DIGITAL ECONOMY COMPASS
2022

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Conflict, inflation, food supply and energy crises, as well as the long tail of the pandemic caused shockwaves across the world in 2022

As 2021 was about to end, there was a broad sense of optimism for the year ahead, a "back to normal" after the pandemic. In fact, the second half of 2022 saw a gradual lifting of most limitations put in place to stop the spread of COVID-19. However, there is little question that the Russian invasion of Ukraine was the event that had the greatest impact on the year. In addition, the unexpected war had a significant effect on the world economy, leading to substantial rises in the cost of food and energy as well as an overall global surge in inflation rates, which led to aggressive monetary tightening and uncertainties triggering a global cost-of-living crisis. Because of these new uncertainties, some topics related to the digital economy need to be re-evaluated.

In this context, we decided to publish the sixth edition of the Digital Economy Compass. It aggregates and makes sense of data from both our own models as well as the most relevant third-party sources out there. Data shown is structured around five topics we want to highlight: eCommerce facing the global recession and resetting expectations, the ascent of the crypto economy, gaming and the Metaverse with the hype around immersive digital worlds, growing cybersecurity challenges, and the future of smart mobility.

Chapter 1 - "From frenzy to fall: is eCommerce back to normal?" (released in August 2022), shows what happened to many digital industries in 2022 after the unparalleled COVID-19 boom in the years before. In 2022 eCommerce finds itself at a turning point. Dramatic developments on a global scale, such as the Russia-Ukraine war, inflation, and supply chain shocks, are pointing at a global recession and have led to a performance slowdown of many major players.

Chapter 2 - "The ascent of the crypto economy" (released in May 2022), debates the turbulent development of cryptocurrencies with its many advances and setbacks. The industry has moved on from concepts and whitepapers to real-life applications, adding over 10,000 different cryptocurrencies, several novel ideas and features such as smart contracts, which unlocked a plethora of possibilities and given rise to an entire crypto ecosystem. Despite significant advancements, cryptocurrencies remain highly controversial due to high volatility, increasing numbers of cyberattacks, and issues related to energy consumption and scalability.

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Chapter 3 – "Gaming and the Metaverse: Will the evolution of gaming give rise to a new digital economy?" (released in December 2022), discusses the hype surrounding the Metaverse, betting on a future of an immersive virtual world that does not yet exist. Many are contributing to this flurry of activity by freely experimenting in this space. As the gaming industry expands, technology and gaming experiences follow suit. There are many unanswered questions surrounding the Metaverse: who will control it, what it will encompass, and how much of an impact it will have on our lives. In its current state, the Metaverse is only a set of potentials and not a reality.

Chapter 4 - "Cybersecurity: fighting the formidable foes of the internet" (released in November 2022), tells how a relentless rise in cyber threats, which were created to some extent by the pandemic, is putting cybersecurity on everyone's agenda. Additionally, dramatic developments on a global scale, such as the Russia-Ukraine war, also continue to accelerate cybersecurity spending and the priorities of organizations.

Chapter 5 - "Smart Mobility – The future is digital, greener, and more efficient" (released in October 2022), undertakes an expedition in our way of moving people in the 21st century. The topic of smart mobility comes with discussions about cleaner, safer, and more efficient mobility. Heated debates about topics centering around global greenhouse gas emissions, the consequences of air pollution, road traffic accidents, and traffic congestion indicate that mobility in the 21st century is not smart yet.

The Digital Economy Compass is published every year by Statista and focuses on finding answers and, in doing so, new questions with the most relevant and recent data out there. Our own research and market analyses are accessible outside the Digital Economy Compass in even greater depth and are bundled into a targeted product family. The Statista Market Outlooks provide 700,000+ data stats on 2,200+ markets, 700+ reports, and cover 150+ countries. The Statista Global Consumer Survey contains data from 1,700,000+ interviews, covering 56 countries and 50+ industries as well as 14,500+ brands. The eCommerceDB.com collects revenue data and 40+ KPIs of 20,000+ online stores in 50+ countries and generates 270+ reports. The Statista CompanyDB provides data about 1.7 million companies, which is clustered into 80+ industries and condensed into 1,000+ reports depicting 28+ different KPIs.

For the Digital Economy Compass 2022, we are proud to have compiled more than 200 slides with the most insightful and exciting data. We hope you find them to be both informative and enjoyable.

Dr. Friedrich Schwandt (CEO)

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CHAPTER 1

From frenzy to fall: is eCommerce back to normal?

Originally released in August 2022 (as Chapter 2)

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From frenzy to fall: is eCommerce back to normal?

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A post-pandemic hangover is ending the celebration of eCommerce growth

The eCommerce rollercoaster is in full swing, and nobody knows where it is going. After an unparalleled boom set in motion by the global COVID-19 crisis, eCommerce finds itself at a turning point. Dramatic developments on a global scale such as the Russia-Ukraine war, inflation, and supply chain shocks are pointing at a global recession and are forcing a performance slowdown of many major eCommerce players. 2022 will be the first time in its long history that the market will see negative revenue growth. Of course, this always has to be seen in perspective, and many industry experts contest the comparison of today's growth figures with pre-COVID-19 data. Nevertheless, the market is now compelled to tackle substantial questions and how to go forward. Even if there is a lot of headwind at the moment, we still believe online shares will eventually increase and revenue growth will get back on track.

Despite turbulent developments on a global scale in 2022, eCommerce still accounts by far for the largest chunk of the digital economy

Revenue of selected markets of the digital economy in billion US\$ in 2022[1]

eCommerce	Digital Advertising
3747	616

Digital Media	Online Food Delivery
360	323

Online Edu-cation	Digital Health	Smart Home
146	139	115
		Event Tickets 65
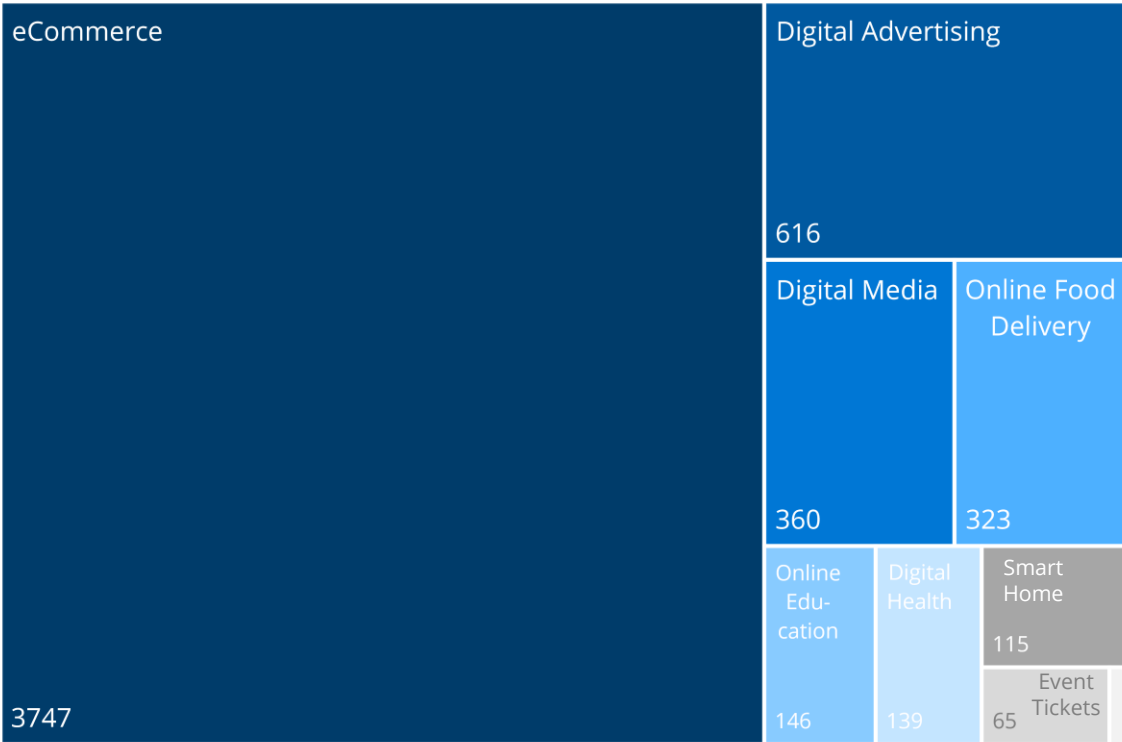
Users of selected markets of the digital economy in million
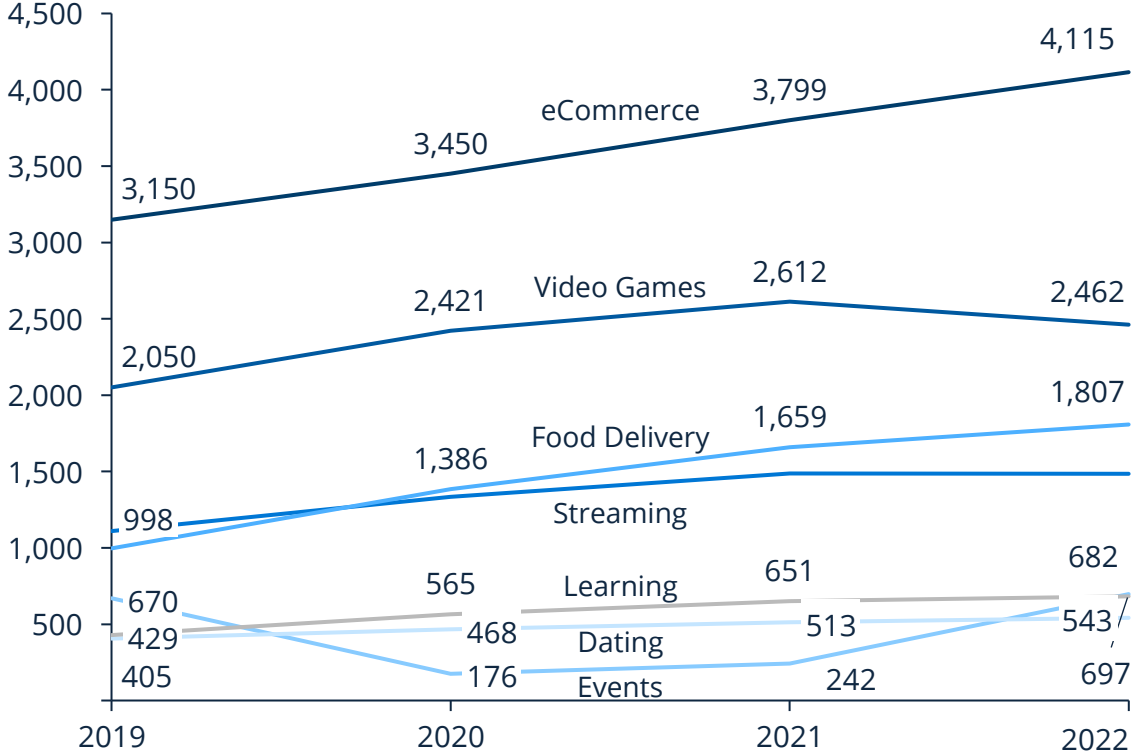
eCommerce
- 3,150
- 3,450
- 3,799
- 4,115

Video Games
- 2,050
- 2,421
- 2,612
- 2,462

Food Delivery
- 998
- 1,386
- 1,659
- 1,807

Streaming

Learning
- 565
- 651
- 682

Dating
- 670
- 513
- 543

Events
- 429
- 468
- 697

- 405
- 176
- 242

2019   2020   2021   2022

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Dramatic developments pointing at a global recession are leading to an extreme slowdown in performance on the stock market for many eCommerce players

Stock prices of selected eCommerce key players in US$

Average % change
from 07/01/2021
till 07/12/2022

-55.2%

Stock prices shown for: sea, Alibaba Group, Etsy, amazon, shopify, Pinduoduo, ebay

X-axis: 07/01/2021, 09/01/2021, 11/01/2021, 01/01/2022, 03/01/2022, 05/01/2022, 07/12/2022

