

2022 TRENDS IN ROBOTICS, AI & HEALTHCARE INNOVATION

INVESTMENT INSIGHTS, EXPERT PREDICTIONS, & RESEARCH

As 2021 draws to a close and investors debate the near-term growth and inflation outlook, businesses around the world are striving to accelerate their digitization and are deploying automation at a record pace.

In this report, we highlight the key growth trends going into 2022, some of the technology and market leaders riding these trends, and the role they will play within our three innovation indices: ROBO, THNQ, and HTEC.



ROBO



ROBOTICS & AUTOMATION

- The Robots are Coming... to Save the Supply Chain
- A Factory Automation Supercycle is Upon Us
- Autonomous Vehicles Take to the Road, Skies, & Seas
- Metaverse Meets Real World

THNQ



ARTIFICIAL INTELLIGENCE

- AI & Machine Learning Will Drive Multi-Cloud Adoption
- Welcome to the Next-Generation of Banking
- All Eyes Will be on Immersive Experience

HTEC



HEALTHCARE TECHNOLOGY

- Data Analytics & AI Will Drive the Efficiencies of Healthcare
- Robotics Solutions Will Free Up Time for Nurses and Pharmacists
- The Next Frontier in Genomic Science: Spatial Biology





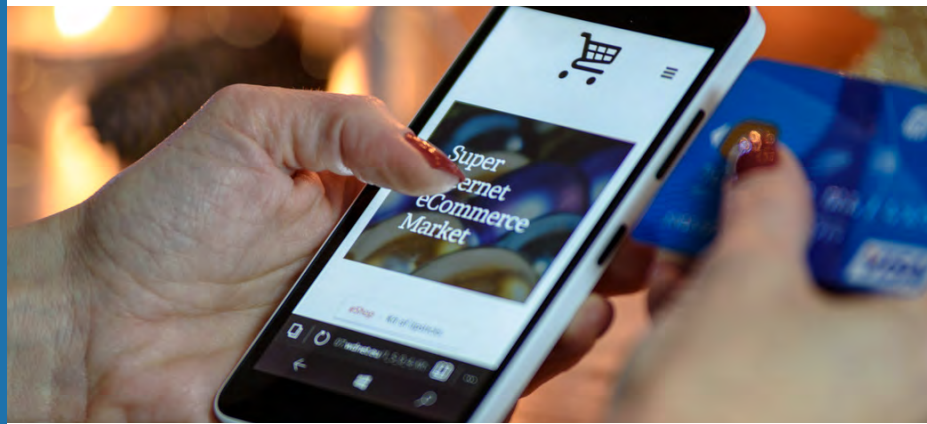
2022 TRENDS IN

ROBOTICS & AUTOMATION

ROBO



THE ARMS RACE TO AUTOMATE



As we expected a year ago, 2021 turned out to be a boom year for robotics and automation with record-high installations and demand exceeding supply in the context of a strong economic recovery. And as we head into the new year, the outlook is stronger than ever.

First, the digitization of the economy is now going full steam ahead. The global pandemic kicked off an arms race to automate and business leaders around the world are now taking full advantage of the increasingly broad set of automation technologies available, from software and the cloud to robots and machine intelligence.

Second, supply chains are under tremendous stress and are screaming for automation. The US consumer boom and its increasing predilection for online shopping have stretched transport and logistics infrastructure to the breaking point.

And lastly, labor shortages are becoming increasingly painful. With more than one million unfilled manufacturing positions in the US alone and service businesses struggling to attract workers, the short answer is automation.



THE ROBOTS ARE COMING... TO SAVE THE SUPPLY CHAIN

In addition to pandemic-related supply chain disruptions, the dramatic rise in e-commerce volumes and ever-speedier delivery timelines have driven explosive demand for logistics and warehouse automation. Orders for material handling equipment, autonomous mobile robots, track and trace technology, and storage & retrieval systems are exceeding supply capacity.

We estimate the logistics and warehouse automation market reached \$70bn in 2021 and will grow to \$105bn by 2025. We view the likes of Daifuku, Zebra Technologies, GXO Logistics, Autostore, Kardex, Manhattan Associates and KION as major beneficiaries.

Recent advancements in computer vision, machine intelligence, materials and sensors have already enabled robotics to make a substantial impact on the world of logistics. Today, robotic picking is helping solve a chokepoint, increasing warehouse throughput and relieving workers from dull and exhausting tasks, with picking speed exceeding 100 an hour, compared to humans 60-80 average.

The face of retail is rapidly changing as robotic and artificial intelligence innovations enable a super-efficient “Goods-To-Person” fulfillment machine.





Emerging advances in AI and automation are bringing together the power of data, computing, and algorithms to allow robots to learn from examples to support the labor force. This reality makes logistics a sweet spot for robotics.

E-commerce demand will continue to grow, and robots will be there to fill the gaps when there are not enough human workers to do the job.”

KEN GOLDBERG, PhD

ROBO Global Strategic Advisor

Co-founder & Chief Scientist | Ambi Robotics





A FACTORY AUTOMATION SUPERCYCLE IS UPON US

The factory automation market should continue to surge in 2022, driven by continuing efforts to digitize production systems, increasingly painful labor shortages, and the reshoring plans of many US companies.

The world's leading robotics companies, such as Fanuc, Yaskawa, ABB, and Kuka, are ending the year with inflated order backlogs and strong visibility. We expect the installed base of industrial robots to exceed 3.7 million units by the end of 2022, which would still represent less than 1% of the number of manufacturing workers around the world.

