpaced by the demand for computing power, so constraints are expected to persist. Industry leaders expect tightness through Q2 2022.^{19,20}

Cybersecurity is an inherent risk in the digital age.

Data is gold today, which means data centers must become virtual fortresses. Concentrating such a valuable resource only increases the interest of malicious actors, and when they see an opening, they take it. For example, attacks on cloud infrastructure providers increased 630% between January and April 2020 compared to the previous four-month period as cyber criminals looked to exploit COVID-related confusion.²¹

Unauthorized access can occur even without malicious activity due to incorrect settings or user and employee errors. In 2019, more than 540 million user records from a large social media company were exposed by a leading cloud provider due to improper data protections.²² Absolute protection of data is likely impossible because there is a direct trade-off between data security and accessibility, but many risks can be mitigated by adequate cybersecurity spending and security awareness training.

From a risk perspective, the Cybersecurity theme looks well-insulated. Cybersecurity technologies work to proactively shield against possible attacks while mitigating and repairing the damage from attacks that already occurred. As a result, there is little risk at the broad theme level because the factors spurring adoption are unlikely to ever wane. Risk remains acute at the individual company level, where malicious actors constantly stress-test specific cybersecurity approaches and tools.

Should a breach occur under a cybersecurity provider's nose, markets are likely to devalue that company compared to its peers. However, in such instances, interest actually increases for the space overall. Cybersecurity stocks and ETFs have a history of positive price performance following the announcement of large-scale hacks, including the Solar Winds incident. In a situation where a data center or application developer falls victim to a large breach, negative share performance could be offset by broader cybersecurity gains.

THEMATIC INTERSECTION: INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE

Internet of Things (IoT)

The proliferation and advancement of connected devices driven by IoT technology looks to enhance the opportunities for Big Data themes. The integration of microchips and networking into more products creates more opportunities for data collection, as well as unauthorized access. Distributed sensors require a central data processing location to receive and aggregate collected information. And as the number of connected devices expands alongside increasingly sophisticated data analysis, so does the need for processing power and cloud computing resources.

But sensors are next to useless if they aren't secure, so IoT also positively impacts the Cybersecurity theme. For a malicious actor, the IoT is a cornucopia of opportunities to attack. Ninety-eight percent of all IoT device traffic is unencrypted, which translates to 57% of IoT devices being highly vulnerable to cyberattacks that can expose personal and confidential data.²³ Successful IoT deployments require multi-layered, end-to-end security that ranges from upfront, baked-in security requirements to the ongoing management and protection of sensitive machine-generated data.²⁴

Artificial Intelligence (AI)

The cloud and AI are also a fitting match. The cloud can democratize access to AI, providing turnkey solutions without significant upfront investment or specialized experience. AI can enhance cloud infrastructure through computing resource management, streamlining workloads, and automating repetitive tasks without human interaction. Additionally, growth in AI capability and complexity requires expanded computing resources. In 2018, AI research lab OpenAI reported that the amount of computational power used to train the largest AI models doubled every 3.4 months, an appetite that cloud providers can quickly satisfy.²⁵

AI technology is a boon for the Cybersecurity theme, given its use of pattern recognition and predictive intelligence to detect unusual network activity or penetration attempts. As cyberattacks grow in complexity, regularity, and intensity, AI can bolster human-based cyber defenses. Spending on AI cybersecurity tools is expected to grow faster in the coming five years than hardware or services, indicating wholesale adoption of the technology.²⁶



BIG DATA IN A PORTFOLIO CONTEXT

Big Data is foundational to our digital future, and is comprised of core themes that we believe have a place in most thematic portfolios. Both Cloud Computing and Cybersecurity fall squarely into the Early majority phase, indicating that adoption levels are high and rising, and that the market has begun to accept these themes at scale.

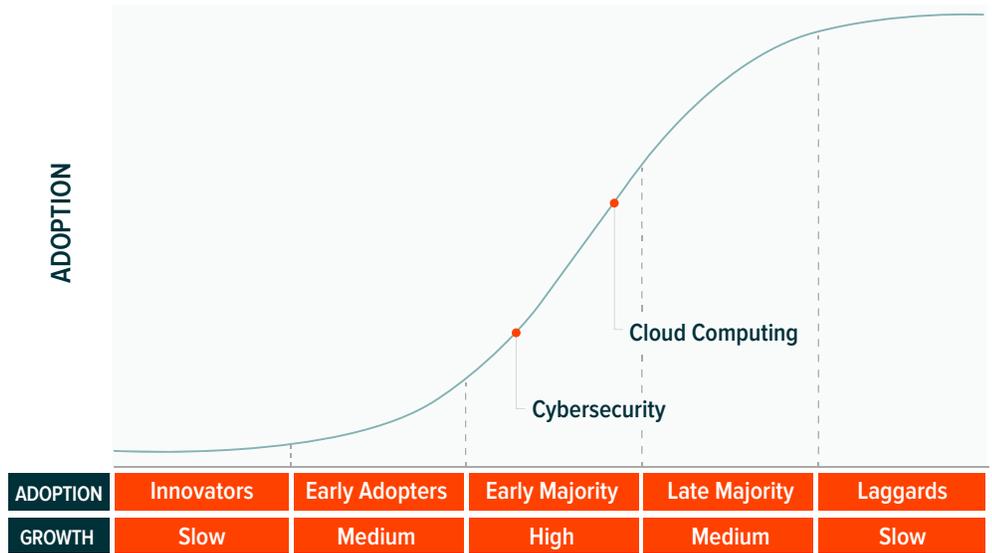
The companies that implementing Big Data technologies are global and stand to benefit as thematic adoption rises across the world. The pie charts below breaks down the geographic exposure of the largest Big Data ETF products. We believe there is ample innovation occurring outside of the states, and that limiting exposure to the U.S. will exclude key players to the detriment of investors over the long term.