Y-axis: 50, 100, 150, 200, 250, 300, 350, 400
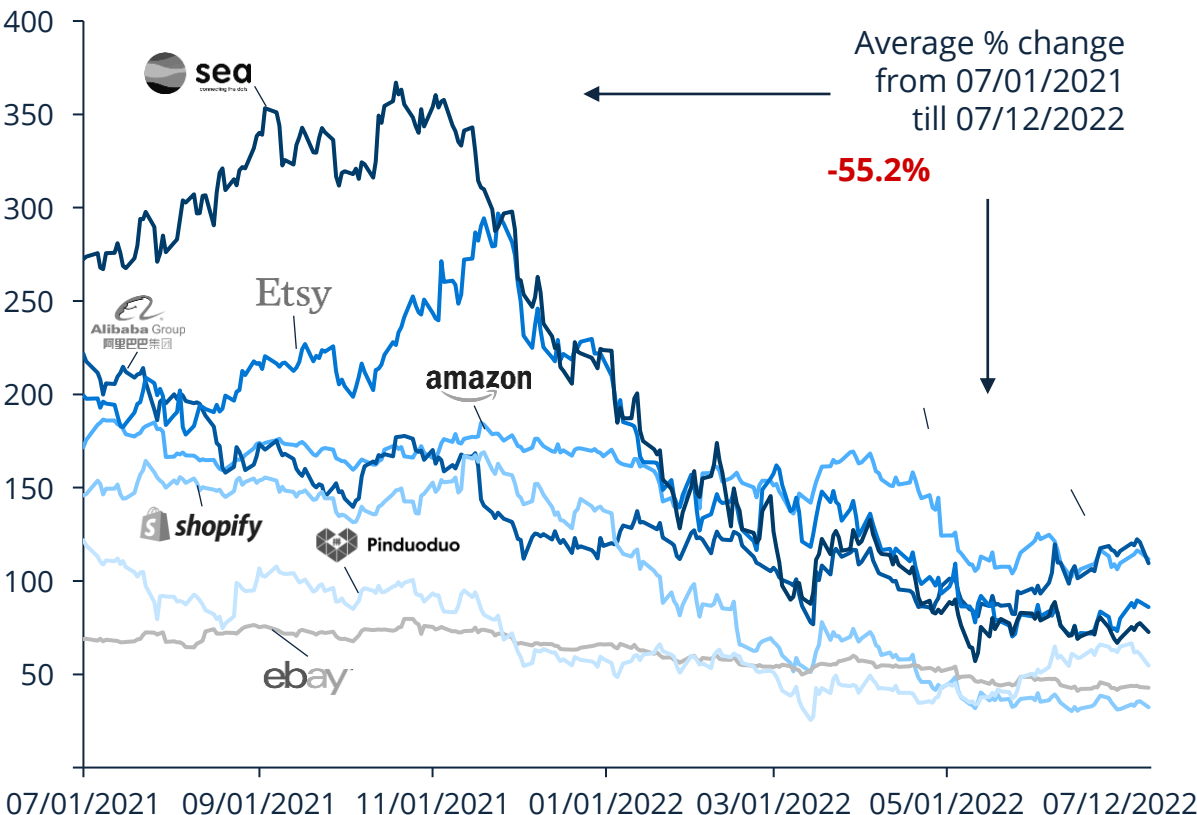
Stock price change from July 2021 to 2022 for selected eCommerce key players

Company	Change
wish	-88%
FARFETCH	-87%
wayfair	-84%
boohoo	-81%
ASOS	-81%
JUMIA	-80%
shopify	-78%
zalando	-74%
sea	-73%
ABOUT YOU	-71%
coupang	-64%
allegro	-64%
苏宁易购 Suning.com	-64%
Rakuten	-58%
mercado libre	-57%
Etsy	-57%
Pinduoduo	-55%
Alibaba Group	-51%
vip.com 唯品会	-50%
chewy	-47%
TARGET	-39%
BEST BUY	-38%
ebay	-38%
amazon	-35%
JD.COM	-21%
Walmart	-9%

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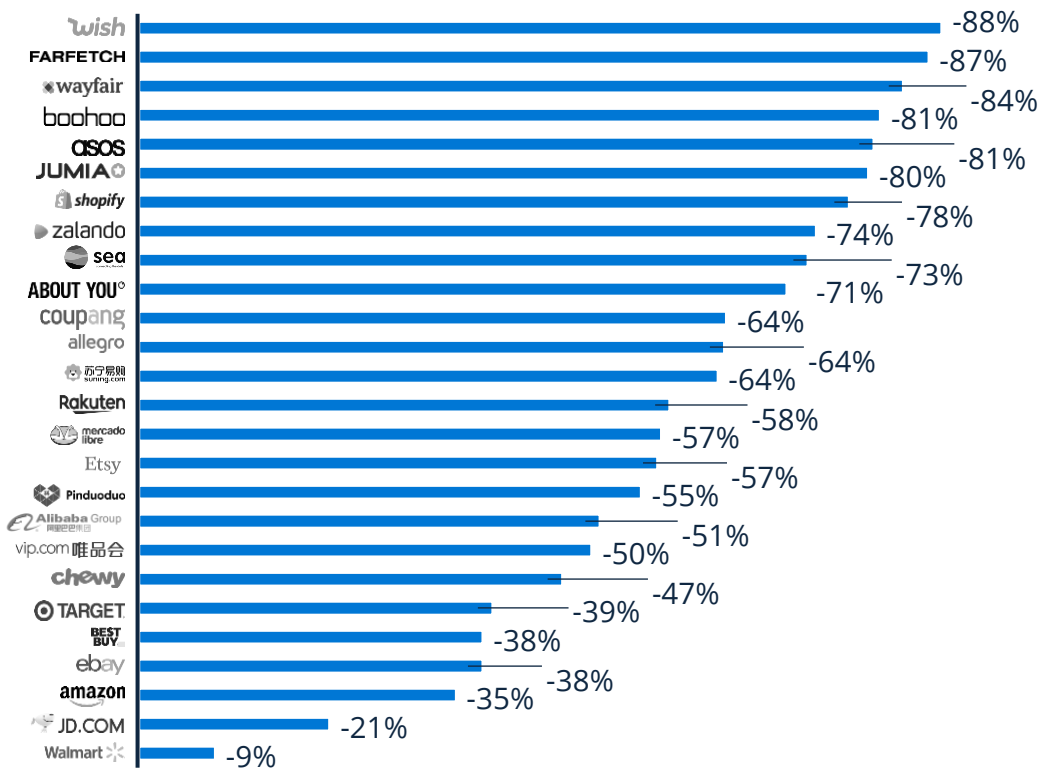
For the first time in its long history, eCommerce growth will be negative in 2022

Global eCommerce revenue forecast in billion US$[1]
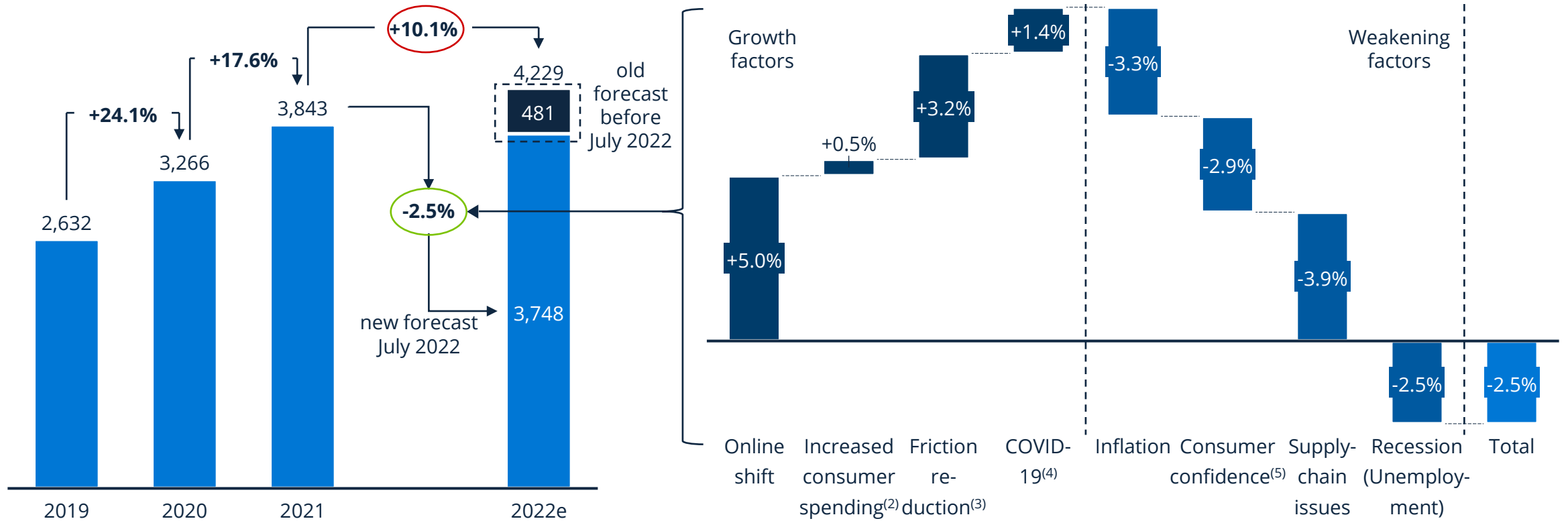
+10.1%

+17.6%

+24.1%

4,229

481

old forecast before July 2022

3,843

3,266

2,632

-2.5%

3,748

new forecast July 2022

2019   2020   2021   2022e

Growth factors

Weakening factors

+1.4%

+3.2%

+0.5%

+5.0%

-3.3%

-2.9%

-3.9%

-2.5%

-2.5%

Online shift | Increased consumer spending[2] | Friction re-duction[3] | COVID-19[4] | Inflation | Consumer confidence[5] | Supply-chain issues | Recession (Unemploy-ment) | Total

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While discretionary segments such as Electronics have been hit hard, others serving essential needs such as Food & Beverages are still performing well

Worldwide eCommerce revenue by category in billion US$ in 2022[1]

852	834	638	415	371	257	225	157

- 249 Accessories
- 488 Apparel
- 115 Footwear
- 616 Consumer Electronics
- 218 Household Appliances
- 255 DIY, Garden & Pets
- 217 Hobby & Stationery
- 71 Sports & Outdoor
- 95 Toys & Baby
- 88 Bedroom
- 30 Floor Covering
- 45 Kitchen
- 71 Lamps & lighting
- 105 Living & Dining-Room
- 69 Other Plastic
- 6
- 52 Beauty Care
- 53 Household Care
- 53 Health Care
- 213 Personal Care
- 46
- 51
- 21
- 26
- 16
- 22
- 31
- 5 — 2
- 10
- 27
- 95 Alkoholic Drinks
- 35 Hot Drinks
- 91 Non-Alcoholic Beverages
- Other 3