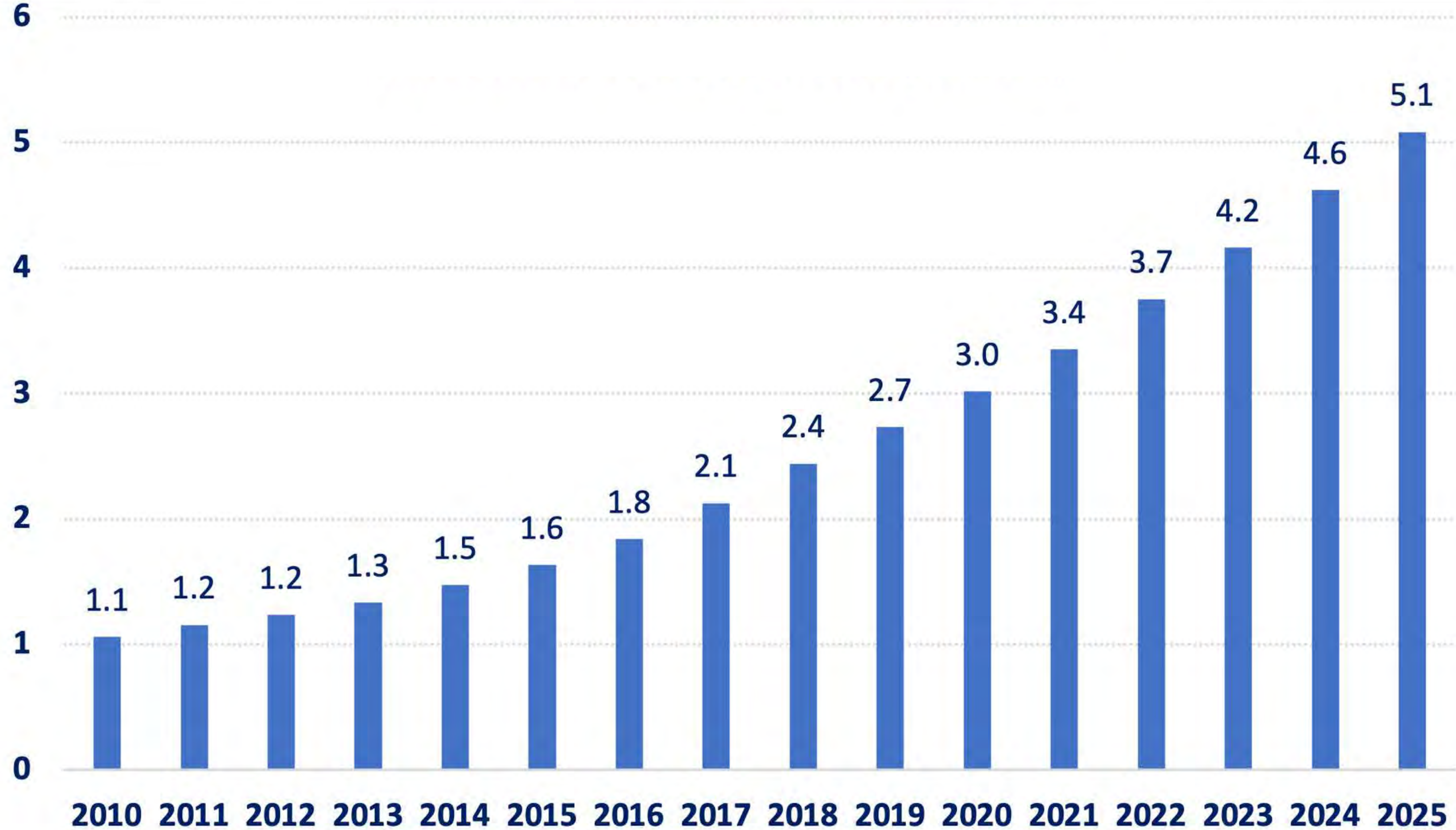
One of the biggest areas of focus is on collaborative robots (cobots) that can work seamlessly with humans and other automated systems in industrial and lifestyle applications. Cobots accounted for less than 5% of the market in 2020, but we expect the segment to grow by over 35% per year from around \$1.5 billion today to over \$15 billion by 2028, with market leader Teradyne set to benefit. Cobots will also start to appear in more consumer and home applications like helping with special needs, disabled, or elderly persons.

Suppliers of key factory automation components and systems, such as Rockwell Automation, Harmonic Drive, Nabtesco, SMC, Airtac, Hiwin, and Keyence also stand to benefit from the growth ahead. This is especially true for those with exposure to China—now the largest and fastest growing market for industrial robotics.



Photo 1 by: [Teradyne](#)

Industrial Robots in operation (millions)