In our view, thematic equity should be targeted, using screens to ensure the underlying companies provide the desired thematic exposure. This pure play exposure minimizes overlap between themes while also differentiating the exposure provided by the theme relative to broad beta products. An overlap analysis between Big Data thematic ETFs and XLK, the Technology Select Sector SPDR Fund, shows that average overlap by weight is 6.4% and 2.5% for cloud computing and cybersecurity funds, respectively.²⁷ As shown above, cloud computing scores higher on adoption than cybersecurity, and this is reflected in the theme's larger level of inclusion in broad tech sector ETFs. The names that overlap tend to be large, well known and active in many business segments, such as Microsoft and Cisco, while those that don't overlap are smaller and relate specifically to the theme. This highlights a key advantage of thematic investing - gaining exposure to key players early in their business lifecycles before they are included at any significant weight in broader indexes.

We believe both Cloud Computing and Cybersecurity will grow in importance over the next decade. Migrating to cloud-based infrastructure and software affords enterprises greater flexibility, predictability, and scale. While the market nears mass adoption, opportunities remain for firms to expand Software-as-a-Service and Infrastructure-as-a-Service offerings. The cloud's effectiveness has been proven; the next leg will maximize its potential. Helping the cloud reach its potential will be the cybersecurity industry, which seems well-positioned to capitalize as people and economies move further online. Cyber threats continue to increase in occurrence and severity, demonstrating the permanent need for cybersecurity spending. Both these Big Data themes benefit from subscription revenue models, helping establish more stable and predictable income streams.

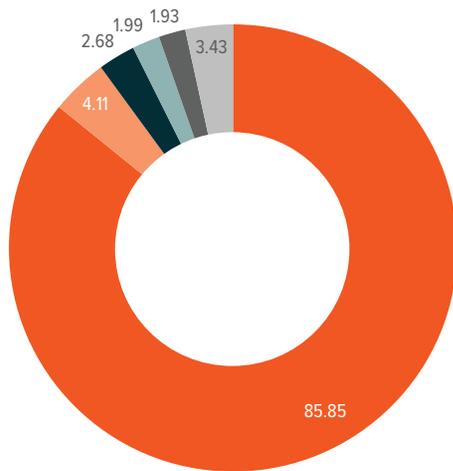
THEMATIC ADOPTION

Source: EM Rogers, "Diffusion of Innovations", 1962, and Global X Research, 2021



CLOUD COMPUTING: AVERAGE GEOGRAPHIC EXPOSURE BY THEME

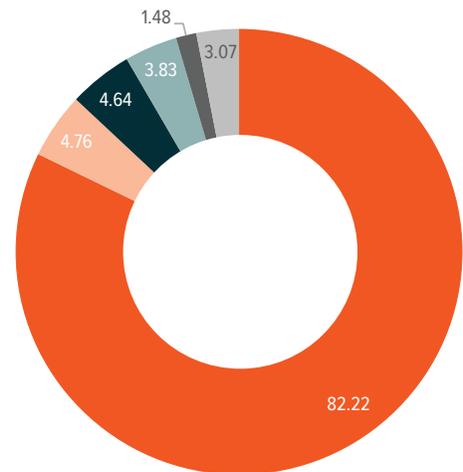
Source: Morningstar data as of 12/31/21.



United States, China, Canada, Israel, Japan, Other Countries

CYBERSECURITY: AVERAGE GEOGRAPHIC EXPOSURE BY THEME

Source: Morningstar data as of 12/31/21.