Fashion | Electronics | Toys, Hobby & DIY | Furniture | Food | Media

Beverages

Beauty, Health, Personal & Household Care

Growth rates of eCommerce categories in %[1]
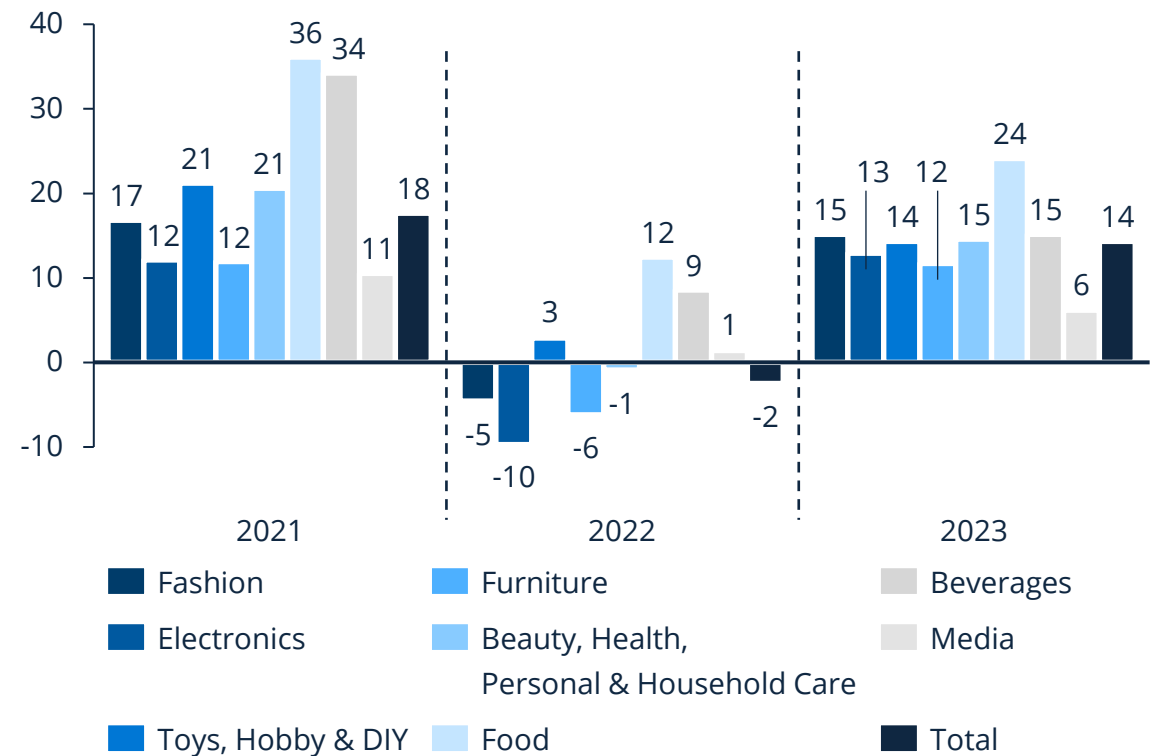
2021: 17, 12, 21, 12, 21, 36, 34, 11, 18

2022: -5, -10, 3, -6, -1, 12, 9, 1, -2

2023: 15, 13, 14, 12, 15, 24, 15, 6, 14

Legend:
- Fashion
- Electronics
- Toys, Hobby & DIY
- Furniture
- Beauty, Health, Personal & Household Care
- Food
- Beverages
- Media
- Total

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As the incidence rates of COVID-19 decline in 2022, the growth of retail done online is more in line with pre-pandemic trends

Growth rates of retail online shares[1]

United States

Brazil

— Retail online share growth — Pre-pandemic retail online share growth
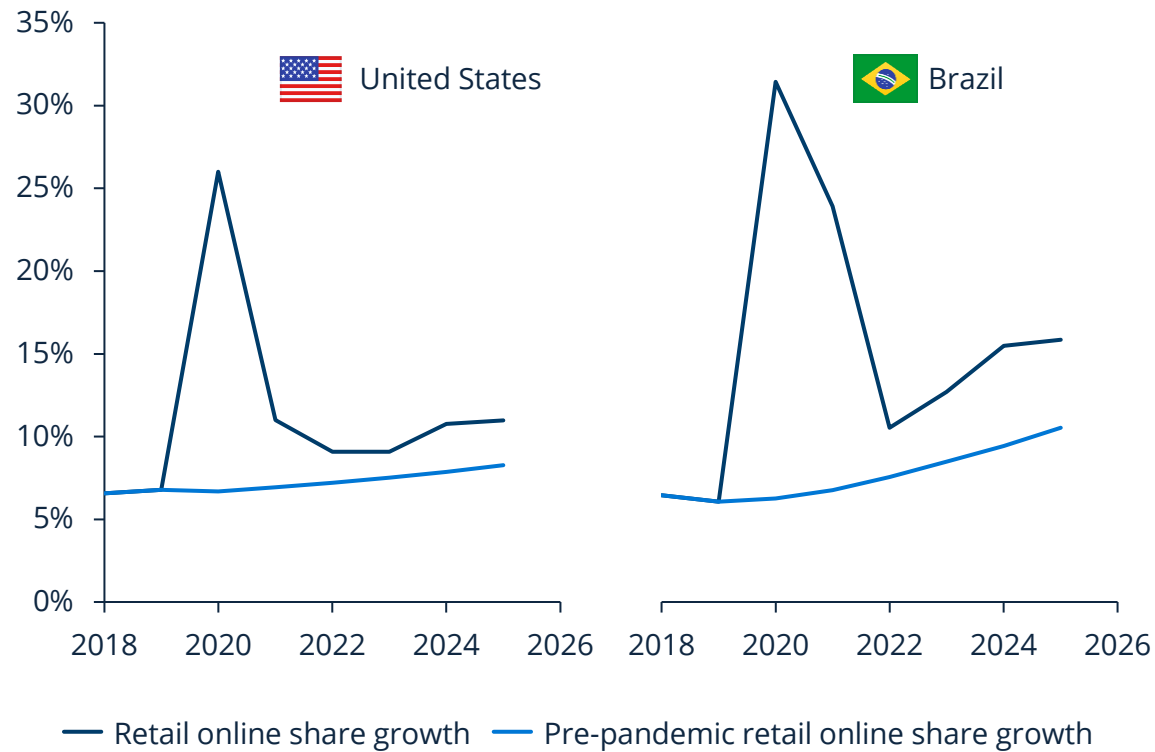
Internet retail sales in comparison to new COVID-19 cases in the UK
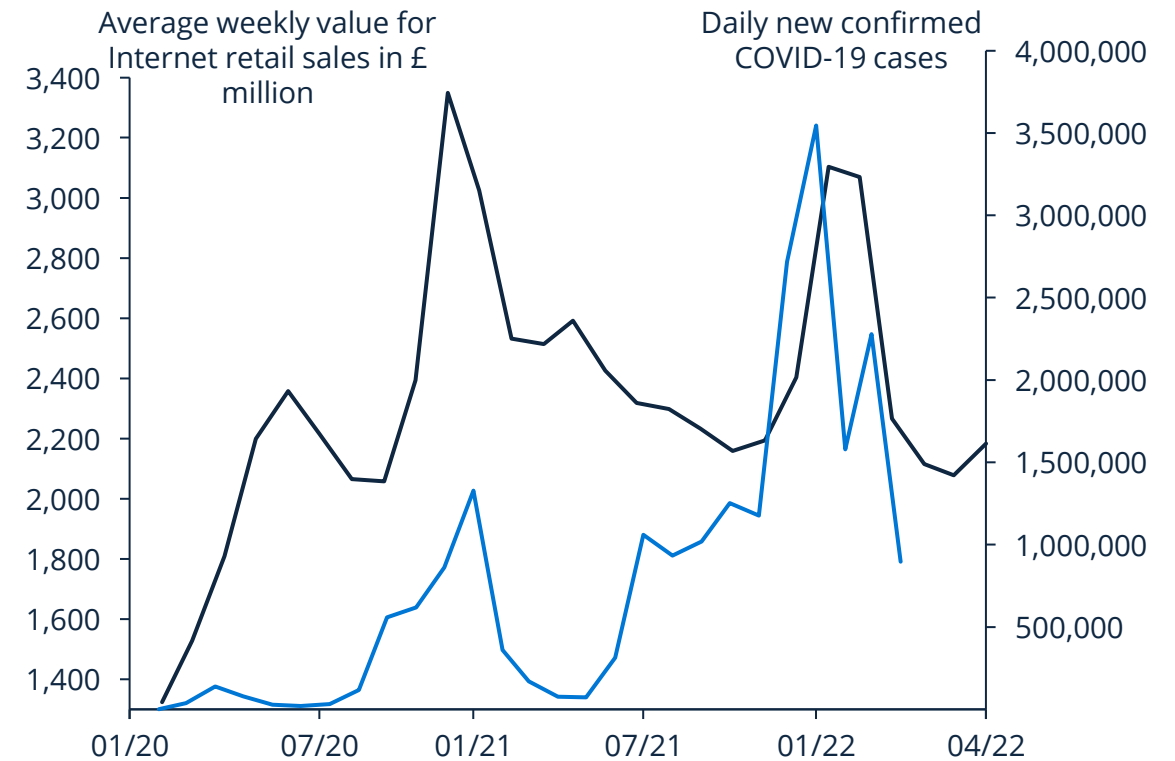
Average weekly value for Internet retail sales in £ million

Daily new confirmed COVID-19 cases

13

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What was once spent on eCommerce during the pandemic is now being budgeted for offline, travel, and event items

Offline sales revenue of selected brands in bn US$

Walmart: 487 (2020), 494 (2021), 521 (2022e) **+5%**

adidas: 13 (2020), 15 (2021), 17 (2022e) **+18%**

H&M: 15 (2020), 16 (2021), 18 (2022e) **+14%**

Legend: ■ 2020 ■ 2021 ■ 2022e
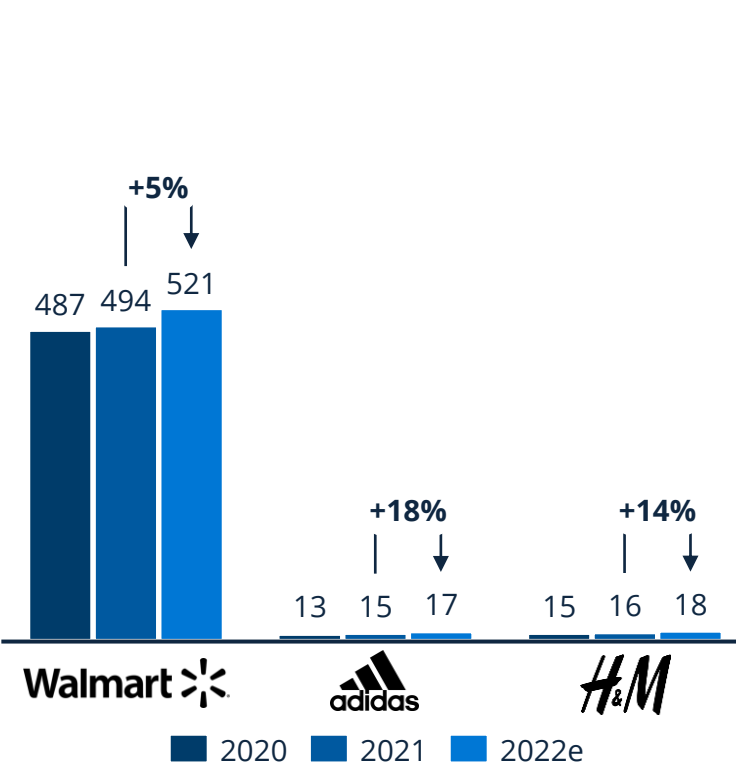
Global revenue of Travel & Tourism in bn US$

2019: 776
2020: 346
2021: 491
2022: 717

+46%
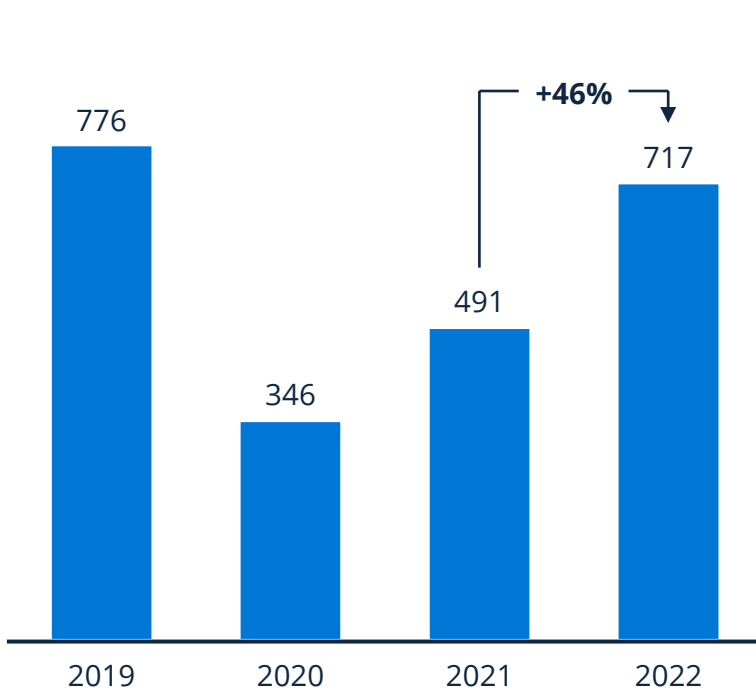
Global revenue of Live Music Ticket Sales in bn US$