Source: ROBO Global, International Federation of Robotics





AUTONOMOUS VEHICLES TAKE TO THE ROAD, SKIES, & SEAS

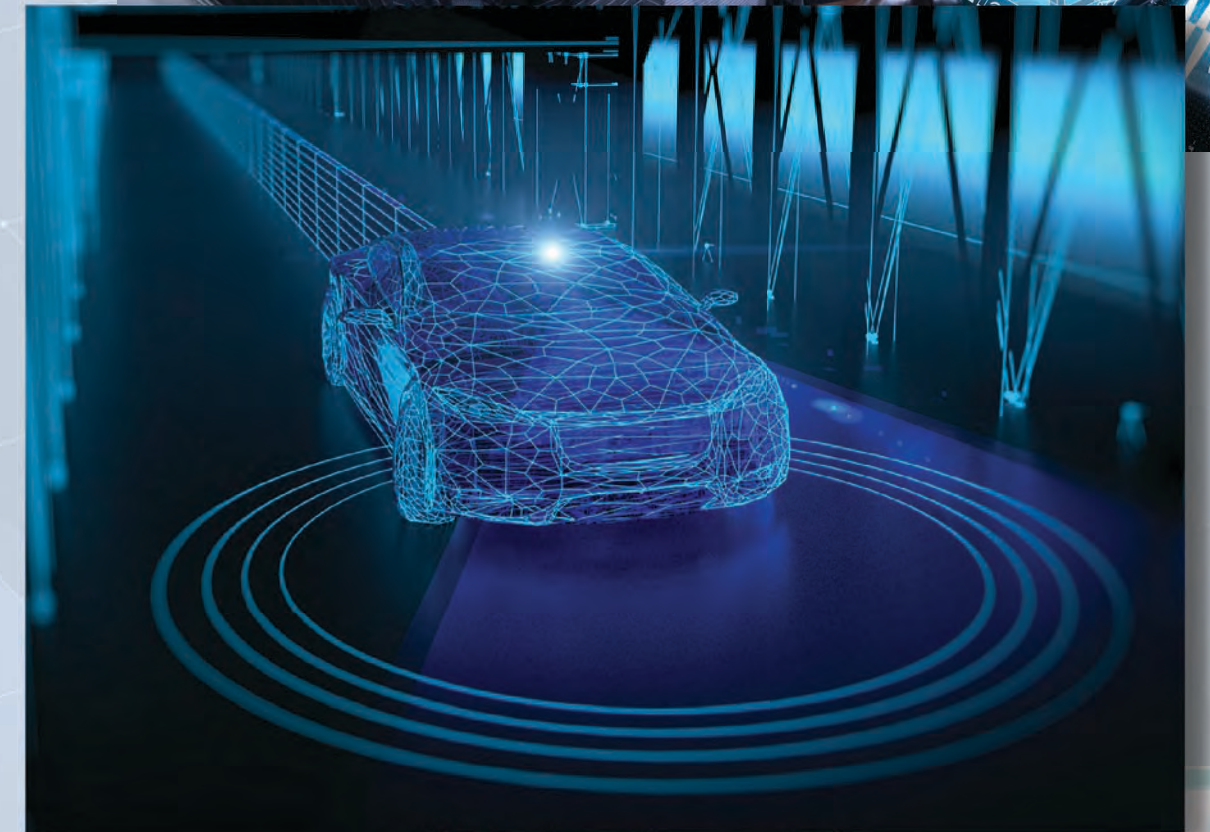
Predicted by many at first to be impossible, autonomous vehicles, from the long haul to the last mile are taking off in 2022. Over the next decade, multitudes of autonomous vehicles will be deployed and utilized for commercial and human transit. By 2050, we could have nearly 100% autonomous transportation in all facets of life.

Autonomous vehicles require sensors, artificial intelligence, and multiple communication technologies, like 5G, which will drive down the cost of goods, speed up deliveries, increase energy efficiency, and lower emissions. For human transit, this will feel like public transit 2.0, with 24/7 availability, hands-free operations, and reduced vehicle collisions.

Today there is just a small number of autonomous cars and trucks around the world. Waymo was the first with autonomous taxis in Arizona (but with a driver up front) in November 2021. However, Cruise became the first company in the USA to launch a fully autonomous taxi with no driver. Tesla, Luminar, NVIDIA, Qualcomm, and Ambarella also offer great exposure to this sector.

Intel's Mobileye division has plans to launch an autonomous taxi service in Germany in 2022. China is also leading the way with Alibaba completing 1 million e-commerce deliveries by their autonomous delivery robots and Baidu receiving approval in Beijing for Apollo Go Robo Taxi.

Additionally, we're seeing autonomous, zero-emission boats, such as cargo ships and water taxis, as well as delivery drones piloting around the world as another enormous opportunity





METAVVERSE MEETS REAL WORLD



Transforming Sustainability with Digital Twin Technology

Further supporting ‘design-to-finished-product’ smart manufacturing is the proliferation of “digital twins” technology, which is helping create fully virtualized products and production simulations, leading to superior products that are also produced faster. ROBO index members Autodesk, Dassault, and PTC are industry leaders in this category that is driving innovation and enormous production gains. From an ESG perspective, this will allow for the discovery and utilization of more sustainable materials, safer warehouse environments, and a more efficient use of energy to help achieve environmental targets.

Digital virtualization and simulations that use AI to improve the product life-cycle management and decision-making in both manufacturing and supply chain operations are going to take center stage in 2022 and beyond.



ROBO OUTPERFORMED GLOBAL EQUITIES OVER THE PAST 1, 3 & 5 YEARS



	YTD	3 Year	5 Year	Full Period
ROBO GLOBAL® ROBOTICS AND AUTOMATION INDEX¹	12.57%	23.61%	20.36%	17.77%
GLOBAL EQUITY INDEX	13.98%	15.95%	13.98%	11.17%

Rebased 100 on November 30, 2012; Total Return through November 30, 2021; Periods greater than 1 year have been annualized

1: Includes back-tested data prior to August 02, 2013

The ROBO Global Robotics & Automation Index (ticker: ROBO)





Technology is a tool - a wonderful tool that's unique to our species. Tools can be used for good, tools can be used for bad, and the more powerful the tool, the more potential it has for good and for bad. The potential use for good is incredible.

In the robotics world, we always talk about the three D's of robotics, meaning the things that are dull, dirty, or dangerous. This is what robotics and automation are great for - getting rid of dull tasks, and that's a service to people."

RAFFAELLO D'ANDREA, PhD

ROBO Global Strategic Advisor

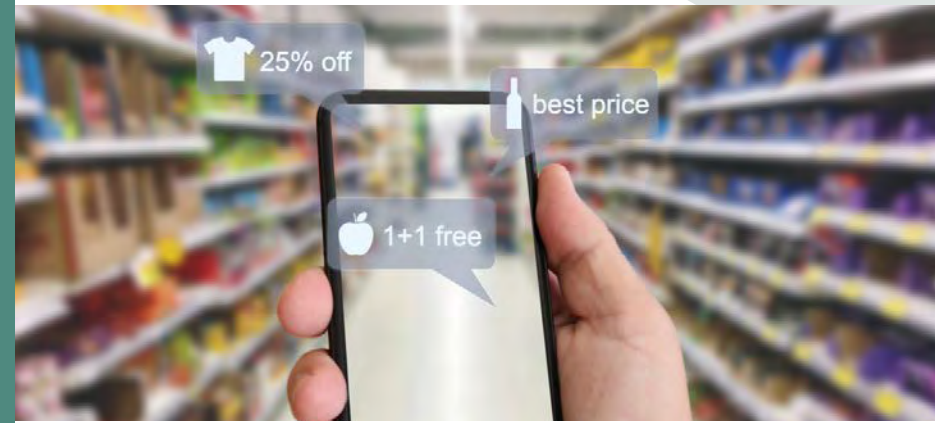
Founder & CEO of Verity, Professor at ETH Zürich





2022 TRENDS IN

ARTIFICIAL INTELLIGENCE



DIGITAL TRANSFORMATION IS THE DEMAND, AI IS THE ANSWER

As companies revise their strategies with a view to permanently increasing their remote workforce over the next decade, digital technology is at the forefront in relation to R&D investments and innovation. As previously predicted, AI is having a major impact on the \$2 trillion e-commerce sector. Aside from personalization engines driving conversion rates for online shopping, AI-powered solutions are also helping merchants make accurate sales predictions and improve customer support for a more seamless experience. AI is going to be the critical element in delivering a strong digital experience—whether that's working from home or engaging in e-commerce.