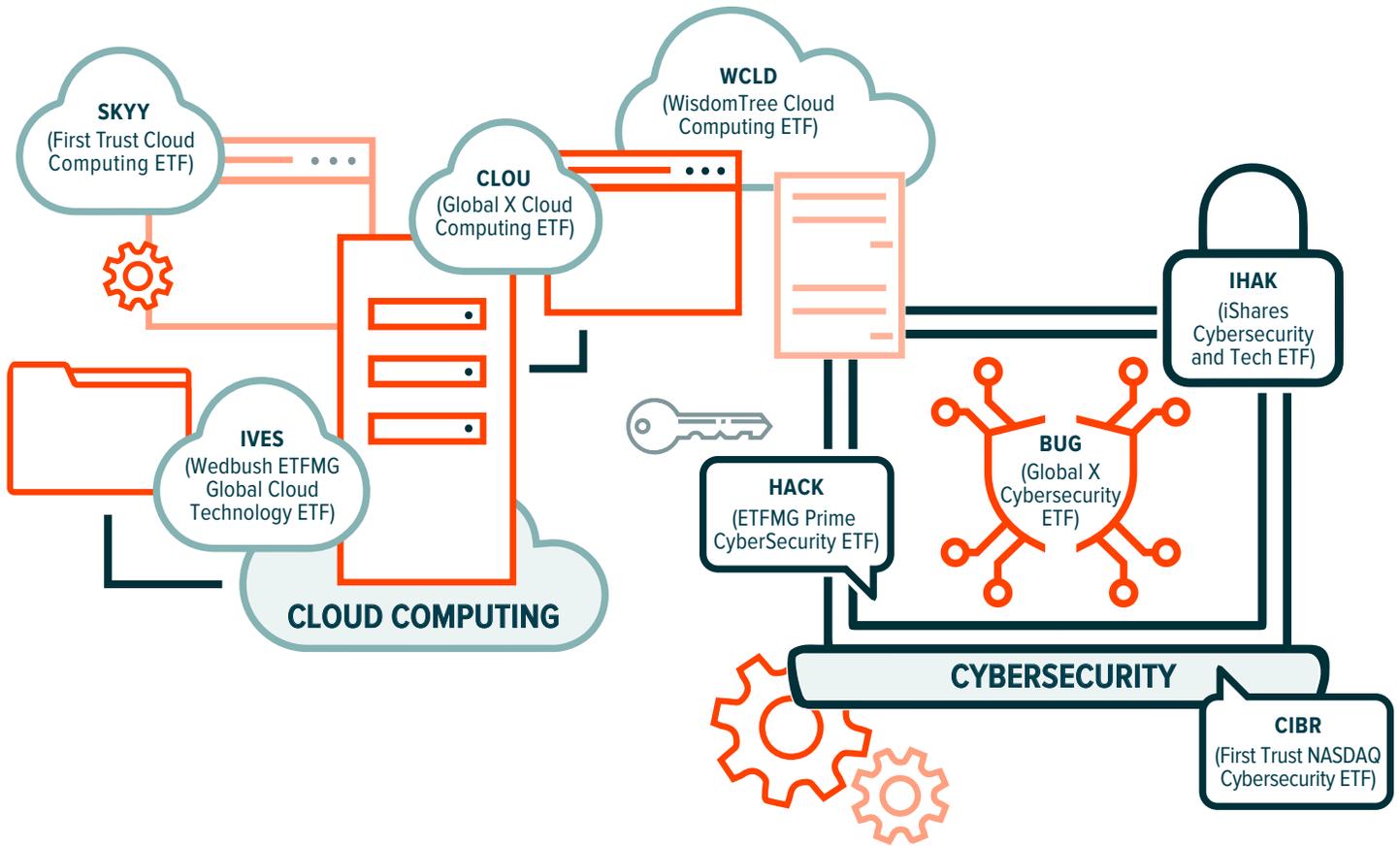
United States, United Kingdom, Israel, Canada, Japan, Other Countries

Note: Pie charts include the largest four cloud computing and the largest four cybersecurity ETFs according to our thematic classification. All Thematic ETFs weighted the same.



HOW TO ACCESS BIG DATA

The graphic below identifies some U.S. listed ETFs that provide direct exposure to the Big Data theme through Cloud Computing and Cybersecurity technology.





BIG DATA FOOTNOTES

- ¹ Flexera, 2021 State of the Cloud Report, 3/15/21
- ² Insight CDCT, Cybersecurity at a Crossroads: The Insight 2021 Report, 2/24/21
- ³ Flexera, 2021 State of the Cloud Report, 3/15/21
- ⁴ Flexera, 2021 State of the Cloud Report, 3/15/21
- ⁵ Grand View Research, Cloud Computing Market Size, Share & Trends Analysis Report By Service (SaaS, IaaS), By Enterprise Size (Large Enterprises, SMEs), By End Use (BFSI, Manufacturing), By Deployment, And Segment Forecasts, 2021 – 2028, July 2021
- ⁶ Cisco, Global Cloud Index (2016-2021), 2/5/18
- ⁷ Flexera, 2021 State of the Cloud Report, 3/15/21
- ⁸ Logicalis, How The Global Chip Shortage Is Driving Data Center Projects To The Cloud, 6/23/21
- ⁹ World Economic Forum, The Global Risks Report 2020, 1/15/20
- ¹⁰ GlobalNewswire, Cybercrime To Cost The World \$10.5 Trillion Annually By 2025, 11/18/20
- ¹¹ Sonicwall, 2021 Sonicwall Cyber Threat Report, 8/29/2021
- ¹² FBI, Internet Crime Report: 2020, 3/17/21
- ¹³ Embroker, 2021 Must-Know Cyber Attack Statistics and Trends, 11/2/21
- ¹⁴ Insight CDCT, Cybersecurity at a Crossroads: The Insight 2021 Report, 2/24/21
- ¹⁵ NPR, A 'Worst Nightmare' Cyberattack: The Untold Story Of The SolarWinds Hack, 4/16/21
- ¹⁶ WSJ, Biden Administration Orders Federal Agencies to Fix Hundreds of Cyber Flaws, 11/3/2021
- ¹⁷ The Register, 'This is the worst I've seen it' says Arista boss as entire network hardware sector battles component shortages, doubled lead times for semiconductors, 8/3/21
- ¹⁸ DataCenter Knowledge, 'It's Little Things' – How the Chip Shortage Is Affecting the Data Center Industry, 5/17/21
- ¹⁹ Logicalis, How the global chip shortage is driving data centre projects to the cloud, 6/15/21
- ²⁰ DataCenter Knowledge, 'It's Little Things' – How the Chip Shortage Is Affecting the Data Center Industry, 5/17/21
- ²¹ McAfee, Cloud Adoption and Risk Report: Work from Home Edition, 5/27/21
- ²² Varonis, 98 Must-Know Data Breach Statistics for 2021, 2021
- ²³ Palo Alto Networks, 2020 Unit 42 IoT Threat Report, 3/10/20
- ²⁴ IoT Cybersecurity Alliance, Demystifying IoT Cybersecurity, 2017
- ²⁵ MIT Technology Review, The computing power needed to train AI is now rising seven times faster than ever before, 11/19/19
- ²⁶ Markets and Markets, Artificial Intelligence in Cybersecurity Market by Offering (Hardware, Software, and Service), Deployment Type, Security Type, Technology (ML, NLP, and Context-Aware), Application (IAM, DLP, and UTM), End User, and Geography- Global Forecast to 2026, May 2019
- ²⁷ ETF Action data as of 2/9/22