2019: 24
2020: 4
2021: 5
2022: 24

+358%
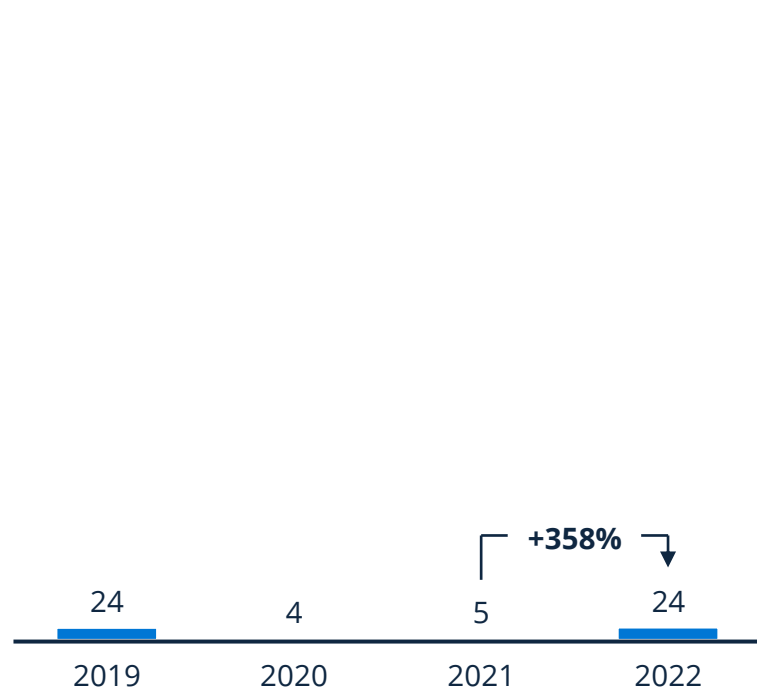
An average exchange rates for respective year have been applied to the findings from the financial report based on the IRS website.

Sources: Company Information; eCommerceDB; Statista Market Outlook 2022

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Although there is a current tendency to return to retail offline sales, online shares are projected to increase on a global scale until 2025

Worldwide offline and online share of total retail revenue[1] and online share of selected categories[2]
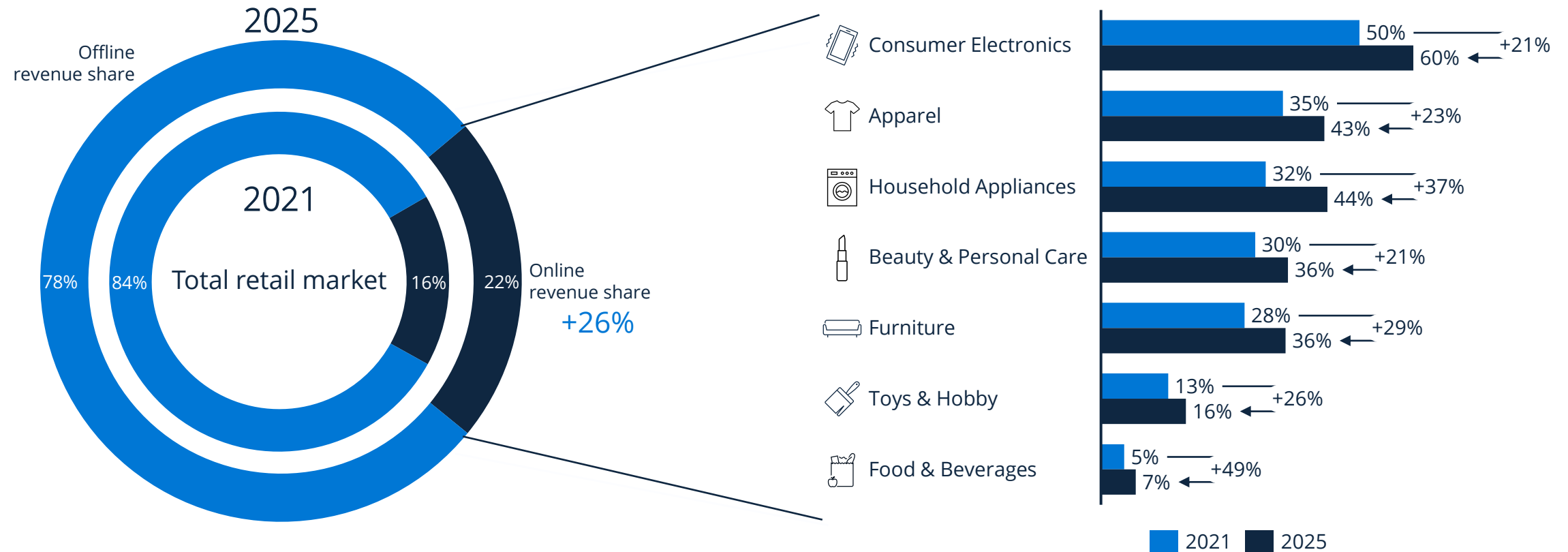
2025

Offline revenue share

78% 84%

2021

Total retail market

16% 22%

Online revenue share
+26%

Category	2021	2025	Change
Consumer Electronics	50%	60%	+21%
Apparel	35%	43%	+23%
Household Appliances	32%	44%	+37%
Beauty & Personal Care	30%	36%	+21%
Furniture	28%	36%	+29%
Toys & Hobby	13%	16%	+26%
Food & Beverages	5%	7%	+49%

2021 2025

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Although 2022 will be a tough year for eCommerce, revenue growth is expected to bounce back next year

Global eCommerce revenue in billion US$ and growth rates[1]

	2017	2018	2019	2020	2021	2022	2023	2024	2025
Revenue	2,240	2,420	2,632	3,266	3,843	3,748	4,284	4,837	5,422
Growth		8%	9%	24%	18%	-2%	14%	13%	12%

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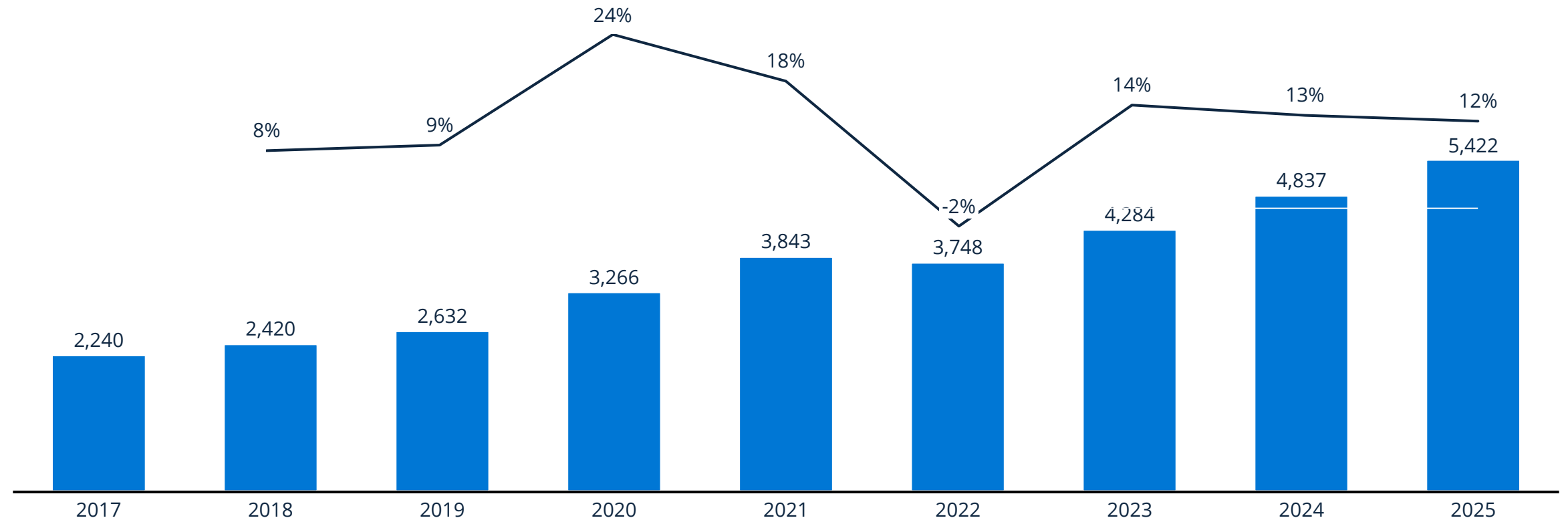
Rising prices, dwindling revenues: eCommerce is facing the global arrival of stagflation

Russia's invasion of Ukraine and its effects on commodity markets, supply chains, inflation, and financial conditions have aggravated the slowdown in global growth. Preexisting deglobalization pressures will likely be exacerbated, with countries seeking a higher degree of self-reliance and companies rebalancing supply chains. Supply chain shocks, which are the key drivers behind congestions in global trade, have dramatically delayed delivery times by suppliers this year. Consumers will notice this most when purchasing durable goods but less so in the areas of staples and services. In general, they will see their budgets squeezed by higher food and fuel prices, which will crowd out other spending. Additional pressure comes in the form of reduced incomes caused by unemployment. Considering all these developments, eCommerce companies are facing substantial challenges, for which, after the golden years of the pandemic, perhaps not everyone was prepared.