This digital shift in the wake of the COVID-19 pandemic has also accelerated the need for next-generation cybersecurity solutions. With constantly evolving cyberattacks and the proliferation of smart devices, AI and machine learning are playing a vital part in automating threat detection and even detecting malicious attacks before they happen. The year 2021 was a year of cybersecurity M&A deals driven by an increase in threat vectors. Two of our THNQ index members received private offers as the need to ramp up investments in AI capabilities became the principal focus. There were over 150 cybersecurity M&A deals in the US in the first three quarters of 2021, compared to 94 in the previous year, according to 451 Research. We expect trends around digitization and data protection to continue throughout 2022.



AI & MACHINE LEARNING WILL DRIVE MULTI-CLOUD ADOPTION

The acceleration of cloud adoption in the past year has been tremendous, but believe it or not, we are expecting another blockbuster year of rapid deployment and growth in cloud technologies. As we enter 2022, we should see even more innovations in enterprise-wide cloud solutions, to address some of the challenges that IT departments are currently facing. Technology requirements within the structure of organizations are vastly different; thus we need different applications and multiple cloud providers for separate environments, along with the flexibility of options as the business grows.

The use of AI applications by developers, data scientists, and cybersecurity teams is on the rise, and this will require the modernization of cloud infrastructure. Gartner expects global cloud services spending will be \$482 billion in 2022—a 35% growth year over year. THNQ index members such as JFrog, Arista Networks, MongoDB, and Cloudflare will benefit from this trend as the remote and hybrid workforces drive demand for a multi-cloud vendor architecture.

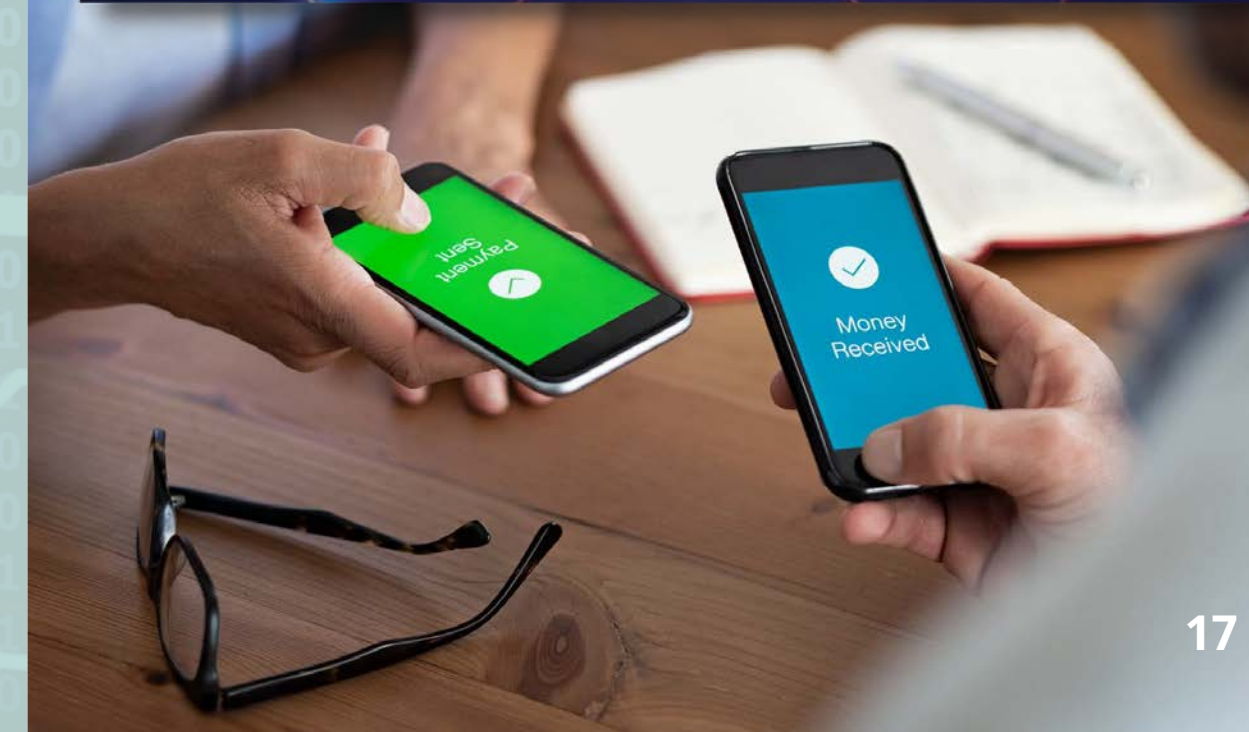
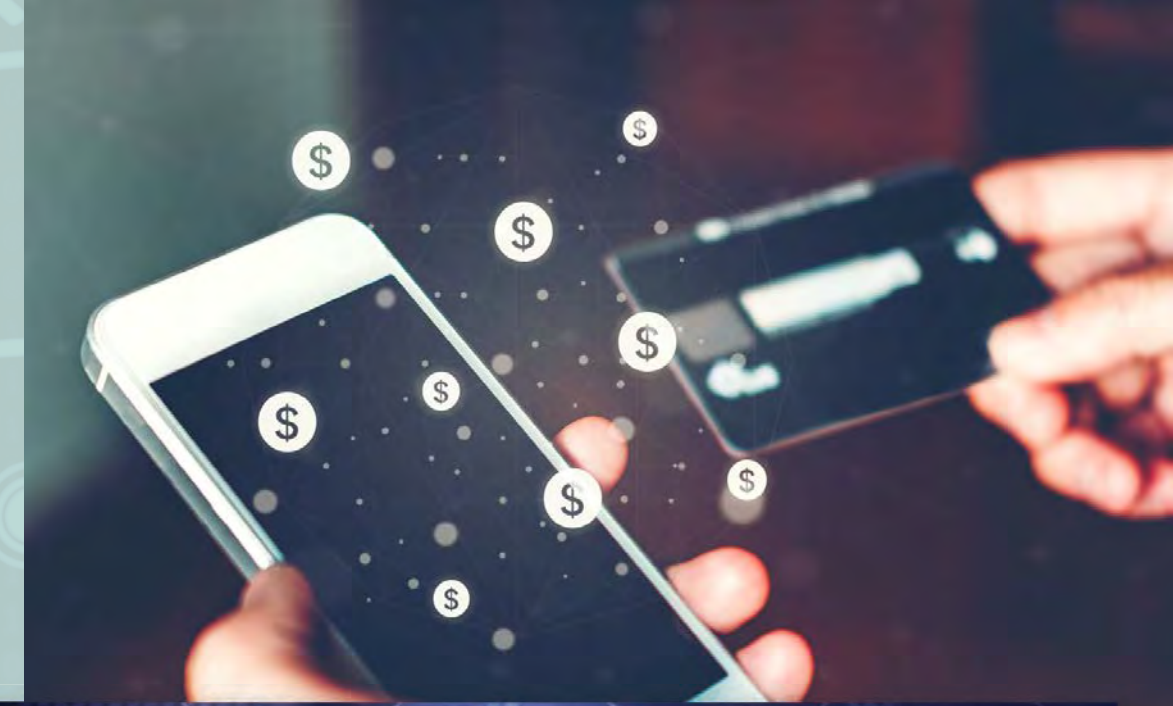