Investing involves risk, including the possible loss of principal. Narrowly focused investments may be subject to higher volatility. Technology-themed investments may be subject to rapid changes in technology, intense competition, rapid obsolescence of products and services, loss of intellectual property protections, evolving industry standards and frequent new product productions, and changes in business cycles and government regulation.

Shares of ETFs are bought and sold at market price (not NAV) and are not individually redeemed from the funds. Brokerage commissions will reduce returns.

Index returns are for illustrative purposes only and do not represent actual fund performance. Indices are unmanaged and do not include the effect of fees, expenses or sales charges. One cannot invest directly in an index. Past performance does not guarantee future results.

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CONNECTIVITY (INTERNET OF THINGS & DIGITAL INFRASTRUCTURE)

Connectivity creates opportunities, and we expect the Connectivity theme to grow as the internet of things (IoT) connects more devices across sectors. Sparked by the continued miniaturization of microchips and receiving a powerful tailwind from the speed and capacity of 5G networks, IoT sensors and connected devices are set to harness the power of collected data. While these technologies appear to occur effortlessly, they rely on an extensive network of towers and data centers. Core to the Connectivity mega theme's growth potential is the significant investment being made to enhance this digital infrastructure.

KEY TAKEAWAYS

- Industrial IoT (IIoT) will be a key component of the Fourth Industrial Revolution (Industry 4.0), which we expect to transform manufacturing and supply chains. IIoT is expected to account for over 70% of all IoT connections by 2024.¹
- Increased connectivity increases the need for investment in digital infrastructure. Between 2016 and 2020, the U.S. wireless industry invested \$140 billion in infrastructure enhancements, building over 417,000 new cell sites in 2020 alone.²
- The Connectivity theme lives up to its name by connecting numerous themes, both innovation-based and physical infrastructure-based. We believe this attribute makes Connectivity particularly dynamic from a portfolio perspective.

combined with computing power increasing by a factor of 10 roughly every four years has resulted in even basic products such as toasters receiving a digital upgrade.⁹

In the short term, the semiconductor shortage has increased the prices of chips and other electronic components, demonstrated by the semiconductor producer price index rising from 54.1 to 55.3 in 2021.¹⁰ The long-term trend of declining costs per unit compute is expected to resume once manufacturing catches up with demand, further aiding IoT adoption.

Industrial IoT creates dynamic growth opportunities in the manufacturing sector.

Recent kinks in supply chains indicate that the current production paradigm isn't sufficiently equipped to handle system-wide stress. The solution is to transform traditional and linear manufacturing supply chains into dynamic, interconnected systems. Bringing Industrial Internet of Things (IIoT) technologies into manufacturing facilities will change how products are made and delivered. Adding sensor technology and adaptive control systems to production lines will transform real-time data into actionable insights that can be used to increase manufacturing efficiency.

A key advantage of Industry 4.0 compared to just-in-time manufacturing is a reduction in downtime due to predictive repairs. Production downtime, even for necessary maintenance, can have large costs. By monitoring the current condition of machinery, reacting to warning signs, and cross-checking input and finished good levels, IIoT-enhanced factories can optimally schedule repairs, thereby reducing downtime and increasing facility throughput.

Further efficiency gains can be derived by utilizing IoT for inventory and asset tracking. With GPS technology, complicated logistics can be monitored and simplified. For example, a manufacturer can know in real time when a shipment of raw materials will arrive at a facility or when finished products arrive at a distribution center. This information can help companies maximize profitability by giving them insight on when to replenish inventory or help them locate and recover lost or stolen equipment and goods. McKinsey data

WHY THE INTERNET OF THINGS AND DIGITAL INFRASTRUCTURE ARE SUCH POWERFUL FORCES

Connected devices are everywhere and growing more powerful.