Major economic institutions adjusted their global GDP projections in 2022

Global GDP projection revision by selected institutions

Institution	Revision
Conference Board	-0.4%
The Economist	-0.5%
NIESR	-0.5%
Moody's Analytics	-0.6%
IMF	-0.8%
Fitch Ratings	-0.7%
Oxford Economics	-1.0%
UNCTAD	-1.0%
Kiel Institute	-1.0%
OECD	-1.1%
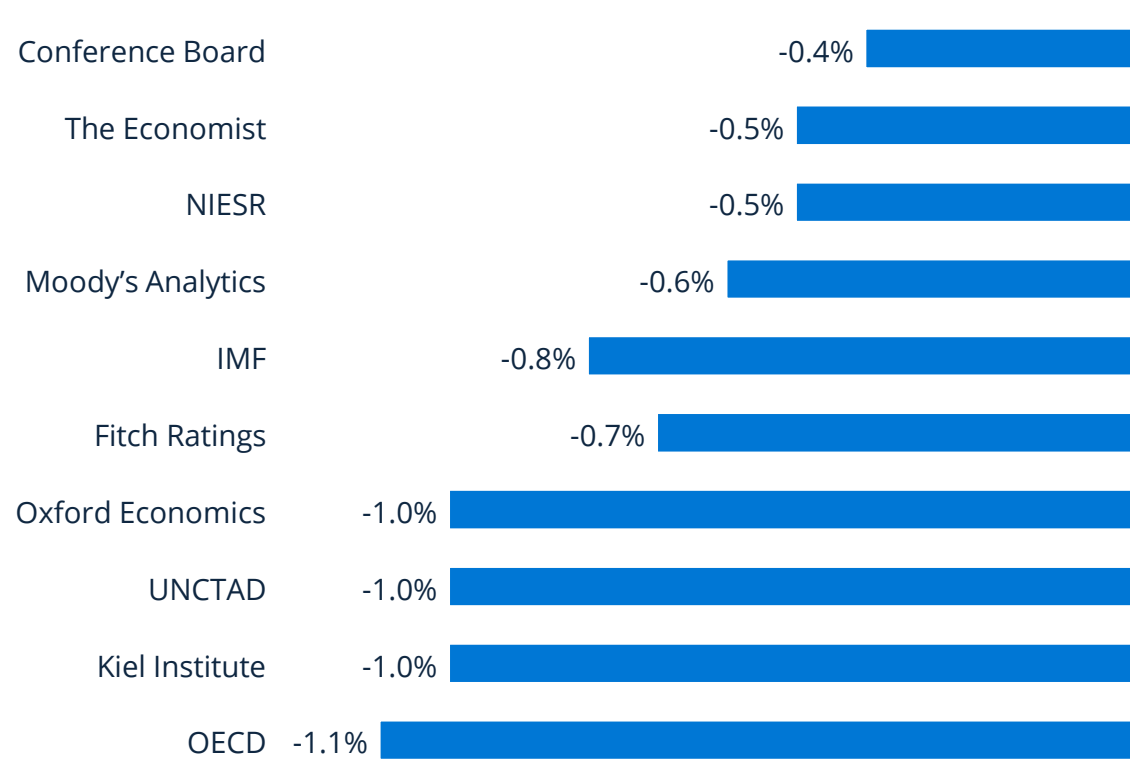
Projected real GDP growth rate
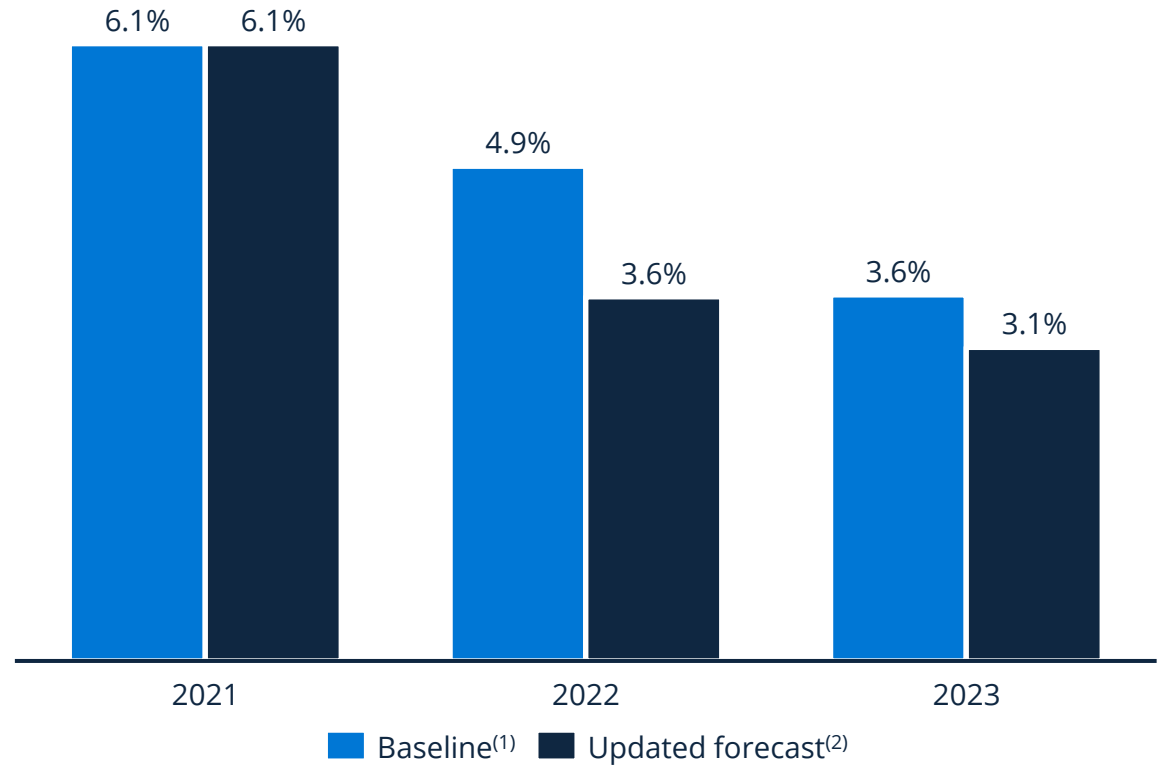
Year	Baseline[1]	Updated forecast[2]
2021	6.1%	6.1%
2022	4.9%	3.6%
2023	3.6%	3.1%

Baseline[1] Updated forecast[2]

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Declining economic growth in 2022 has been affected by a wide array of ongoing global disruptions

Magnitude of disruptions, frequency, and ability to anticipate
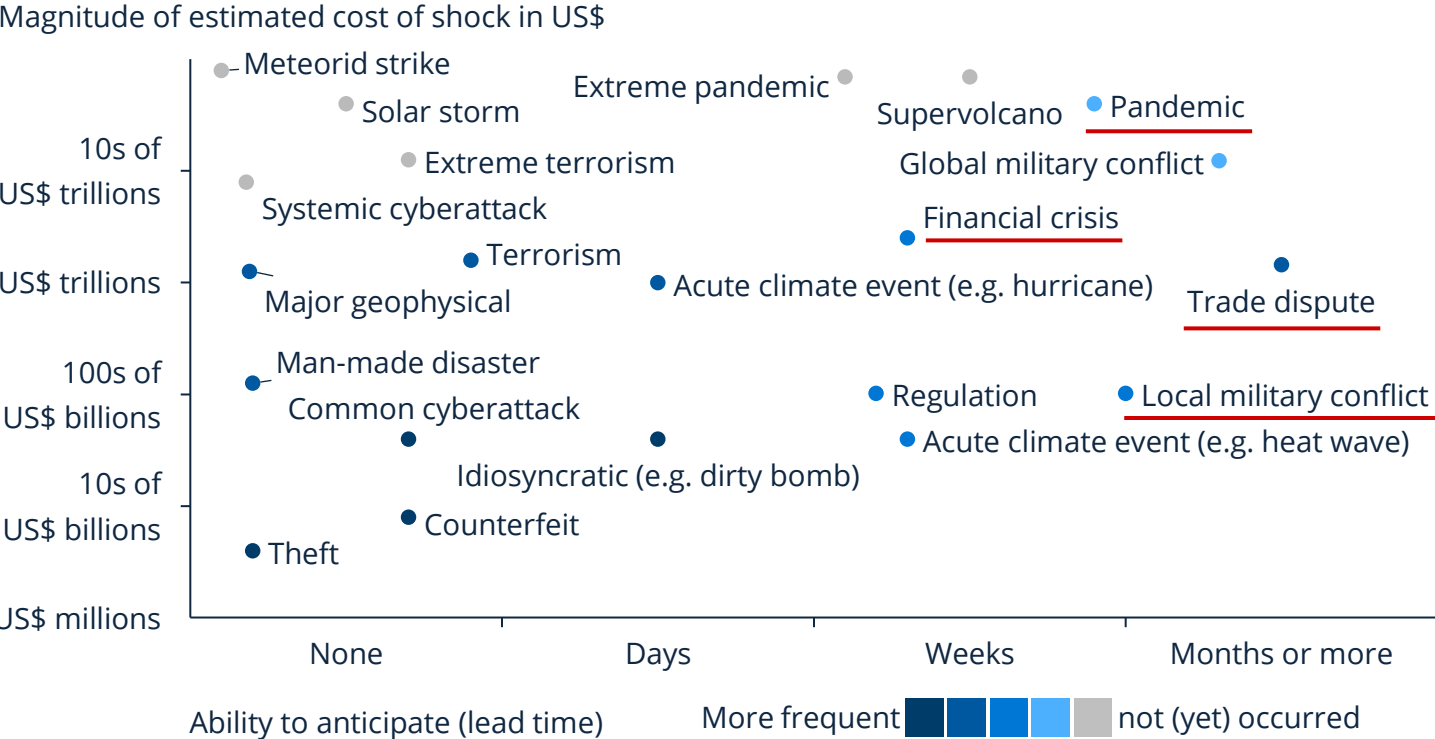
Disruptions the economy is facing in 2022

Magnitude of estimated cost of shock in US$

- Meteroid strike
- Extreme pandemic
- Supervolcano
- Pandemic
- Solar storm

10s of US$ trillions
- Extreme terrorism
- Global military conflict
- Systemic cyberattack
- Financial crisis

US$ trillions
- Terrorism
- Acute climate event (e.g. hurricane)
- Trade dispute
- Major geophysical

100s of US$ billions
- Man-made disaster
- Common cyberattack
- Regulation
- Local military conflict
- Acute climate event (e.g. heat wave)

10s of US$ billions
- Idiosyncratic (e.g. dirty bomb)
- Counterfeit
- Theft

US$ millions

None | Days | Weeks | Months or more

Ability to anticipate (lead time)

More frequent ■■■■■ not (yet) occurred

COVID-19 Pandemic

Acute climate events due to global warming

Local military conflict Russia-Ukraine War

Financial challenges and trade disputes

contributing to

Inflation

Supply chain disruption

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In some countries, stringent government policies related to COVID-19 continue to affect the global economy in diverse ways

COVID-19 stringency index for selected countries[1]
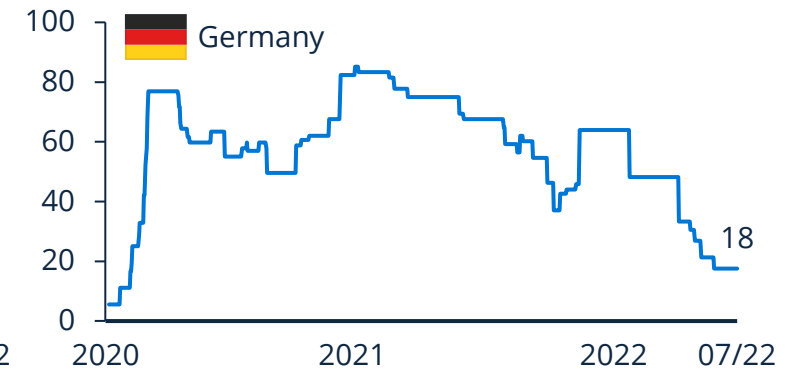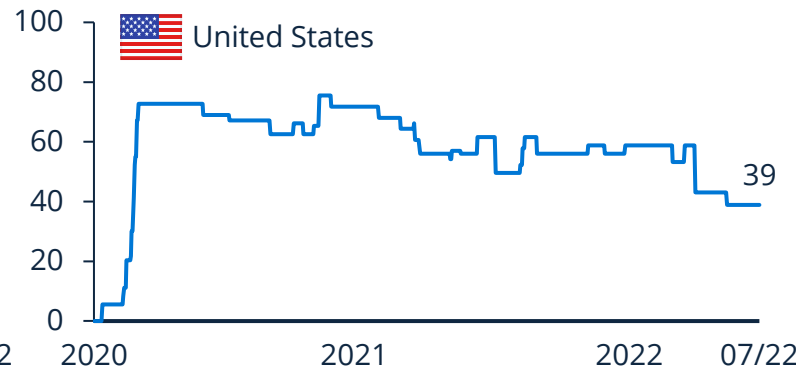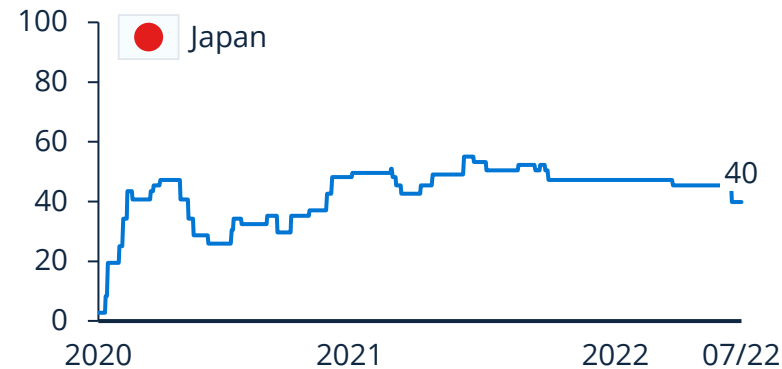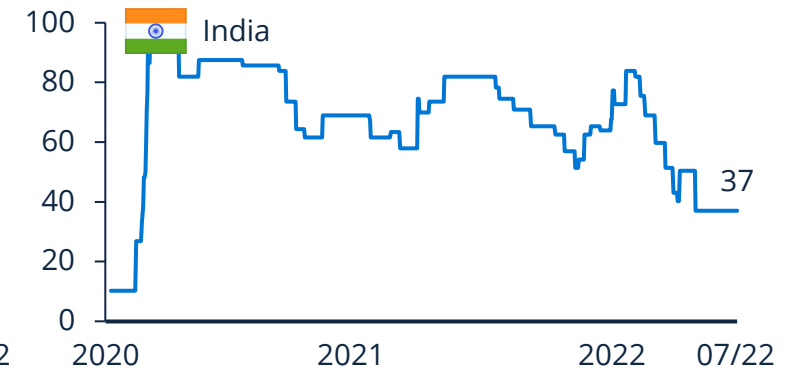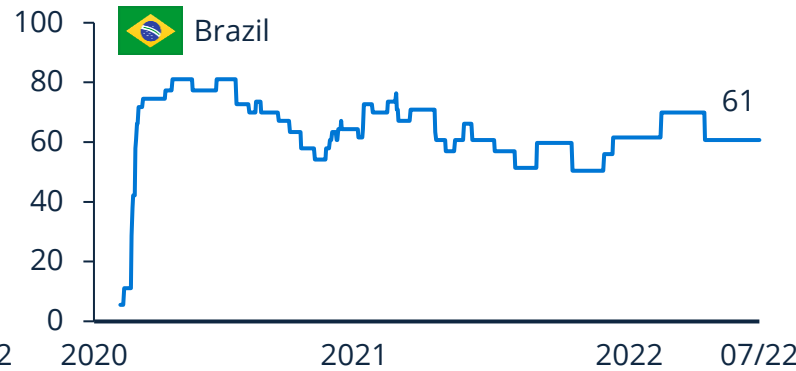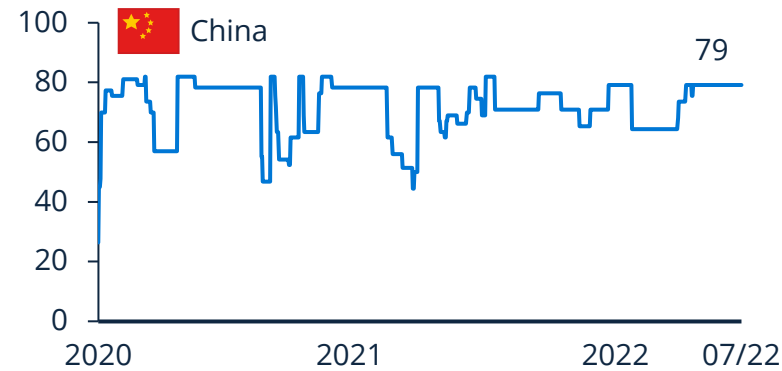
Notes: (1) The stringency index is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest)