WELCOME TO THE NEXT-GENERATION OF BANKING

We are looking at another bumper year of banks doubling down on innovation. Technologies like blockchain, digital assets, touchless capabilities, voice recognition, real-time cross-border payments, and self-service banking will continue at a rapid pace of adoption. Machine learning applications are enabling the processing of massive amounts of quality data sets that allows the systems to provide intelligence and more accurate predictions of risk factors and monitoring for AML screening and loan candidates.

We are still in the early stages of the impact of AI on financial services, and the fintech industry will continue to benefit from the evolution of machine learning and natural language processing. Consumers are driving change at an unprecedented scale and AI is delivering new solutions to solve some of the challenges that banks are currently facing. Statista reports that digital banks are poised to grow at a rate of 48% CAGR (compound annual growth rate) over the next eight years. Whether it's digital payments or getting a personal loan in a matter of seconds using an AI-powered engine, customers will continue to leave traditional banks for the promise of no fees and touchless banking solutions powered by AI. THNQ index members such as Lemonade, Upstart, Fair Isaac, and Square are leading the digital fintech revolution.





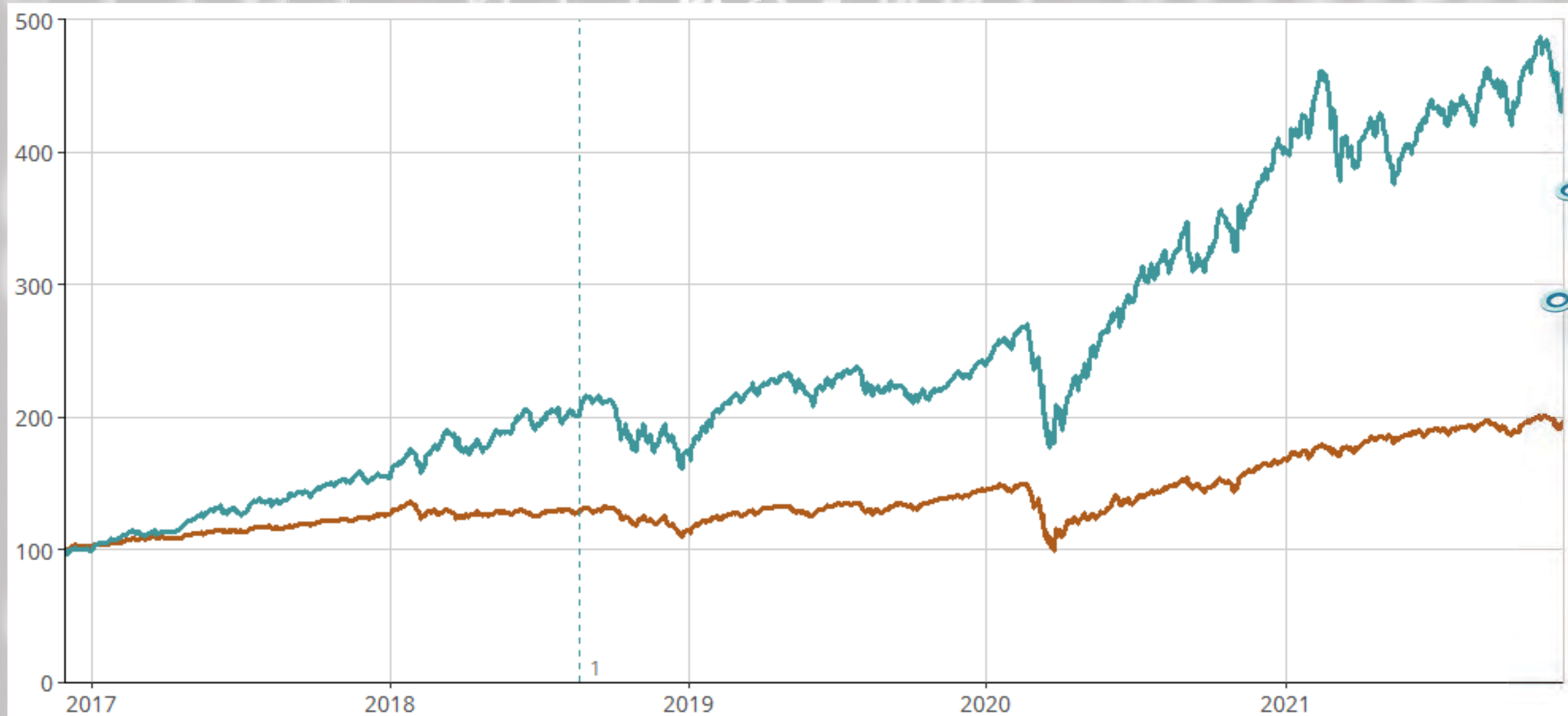
ALL EYES ARE ON IMMERSIVE EXPERIENCE

The boundaries between the real and virtual worlds have officially blurred, and this will only continue into next year. Immersive experiences such as the Van Gogh exhibit and multi-player video games for consumer entertainment are now extending into industries ranging from healthcare technology to manufacturing. Technology-driven healthcare companies are exploring the use cases of reinforcement learning and virtual reality to provide medical diagnoses and therapy for chronic pain. To counteract travel restrictions, auto makers are using AR glasses in dealerships to perform repairs.

We predict that augmented and VR technology is not just here to stay but will finally become more affordable and dependable. We should see a rise of simulation-based technical and medical training, interactive environments in the school setting, and virtual boutiques incorporating 3D images of cosmetics and specialty apparel for a “virtual” try-on. Powerful brands and social media platforms are investing heavily in this technology as the pandemic has shifted consumer buying behaviors and accelerated the need for digital experiences. THNQ index members such as Nvidia, AMD and MediaTek have already made their bets on AI and AR/VR solution sets as these look set to be one of the most interesting disruptions that we will experience over the next few years.



THNQ OUTPERFORMED GLOBAL EQUITIES OVER THE PAST 3 YEARS



ROBO GLOBAL® ARTIFICIAL INTELLIGENCE INDEX¹

GLOBAL EQUITY INDEX

	YTD	3 Year	5 Year	Full Period
ROBO GLOBAL® ARTIFICIAL INTELLIGENCE INDEX¹	11.35%	34.96%	34.93%	34.80%
GLOBAL EQUITY INDEX	16.94%	18.31%	14.11%	14.51%

Rebased 100 on November 30, 2016; Total Return through December 07, 2021; Periods greater than 1 year have been annualized

1: Includes back-tested data prior to August 21, 2018