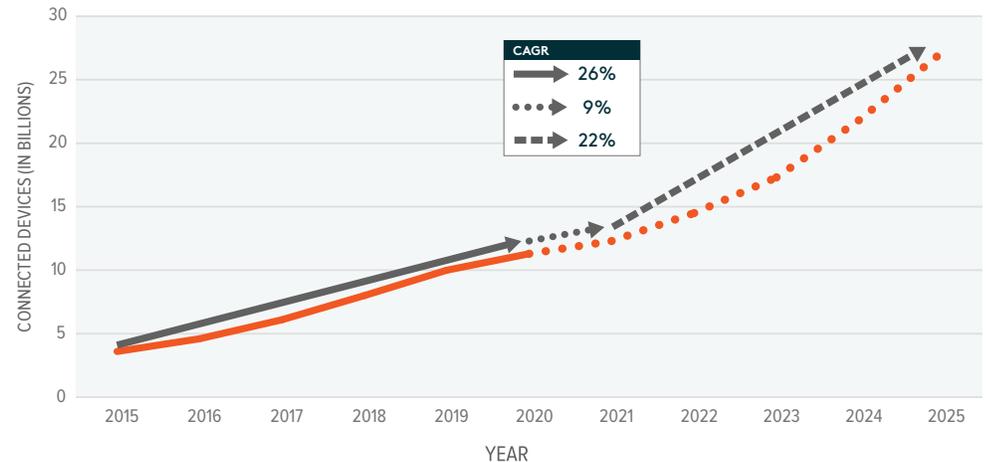
Connected devices produce an almost unimaginable amount of data. Technology conglomerate Cisco estimates that IoT devices produced 500 zettabytes (1ZB = 1 trillion gigabytes) of data in 2019, and it expects that number to grow exponentially each year as more devices come online.³

In 2021, the average American household had 25 connected devices, up substantially from 11 at the end of 2020.^{4,5} In total, the U.S. had 468.9 million connected devices online by the end of 2021, including 190.4 million data-only devices such as smartwatches or medical sensors. Data only IoT-focused connections have increased 272% in the U.S. since 2013.⁶ Globally, the number of connected IoT devices is expected to grow from 11.3 billion in 2020 to 27.1 billion by 2025 as the chipsets and wireless communication services that enable connectivity become more available.⁷

Cheap and readily accessible sensor and communications chips enhance the capabilities of everyday devices. Microsoft data shows that the average price of an IoT sensor declined from \$1.30 in 2004 to \$0.44 in 2018.⁸ This trend

GLOBAL IoT CONNECTED DEVICES

Source: IoT Analytics data as of September 2021.



“Globally, the number of connected IoT devices are expected to grow from 11.3 billion in 2020 to 27.1 billion by 2025.”



shows that firms who implemented Industry 4.0 technologies were able to respond to the COVID-19-induced supply chain crisis in 96% of cases, while those firms without these technologies were able to respond just 19% of the time.¹¹

Towers and data centers combine innovation and real estate.

Communications networks are essential digital infrastructure because they facilitate connections between the massive processing power of data centers and end users. Significantly, towers and data centers marry elements of growth-oriented technology investing and income-oriented real estate. Data centers provide physical space for customized server infrastructure while addressing cooling, power management, and security responsibilities, in exchange for regular fee payments. Data centers also serve a diverse set of clientele, including big tech companies, government agencies, financial services firms, and health care providers.

In 2020, the U.S. accounted for over 80% of new data center construction and expansion projects globally. Investment in this infrastructure totaled more

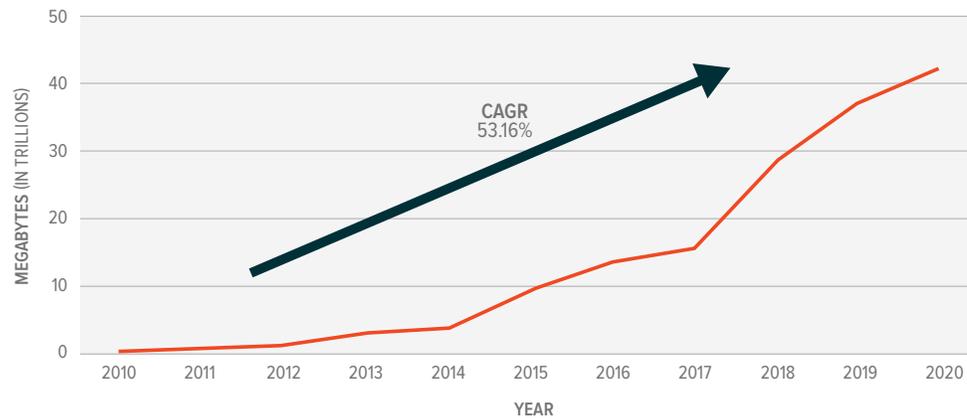
offer a potential solution. Next-generation wireless networks offer more spectrum over more channels, increasing the number of devices able to actively connect to a tower at once, and allocating additional bandwidth to each device. 5G also uses small cell antennas, which have much shorter ranges than their macro counterparts.

The overlapping coverage areas that small cell antennas create raise wireless coverage density, which improves connections while alleviating pressure on any one tower. Coverage remains spotty compared to the more established 4G networks, but 20% of new smartphone sales in the U.S. were expected to contain 5G chips by the end of 2021, so improvement is inevitable.¹⁹

Wireless network providers are increasing investment in digital infrastructure. Data from wireless communications trade association CTIA shows that the wireless industry invested \$30 billion into infrastructure projects in 2020, the third consecutive year capital expenditures increased, and the largest year of investment in the last five. Between 2016 and 2020, the industry's investment

ANNUAL U.S. WIRELESS DATA TRAFFIC

Source: CTIA data as of 7/27/21.



“Taking a longer-term view, U.S. mobile data traffic has increased by 108x over the last decade, indicating that much more tower capacity will be needed as data demand continues to expand.”

than \$700 million.¹² But more is needed, as demands on digital infrastructure will only increase. The vastly improved bandwidth, latency, and speed that 5G networking technologies offer will be required for widespread adoption of advanced IoT-enabled devices like autonomous vehicles. However, current infrastructure is likely to crack under the additional load, [making the need for cell towers greater than ever](#).