Sources: Oxford COVID-19 Government Response Tracker

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The Russia-Ukraine war is expected to cause severe pressure on both supply chains and consumer budgets, and effects are likely to last long-term

Starting point

- Consumer markets are still recovering from the pandemic-induced recession, with spending on services still being subdued as compared to pre-crisis levels and spending on physical consumer goods having heightened.

- Fiscal measures have stabilized and boosted household incomes, leading to many households having excess savings. Additionally, lockdowns and social distancing have resulted in reduced out-of-home spending on services.

- Excess savings and limited supply (supply chain issues) have led to inflationary pressures, which were originally expected to ease once economies reopened.

Expected immediate impact

- The war will have long-term, severe consequences: global growth could decrease by 1 to 2 percentage points as compared to prewar forecasts.

- Although Russia and Ukraine make up only around 2% of global trade, they are key suppliers for some mineral and agricultural commodities, so the war will trigger additional supply chain pressures.

- Energy-intensive industries as well as industries reliant on affected commodities are most exposed.

- Consumers will see their budgets squeezed by higher food and fuel prices, which will crowd out other spending. Discretionary consumer goods spending will be most affected.

- Additionally, consumers might be affected by a possible recession in the form of reduced incomes caused by unemployment.

Possible long-term consequences

- Due to disrupted crop cycles and increased risk perception, a COVID-like V-shape recovery of food supply is not in the cards, and there is likely to be long-term scarring.

- Globally, preexisting deglobalization pressures will likely be exacerbated, with countries seeking a higher degree of self-reliance and companies rebalancing supply chains.

- As in classic recessions, the most affected areas will be durable consumer goods and vehicles, versus consumer staples and services.

- Due to inflationary pressures, fiscal stabilizing measures are expected to be more limited than those in response to the COVID-19 recession.

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After the pandemic pressure seemed to ease, the Russia-Ukraine war has again thrown global supply chains into disarray

Cargo and tanker vessels jammed on the North Sea on June 9, 2022[1]

Hamburg

Rotterdam

Antwerp

● Cargo   ● Tanker   ○ Anchored   ▷ Moving

Global Supply Chain Pressure Index (GSCPI)[2]

1.5 2.0 2.2 2.6 3.0 2.7 3.0 3.4 3.9 4.4 3.7 2.8 3.3 3.1 2.9 3.2 3.5 4.0 4.5 3.8 3.3
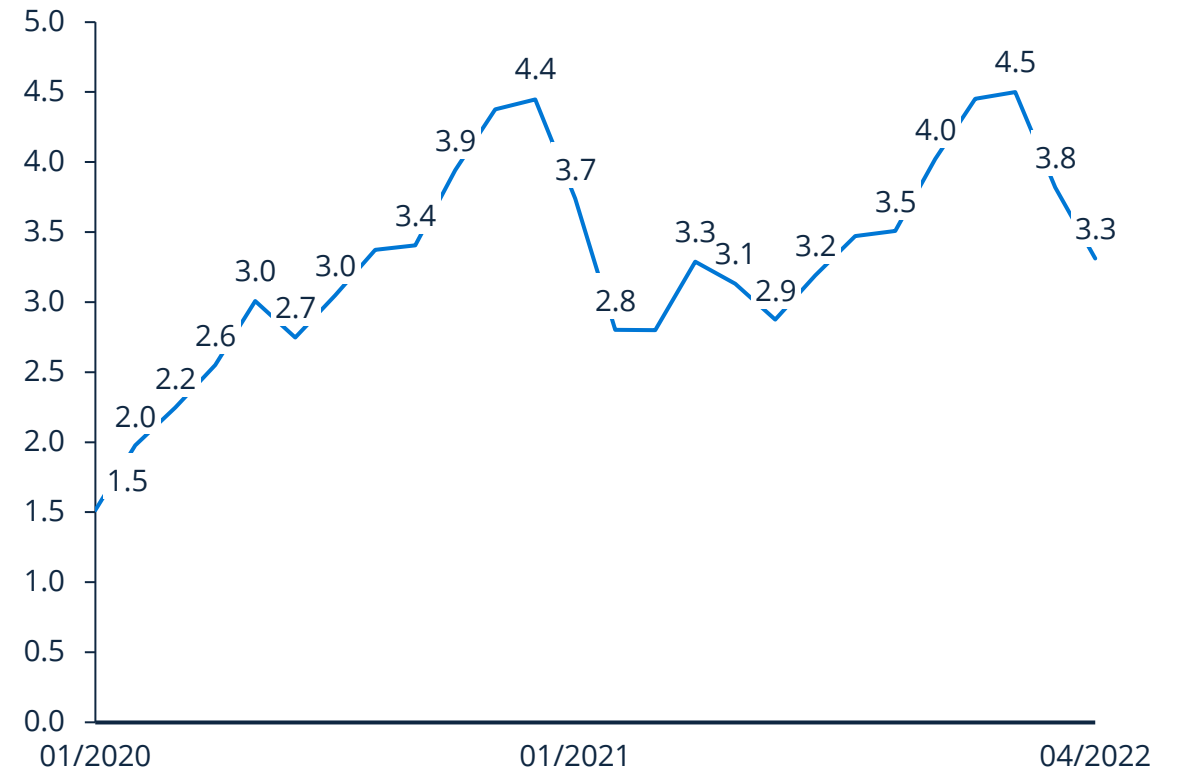
01/2020   01/2021   04/2022

Notes: (1) 9-10am CET (2) Measured in standard deviations from average; values of +1 or higher indicate significant stress. The GSCPI, from Federal Reserve Bank of New York, uses data from shipping, purchasing managers' index surveys and manufacturing to chart disruption across the globe
Sources: FleetMon, New York Federal Reserve

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Supply chain shocks have dramatically delayed delivery times

Manufacturing PMI suppliers' delivery times[1]

Delivery times decrease

Delivery times increase

Europe

U.S.
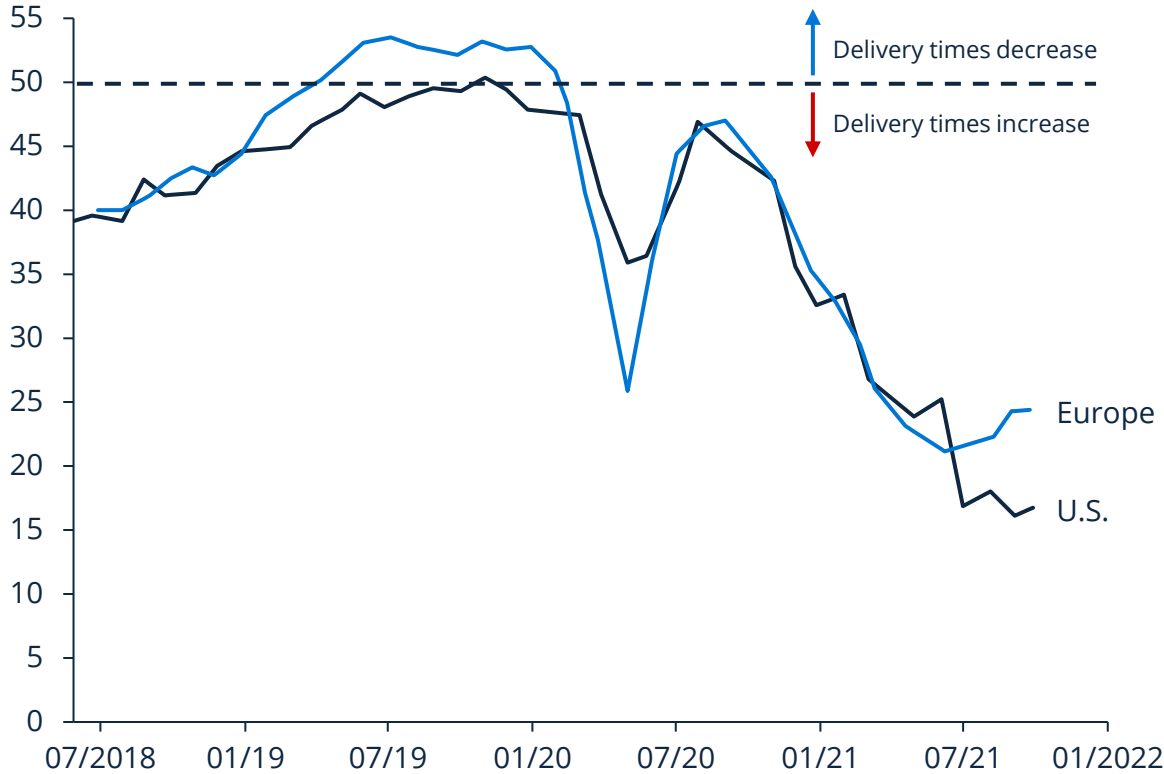
Factors exacerbating supply chain disruptions

Supply-side factors

- COVID-19 lockdowns, shutdowns of factories and ports
- Shortages of intermediate inputs such as chemicals and chips
- Labor shortages, particularly in the US and Europe
- Extreme weather events
- Industrial accidents
- Aging or insufficient logistic infrastructure (e.g., congested ports and canals)
- Ripple effects of Russia-Ukraine war (e.g., energy supply insecurity)

Demand-side factors

- Weaker demand for services such as tourism and recreational activities
- Stronger demand for manufactured goods

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Demand and supply chain shocks are the key drivers behind congestions in global trade

PMI supplier delivery times deviation from mean, percent contribution of economic factors (demand) and supply shocks[1]

PMI STD[2] ▬   ■ Economic Factors   ■ Supply Chain Factors

Notes: (1) Region: Global ex. Europe; percentage point contributions determined using Bayesian VAR model (2) PMI (Purchasing Manager's Index) STD denotes the deviation of the long-term mean of the Purchasing Managers' Index Supplier Delivery Times