The ROBO Global Artificial Intelligence Index (ticker: THNQ)





2022 TRENDS IN

HEALTHCARE TECHNOLOGY



IN HEALTHCARE, INNOVATION IS THE ONLY WAY FORWARD

Upon entering 2021, we expected the pandemic to have lingering impacts throughout the year. However, no one anticipated the magnitude of SARS-CoV-2's ripple effects, such as the Delta Variant. As we near the end of the second year of the pandemic and reflect on its wake, one of the costliest effects we've observed is the toll it has taken on healthcare workers. Globally, over 100,000 healthcare workers have been killed by COVID [1]. Of those remaining, a range of pandemic effects, from physical and mental health issues to vaccine mandates, are driving an exodus and further shrinking the workforce. In the US alone, healthcare worker employment has declined by nearly half a million since February 2020 [2].

We expect that it will get worse before it gets better. Staff shortages are driving lower capacity for medical services. Lead times for medical procedure bookings — already playing catchup following the COVID infection waves of 2020 and 2021 — will stretch even longer.

Given these challenges, we expect accelerated demand for automation, artificial intelligence, and data analytics. This will drive compelling investment opportunities as we head into 2022. Healthcare innovation will progress, and the companies that can facilitate the doing of “more with less” will thrive.

[1] <https://www.icn.ch/news/icn-reaction-who-dg-dr-tedros-confirms-least-115000-health-workers-have-died-due-pandemic>

[2] <https://www.bls.gov/news.release/pdf/empsit.pdf>





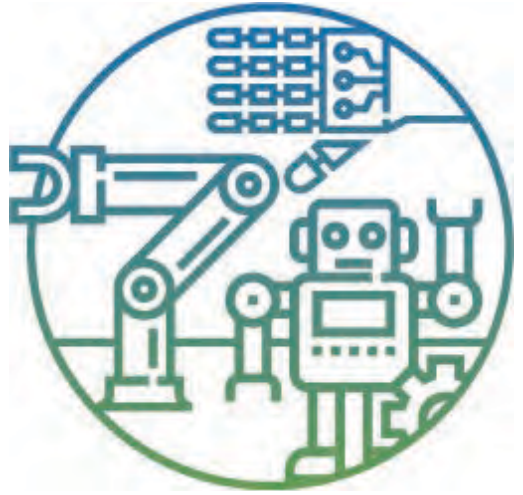
DATA ANALYTICS & AI WILL MEND THE DISFUNCTION

A massive trove of healthcare data has been accumulating and sitting relatively useless for years. Now companies like Health Catalyst, a leading provider of data analytics and AI, are lowering costs and driving efficiencies for hospitals by analyzing that data and making it actionable. For example, the company helped a hospital identify patients with an elevated risk of worsening health, implemented a care plan, and prevented them from being hospitalized. This resulted in \$32 million in cost savings.

There's also a tremendous opportunity to drive efficiencies on the patient floors, where clinicians are bombarded with alarms from the array of devices used for patient care. An overload of beeps and tones causes alarm fatigue, and can ultimately cause high-priority alerts to be missed, particularly in an understaffed setting. Vocera, a leading provider of software communications technology, offers a middleware platform that works behind the scenes to prioritize the alarms and alert only the necessary individuals when intervention is needed.

Another way to address healthcare constraints is by increasingly moving care to lower cost settings; i.e., outside the walls of the hospital. This can be challenging for some services like ultrasound, which requires massive equipment, data storage and specialists, many of which are limited in global availability. Butterfly Network is bringing ultrasound to the patient with its hand-held ultrasound devices, enabling quicker diagnosis and providing access to vital services for those who can't make it to a hospital.