Currently, there are approximately 128,000 macro cell towers in the U.S., but each tower only has so much range and capacity. A typical cellphone only has enough power to reach a tower up to 5–7 miles away, and a single Long Term Evolution (LTE) cell can only manage about 200 active device connections per 5 megahertz (MHz) of spectrum before speeds begin to slow.^{13,14} The expansion of IoT means a higher demand for towers and wireless spectrum to ensure adequate coverage. Tower demand is expected to remain robust with 6.37 billion active smartphone users globally.¹⁵ But construction and permitting hurdles often limit expansion, making existing towers increasingly valuable. In the U.S., suppliers of macro cell towers increased tower capacity by about 8% from 2019 to 2020.¹⁶ But over the same period, mobile data per smartphone increased 29%.¹⁷ Taking a longer-term view, U.S. mobile data traffic has increased by 108x over the last decade, which indicates that much more tower capacity will be needed to meet data demand.¹⁸

Solutions for capacity constraints coming with 5G, continued investment.

With more data being collected by sensor-enabled devices than ever, transferring information in a timely manner can be a challenge. 5G networks

in infrastructure totaled \$140 billion. Over 417,000 new cell sites were built in 2020, a 35% increase from 2016. Over the last two years, a lighter regulatory touch facilitated more cell site construction than in the previous seven years combined.

This investment is in addition to the almost \$200 billion spent on wireless spectrum auctions over the same period.²⁰ Spectrum refers to the radio wave frequencies used to transfer wireless signals and is a core component of wireless communications. Auction winners are licensed to transmit on a larger swath of the electromagnetic spectrum, furthering the rollout of 5G technology and increasing the quality of end-user connectivity.

RISKS TO THE CONNECTIVITY THEME

The semiconductor shortage is a headwind for IoT.

Surging demand, including demand from 5G expansion plans, forced foundries to focus on high-margin production, typically the newest and most advanced chips. As a result, the production of lower-tier chips took a backseat. These commodity-type chips are typically used in consumer-focused IoT devices because they generally don't require the fastest networking or processing speeds. An estimated 20 million cellular chipsets will go undelivered due to shortages in 2021, influencing 80% of global manufacturers to report challenges producing digital products and services.^{21,22} The result is increased prices and decreased availability of some connected devices, likely negatively affecting sales of consumer goods in the short term.



VISUALIZING THE MARKET OPPORTUNITY

DIGITAL INFRASTRUCTURE



INTERNET OF THINGS



Expanding opportunity that lays the foundation for the digital future.

The chip shortage also affects the 5G rollout because routers, switches, and base stations face longer delivery times. Smaller network providers indicate that equipment delays stalled deployments by 18–24 months.²⁶ These delays look to be more acute outside of the U.S., given the robust purchasing relationships and financial heft of the large U.S. networks.

IoT devices create more network vulnerabilities.

IoT devices can be easy targets for cybercriminals due to the network integration of many endpoint devices. With more points of failure, network maintenance becomes a larger task, increasing the chances of a missed software update or incorrect device setup. Comcast estimates that U.S. households can be exposed to as many as 104 cybersecurity threats per month, with the most vulnerable devices being smart home gadgets.²⁷ The general market immaturity of connected devices is the main reason, as cybersecurity issues are often addressed after product creation and through firmware updates. Connected ecosystems such as Google’s Nest and Apple’s HomeKit could provide solutions, but the risk remains.

THEMATIC INTERSECTION WITH CONNECTIVITY

Robotics & AI and Cloud Computing

The Robotics & AI and Cloud Computing themes intersect with IoT, particularly from an industrial perspective. Industrial IoT can take many forms, but it mainly focuses on increasing operational efficiency via sensor-based monitoring. Future growth in the industrial space will stem from the integration of robotics, cloud computing and connected IoT devices to build smart, automated factories. Artificial intelligence (AI) utilities will rely on data gathered by IoT systems and sensors to present real-time insights about the world around them.

If AI is a system’s brain, IoT acts as the digital nervous system. Connectivity will be essential, with private 5G and low power wide area (LPWA) networks playing a critical role in manufacturing automation that enables real-time and remote monitoring of autonomous systems. Juniper Research predicts that the industrial sector will account for over 70% of all IoT connections by 2024.²⁸

Health & Wellness

Connected fitness trackers record some of the most intimate data an individual can produce. The health and wellness economy is growing, especially after the pandemic inspired many to be more active and conscious about their wellbeing. The global fitness tracker market grew 19.5% year-over-year in 2020, expanding at a faster rate than the overall IoT space.²⁹ Fifty-eight percent of U.S. consumers now use smartwatches or fitness trackers to quantify their daily steps, workouts, and sleep.³⁰

Additional upside stems from clinical settings, where medical grade sensors can provide lifesaving information. For example, blood sugar tracking and advanced heart monitoring are two key growth areas, as they can take readings in real-time and then share and store patient data with their care team.