Sources: European Central Bank; IHS Markit

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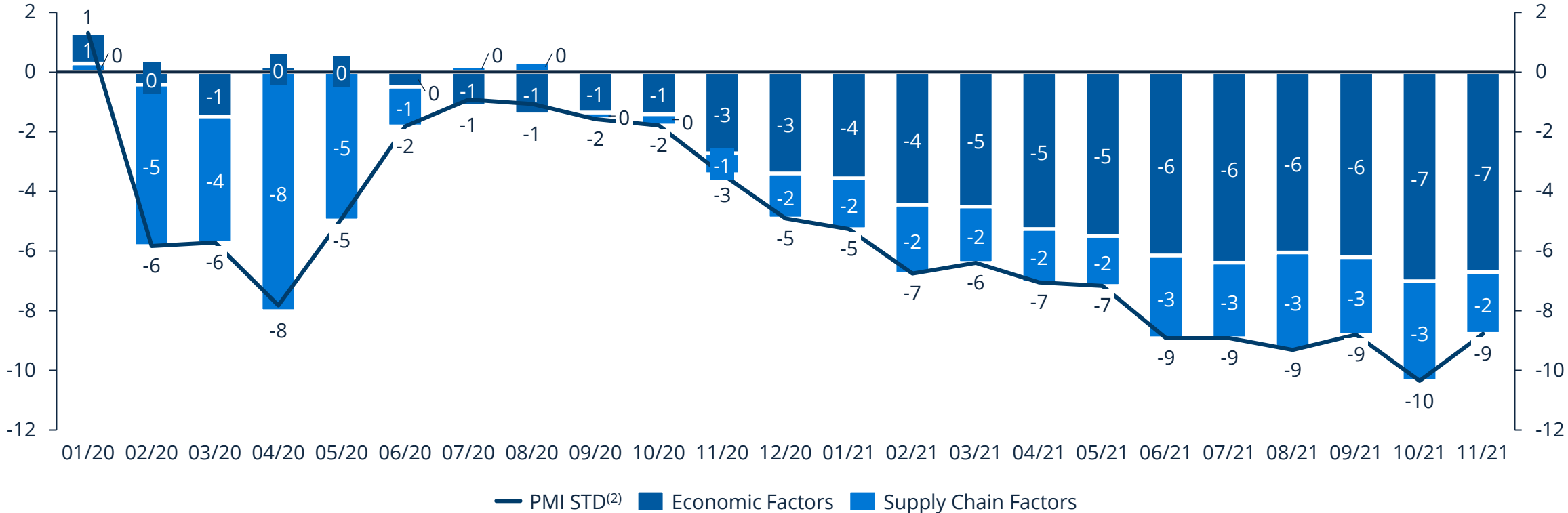
Industries reliant on energy and other key commodities are most affected by the Russia-Ukraine war, with collateral damage inflicted on domestic consumption

Expected impact by industry (ISIC[1])

Agriculture[2]	Banking, Finance & Insurance	Accommodation, Restaurants & Nightlife
Mining & Quarrying[3]	Manufacturing	Real Estate
Energy Supply	Transportation & Storage	Professional, Scientific & Technical Activities
Wholesale, Retail Trade & Car Dealers	Construction	Administrative & Support Services
Water Supply, Sewerage & Waste Management	Information & Communication	Other

Strong negative impact	Medium negative impact	Slightly negative impact	No or positive impact

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Due to the war, the global economy is also facing substantial inflationary consequences

Global inflation revision by selected institutions in percentage points

Institution	Value
IMF	3.6%
Kiel Institute	3.3%
NIESR	2.9%
OECD	2.5%
Oxford Economics	2.3%
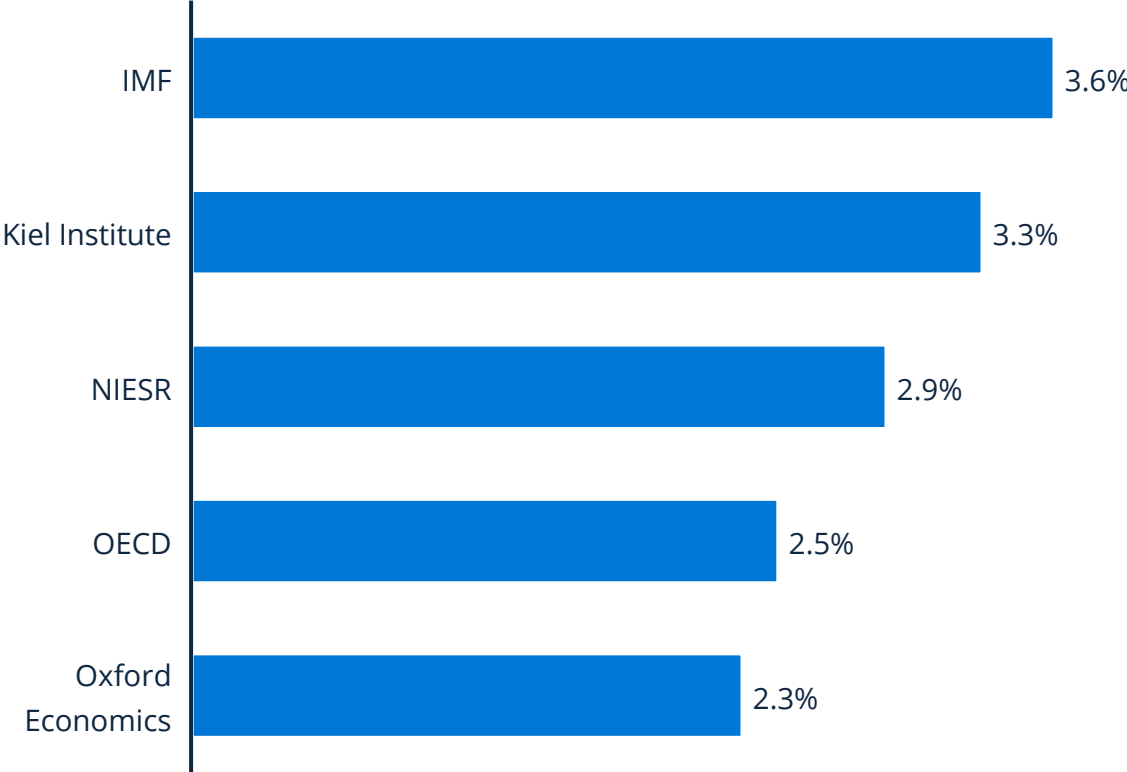
YoY inflation rate in 2022[1]
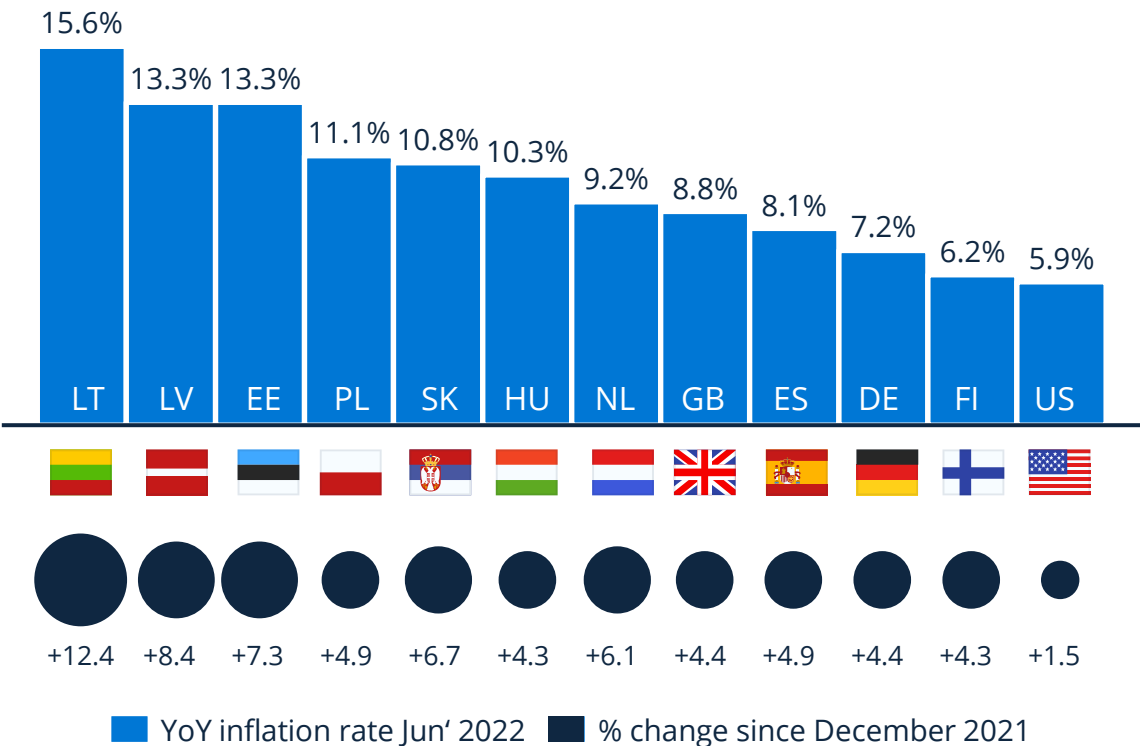
	LT	LV	EE	PL	SK	HU	NL	GB	ES	DE	FI	US
YoY inflation rate Jun' 2022	15.6%	13.3%	13.3%	11.1%	10.8%	10.3%	9.2%	8.8%	8.1%	7.2%	6.2%	5.9%
% change since December 2021	+12.4	+8.4	+7.3	+4.9	+6.7	+4.3	+6.1	+4.4	+4.9	+4.4	+4.3	+1.5

■ YoY inflation rate Jun' 2022   ■ % change since December 2021

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A significant price increase of commodity products became apparent in mid-2022 and is expected to remain high in the medium term

YoY consumer price index(1) change

Bar chart data (YoY 2021 / YoY 2022):
- TR: 20% / 72%
- AR: 49% / 60%
- RU: 7% / 16%
- BG: 3% / 14%
- CZ: 4% / 13%
- RO: 5% / 12%
- PL: 5% / 11%
- HU: 5% / 10%
- BR: 8% / 10%
- US: 5% / 7%

Legend: ■ YoY 2021 ■ YoY 2022
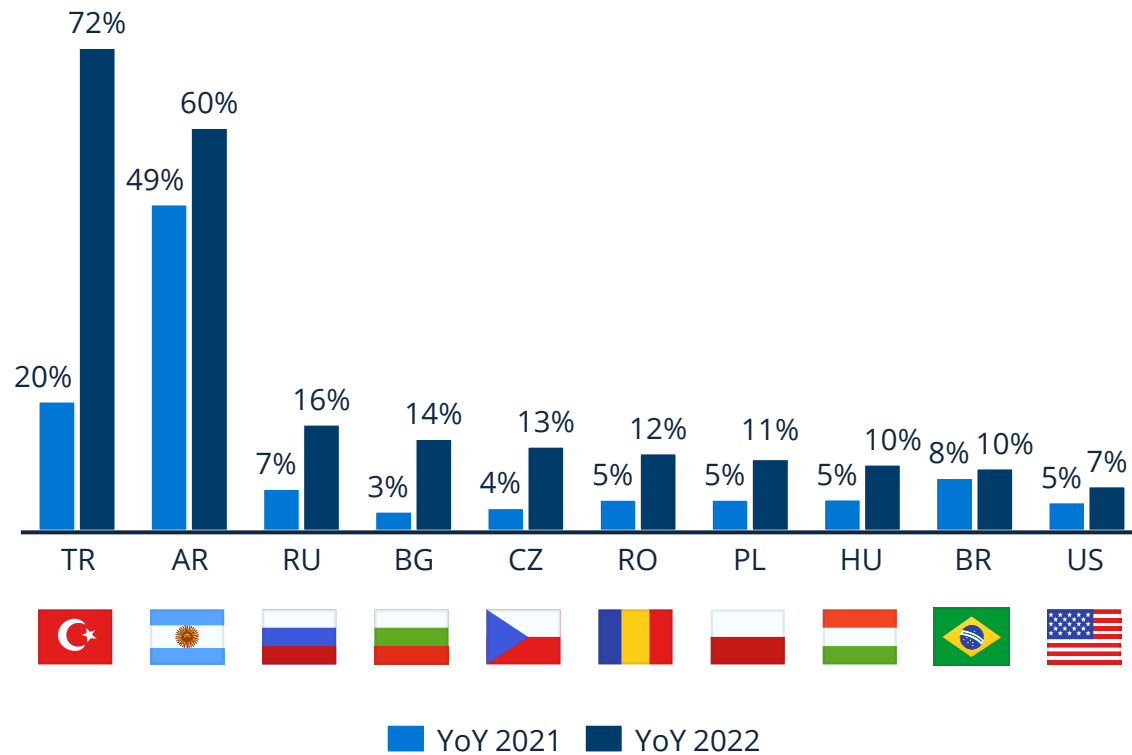
12-month change consumer price index by category in the U.S. in May 2022