NEED A HAND? BRING ON THE ROBOTS

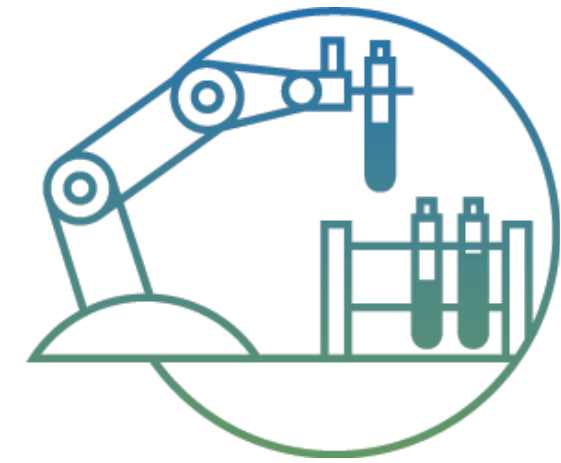
In the operating room, the industry is already seeing long lead times for surgical procedures due to capacity constraints. Errors could result in readmission and further tie up precious resources. Robotic-assisted technology from HTEC companies Intuitive Surgical and Styker are helping to reduce errors, post-operative recovery time and readmission rates, thus freeing up significant capacity for other patients in need of care.

Intuitive Surgical is taking efficiency a step further by improving diagnostic capabilities in lung cancer. It is difficult to biopsy lung tissue and obtain the right sample to glean an accurate diagnosis. Intuitive's new bronchoscopy platform Ion uses computer vision, shape-sensing, and ultra-thin maneuverable catheters to enable navigation into the hardest-to-reach places of the lung. The company is conducting a large multi-center study, and early evidence shows that using Ion for biopsy results in an 83% likelihood of providing clinicians with enough information to establish a diagnosis. This is game changing for lung cancer, because the right diagnosis is the key to determining treatment. The company plans to release final results of this study in 2H22.

Hospitals aren't the only healthcare stakeholder with staff shortages. In a recent survey by the National Community Pharmacists Association, 90% of respondents indicated that pharmacies having trouble hiring pharmacy technicians.

Omniceil is particularly well positioned to fill staffing gaps with its autonomous pharmacy platform. Omnicell is the market leader for automated medication management solutions. Their robotics, dispensing systems, and data analytics are designed to reduce manual and administrative tasks and enable workers to focus more on patient care.