CONNECTIVITY IN A PORTFOLIO CONTEXT

The Connectivity theme lives up to its name by connecting innovative technology and physical infrastructure. We believe this attribute makes the space particularly attractive from a portfolio perspective. Digital infrastructure is further along the adoption curve, falling into the core of the Early Majority phase, and indicating that adoption levels are high and rising. IoT is growing in interest, moving further into the Early Adopters phase, but remaining at a low absolute level.

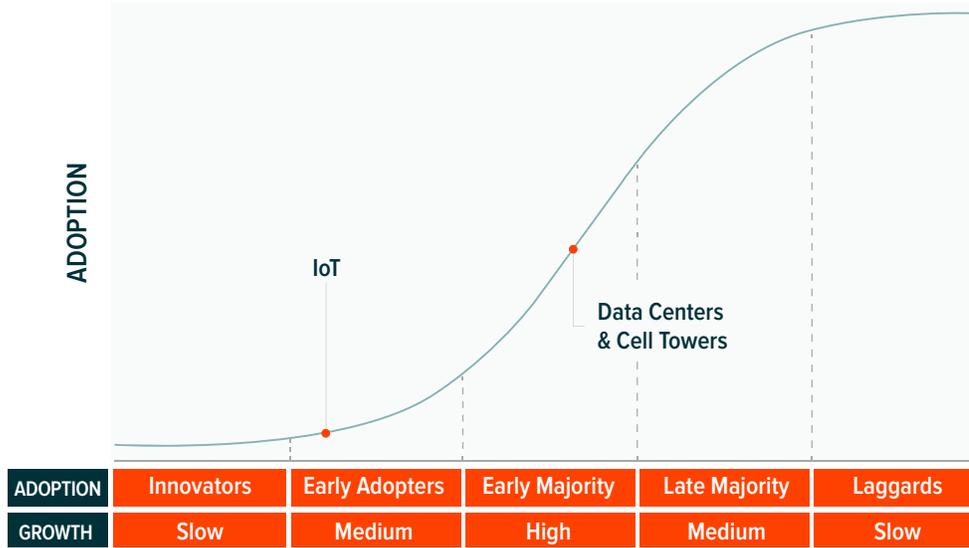
The companies implementing Connectivity technologies are global and stand to benefit as thematic adoption rises across the world. The pie charts on the next page break down the geographic exposure of the largest Connectivity thematic ETF products. We believe there is ample innovation occurring outside of the states, and that limiting exposure to the U.S. will exclude key players to the detriment of investors over the long term.

In our view, thematic equity should be targeted, using screens to ensure the underlying companies provide the desired exposure. This pure play focus minimizes overlap between themes while also differentiating the exposure provided by the theme relative to broad beta products. We conducted an overlap analysis between Connectivity thematic ETFs, the S&P 500, MSCI ACWI and the most applicable S&P 500 sector ETF for each exposure,



THEMATIC ADOPTION

Source: EM Rogers, "Diffusion of Innovations", 1962, and Global X Research, 2021



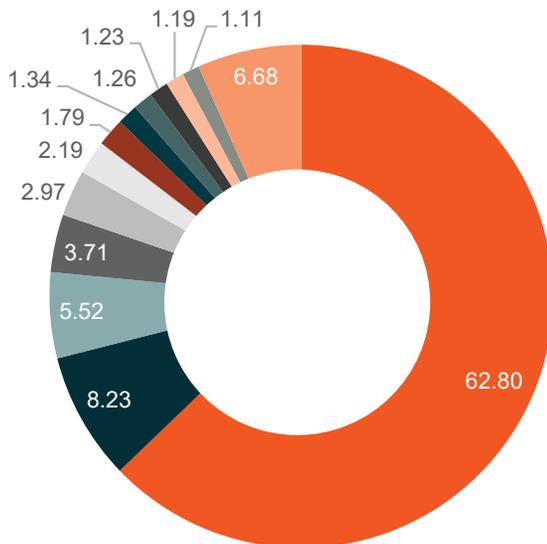
XLK (Technology Select Sector SPDR Fund) for internet of things, and XLRE (Real Estate Select Sector SPDR Fund) for digital infrastructure. We found that average overlap by weight for internet of things was 8.9% when compared to the S&P 500, 7.2% vs. the MSCI ACWI, and 11.7% vs. XLK. Digital Infrastructure scored lower on broad indexes, 2.1% when compared to the S&P 500 and 1.3% vs. the MSCI ACWI, but scored much higher compared to XLRE at 28.0%.³¹ These low levels of overlap with broad indexes reflect the benefits of thematic exposure.

The Connectivity theme continues to mature, creating attractive opportunities for long-term investors. The internet of things is now a core technology with connected consumer devices growing in capability and commonality while industrial applications catalyze the Fourth Industrial Revolution. Simultaneously, the digital infrastructure that this connectivity requires continues to advance, including 5G networking technology that provides users with wireless speeds that dwarf those of previous generations.

With data expected to increase exponentially, investment in digital infrastructure has skyrocketed in recent years with wireless providers looking to ensure that their networks can handle the demand. Investment in new and enhanced cell towers and data centers is another sign of the Connectivity theme's maturation, as they can democratize access to the massive processing power of the increasingly connected world.