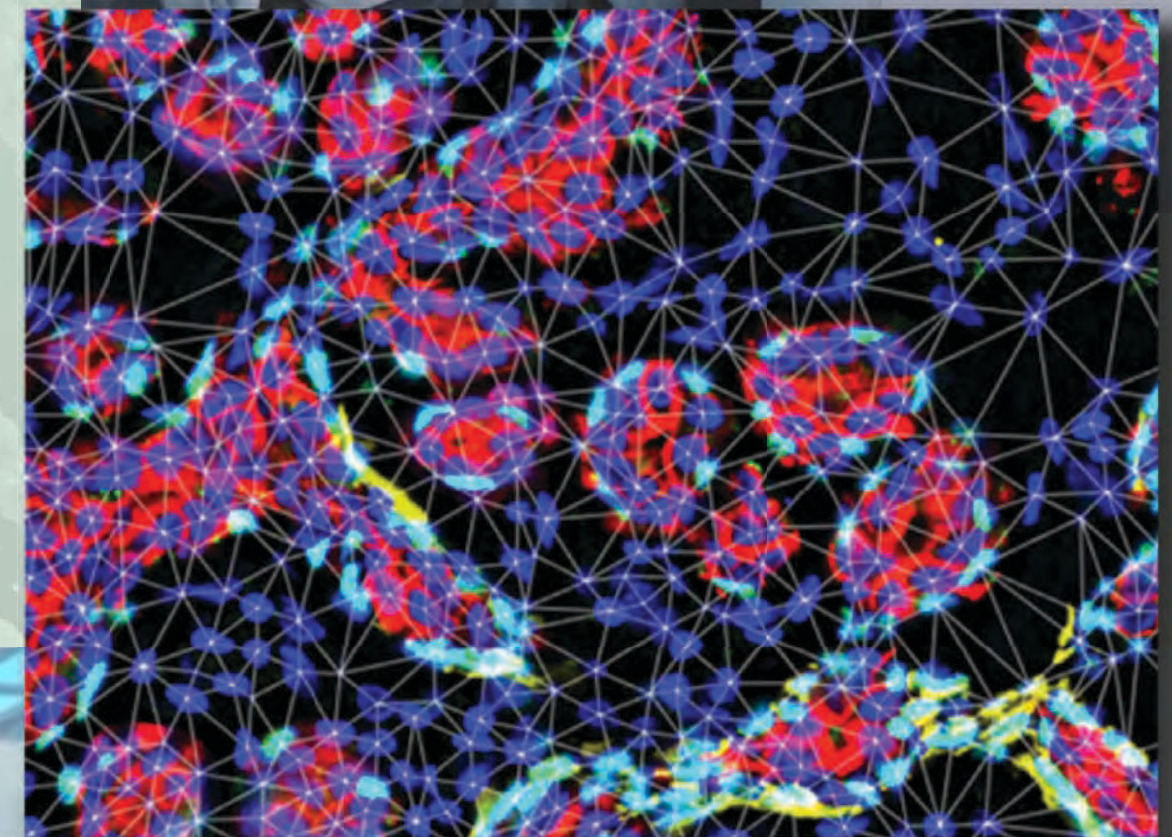


THE NEXT FRONTIER OF GENOMIC SCIENCE: SPATIAL BIOLOGY

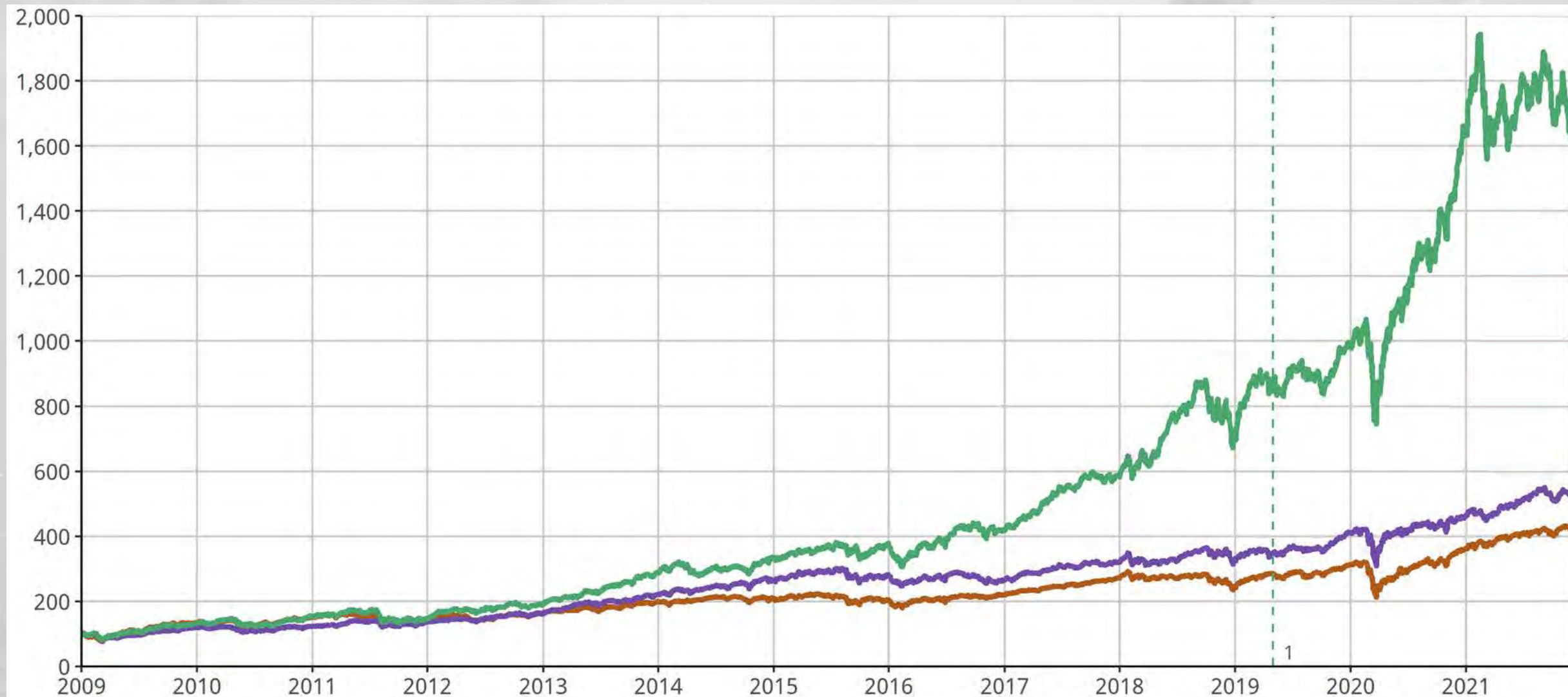
Over the last few decades, scientists have been sequencing genes to gain a deeper understanding of biology and get answers to questions like which cells are causing cancer. Academic research centers and pharma companies alike use this gene sequencing to understand disease and develop treatments.

Today, a new area of science known as spatial biology is providing much more insight into these cells, such as their precise location within the tissue, what other cells they interact with. This information provides a far more comprehensive view than that obtained with gene sequencing, and provides explanations for why a certain cancer drug meant for a certain gene isn't working. It is only with this more comprehensive view that the industry can seek true precision medicine. HTEC provides exposure to this \$17 billion market opportunity with Nanostring, the market leader for spatial biology instrumentation, and Akoya Biosciences, an emerging disruptor in the space.

Akoya's instrumentation offers both scale and higher throughput, which will allow researchers to analyze more samples in less time by orders of magnitude. This means faster discovery, and ultimately faster clinical trials for pharma companies. We expect to look back at 2022 in a few years as the year spatial biology hit an inflection point and accelerated therapeutic and diagnostic innovation.



HTEC OUTPERFORMED GLOBAL EQUITIES OVER THE PAST 2 YEARS



	YTD	3 Year	5 Year	10 Year	Full Period
ROBO GLOBAL® HEALTHCARE TECHNOLOGY AND INNOVATION INDEX¹	-1.41%	26.12%	31.18%	27.04%	24.03%
GLOBAL HEALTHCARE INDEX	11.69%	13.00%	14.87%	14.65%	13.60%
GLOBAL EQUITY INDEX	13.98%	15.95%	13.98%	11.38%	11.62%

Rebased 100 on December 31, 2008; Total Return through November 30, 2021; Periods greater than 1 year have been annualized

1: Includes back-tested data prior to April 30, 2019



The ROBO Global Healthcare Technology and Innovation Index (ticker: HTEC)



ABOUT THE AUTHORS



JEREMIE CAPRON
Director of
Research

Jeremie Capron joined ROBO Global in 2017 with more than 10 years of experience as an equity research analyst in Asia, Europe, and the U.S. with a focus on industrial technology.



NINA DEKA
Senior Research
Analyst

Nina Deka brings nearly two decades of healthcare industry and investment research experience to the ROBO Global research team.



LISA CHAI
Partner
(ROBO Global Venture)

Lisa Chai brings more than 17 years of experience investing in disruptive technology companies to her role as ROBO Global's Senior Research Analyst.



ZENO MERCER
Research
Analyst

Zeno brings nearly a decade of experience in research, due diligence, growth strategy, and partnership development across enterprise SaaS, healthcare, AI and blockchain.



WILLIAM STUDEBAKER
President
& CIO

Bill Studebaker joined the ROBO Global team in 2015 after more than 20 years in capital markets and investment management.



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