IOT: AVERAGE GEOGRAPHIC EXPOSURE BY THEME

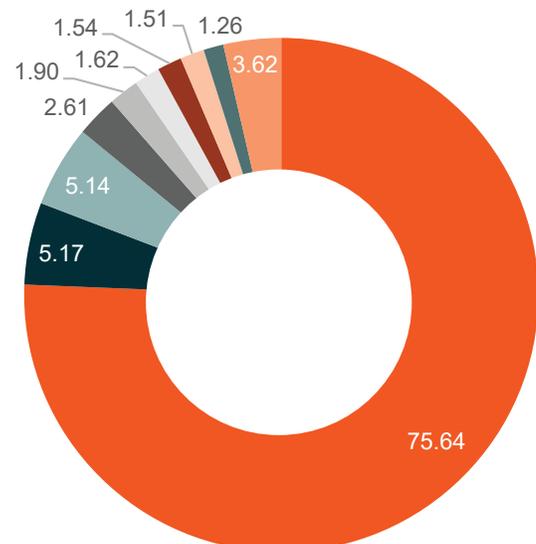
Source: Morningstar data as of 12/31/21.



- United States
- Taiwan
- China
- Singapore
- Japan
- Switzerland
- India
- France
- South Korea
- Sweden
- Finland
- Canada
- Other

DIGITAL INFRASTRUCTURE: AVERAGE GEOGRAPHIC EXPOSURE BY THEME

Source: Morningstar data as of 12/31/21.



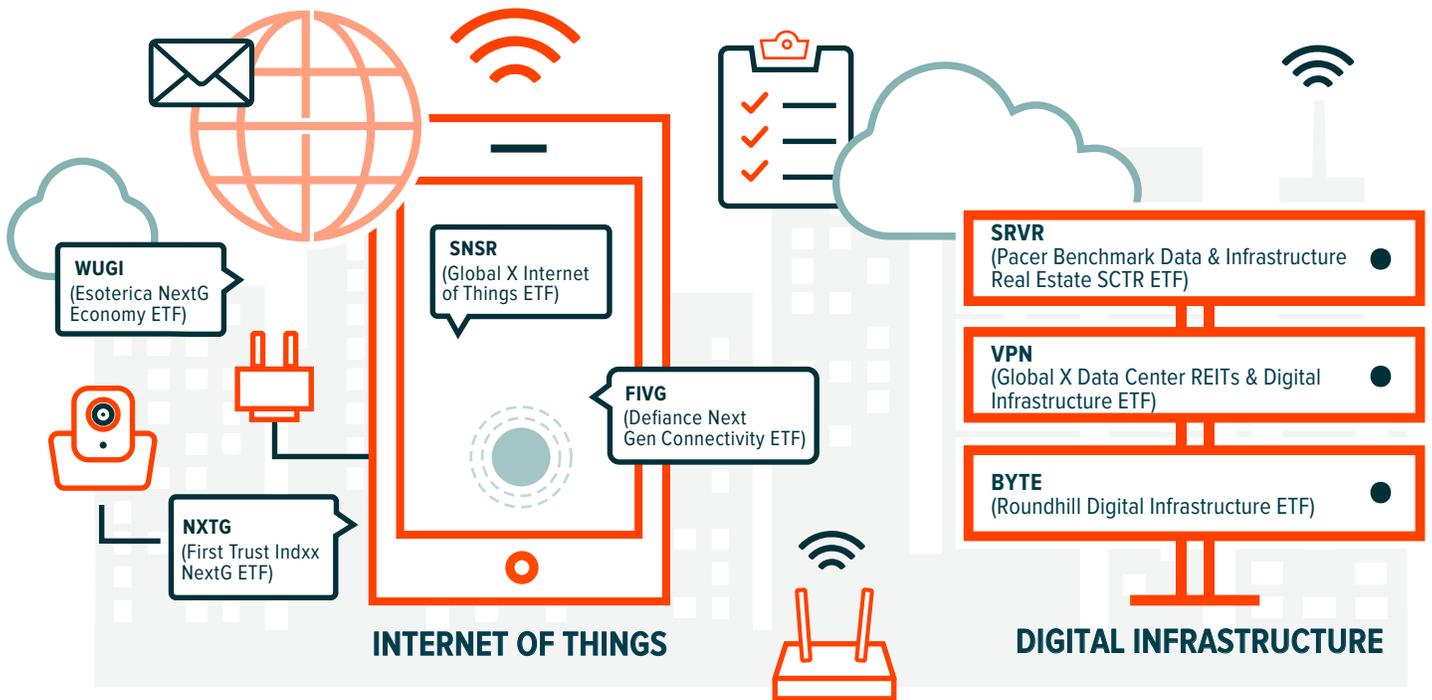
- United States
- China
- Australia
- United Kingdom
- Indonesia
- Spain
- Singapore
- Mexico
- Italy
- Other

Note: Pie charts include the largest four internet of things and all three digital infrastructure ETFs according to our thematic classification. All Thematic ETFs weighted the same.



HOW TO ACCESS CONNECTIVITY

The graphic below identifies some U.S. listed ETFs that provide direct exposure to the Digital Infrastructure and Internet of Things themes.





CONNECTIVITY FOOTNOTES

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- ²⁸ Juniper Research, IoT Connections to Reach 83 Billion by 2024, Driven by Maturing Industrial Use Cases, 3/31/20
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- ³¹ ETF Action data as of 2/17/22

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Digital Innovation (6/1/2021)	2 Sustainable Core Series Portfolios (8/1/2020)		
	Equity Sectors and Themes		
Thematic Trends (11/22/2021)	Equity Sectors and Themes (11/1/2017)		

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