- Fuels: 76%
- Gasoline: 49%
- Eggs: 32%
- Electricity: 16%
- Dairy: 12%
- Beef: 10%
- Fruit: 9%
- Sweets: 8%

statista
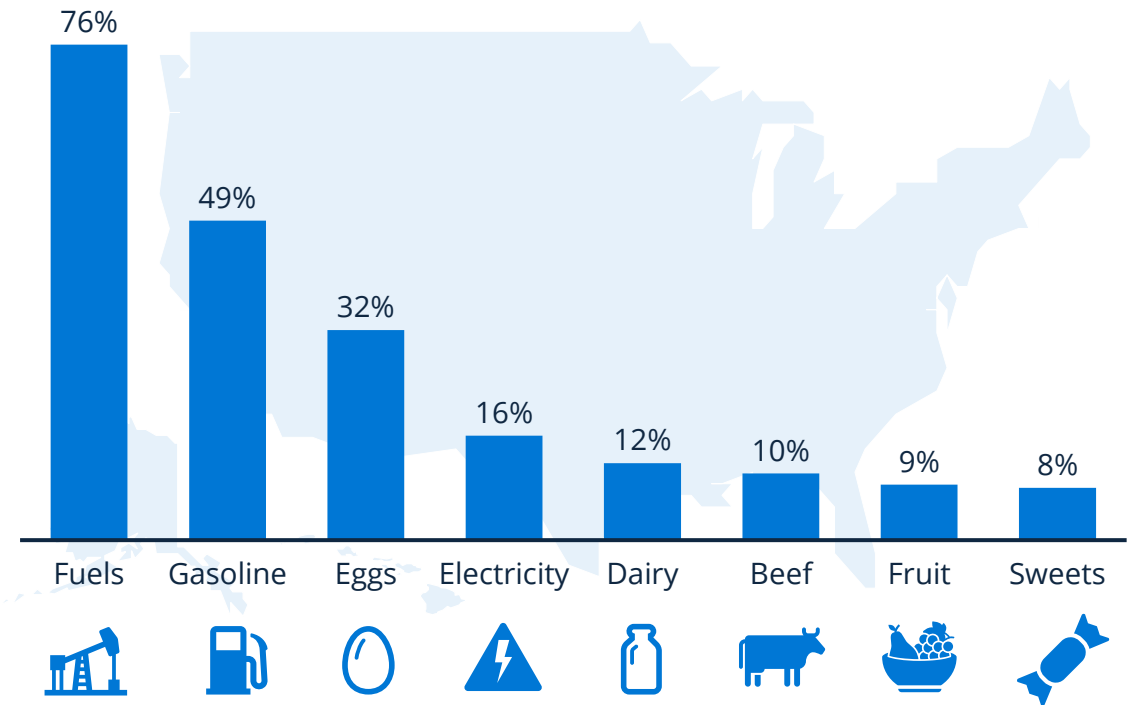
Our projections translate to additional spending of up to US$1.4 trillion on food and fuel in 2022, which would crowd out other spending

Global projected consumer spending on food and fuel items by impact scenario in trillion US$

original forecast — bad — worse — worst
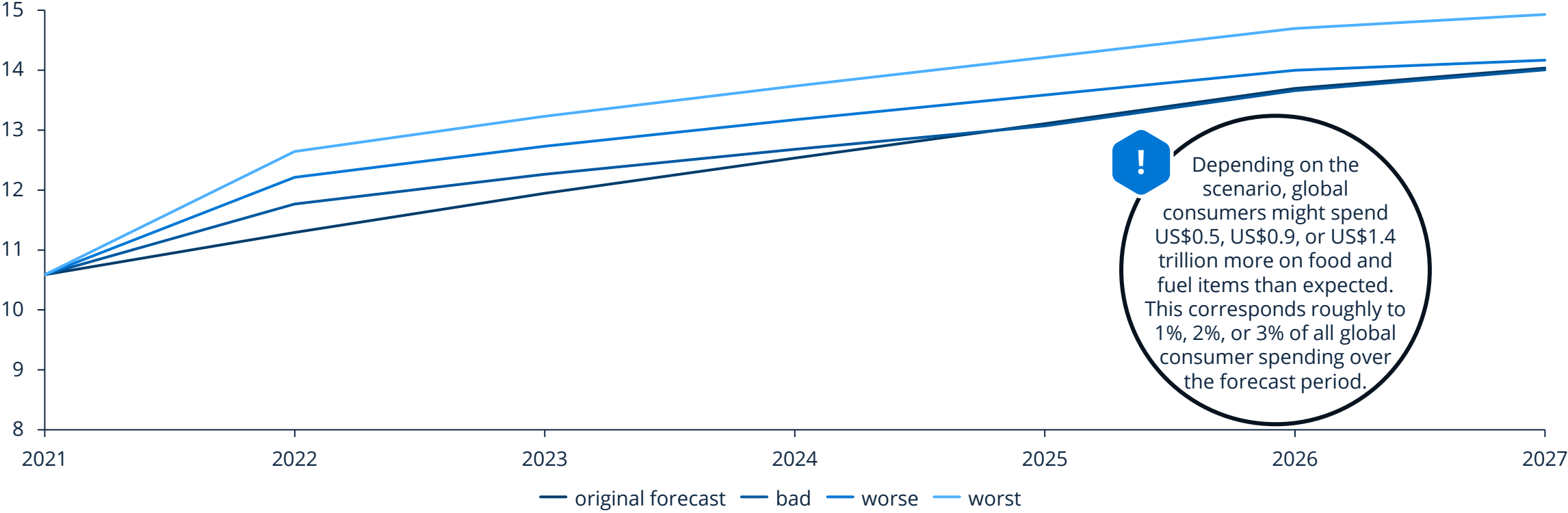
> Depending on the scenario, global consumers might spend US$0.5, US$0.9, or US$1.4 trillion more on food and fuel items than expected. This corresponds roughly to 1%, 2%, or 3% of all global consumer spending over the forecast period.

statista

Durable consumer goods will likely take a blow because higher food and fuel bills need to be paid

Modeled impact on forecast by category (COICOP[1])

Food	Housing maintenance and repairs	Goods for routine household maintenance	Transportation services	Newspapers, books, and stationery	Social protection
Non-alcoholic beverages	Water, garbage disposal, etc.	Services for routine household maintenance	Postal services	Package holidays	Insurance
Alcoholic beverages	Electricity, gas, etc.	Medical products	Telephone and telefax equipment	Education	Financial services n.e.c.[2]
Tobacco	Furniture	Medical services	Telephone and telefax services	Catering services	Other services n.e.c.[2]
Clothing	Household textiles	Purchase of vehicles	Audiovisual, photographic, and information-processing equipment	Accommodation services	
Footwear	Household appliances	Vehicle fuel and oil	Major recreational durables	Personal care products	
Actual rent	Glassware, tableware, etc.	Vehicle parts	Other recreational items	Personal care services	
Imputed rent	Tools and equipment for house and garden	Vehicle services	Recreational and cultural services	Personal effects n.e.c.[2]	

Strong negative impact (-5% or less)	Medium negative impact (-3% to -4%)	Slightly negative impact (-1% to -2%)	Positive impact (0% to 24%)

statista

Total consumer spending is holding up rather well, but significant amounts are being reallocated from discretionary items to food and fuel

Projected consumer spending worldwide by impact scenario in trillion US$ in 2022
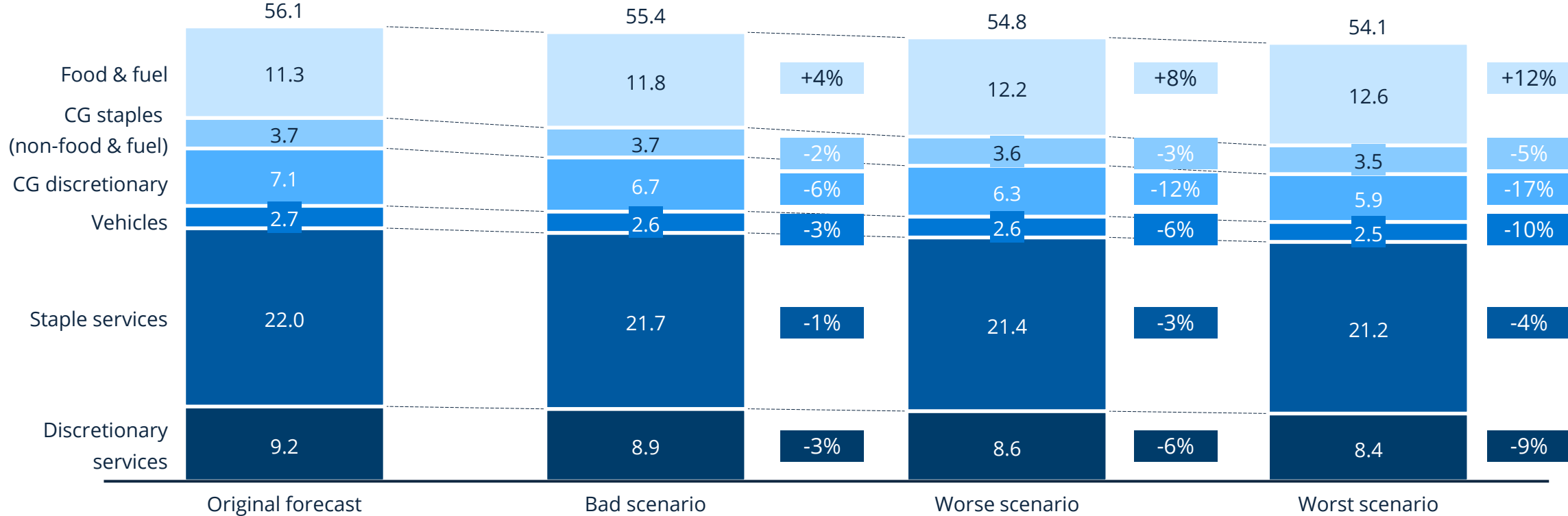
	Original forecast	Bad scenario		Worse scenario		Worst scenario	
Total	56.1	55.4		54.8		54.1	
Food & fuel	11.3	11.8	+4%	12.2	+8%	12.6	+12%
CG staples (non-food & fuel)	3.7	3.7	-2%	3.6	-3%	3.5	-5%
CG discretionary	7.1	6.7	-6%	6.3	-12%	5.9	-17%
Vehicles	2.7	2.6	-3%	2.6	-6%	2.5	-10%
Staple services	22.0	21.7	-1%	21.4	-3%	21.2	-4%
Discretionary services	9.2	8.9	-3%	8.6	-6%	8.4	-9%

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Over-stocked, over-hired, over-built? Are eCommerce companies resetting expectations?

The COVID-19 pandemic and the following restrictions imposed by governments on the public presented a unique opportunity for eCommerce businesses and platforms to thrive. Massive consumer demand in the sector accelerated the pace and scope of hiring practices, logistics investments, and digital advertising to bridge the gap. However, this exaggerated growth led several eCommerce companies to march into the post-pandemic era with a mindset all too similar to the one they had during the rapid phase of expansion. This strategy left these companies overstocked, overstaffed, and unable to optimize their overhead expenses. Major players are recalibrating their performance in 2022 from the pandemic-driven surge by downsizing their human resources, redirecting advertising budgets, and optimizing inventory costs. eCommerce companies need to build resilience, survive the downturn, and thrive in the next cycle.

eCommerce growth was overshadowed by sourcing, fulfillment, and advertising becoming costlier, slower, and less effective

Global container freight rate index in US$

Global schedule reliability in Dec' 21 of 32% was the lowest since metric has ever been recorded (2011)

Y-axis: 1,000 / 2,000 / 3,000 / 4,000 / 5,000 / 6,000 / 7,000 / 8,000 / 9,000 / 10,000 / 11,000

X-axis: 01/2019 — 01/20 — 01/21 — 01/22 — 06/22
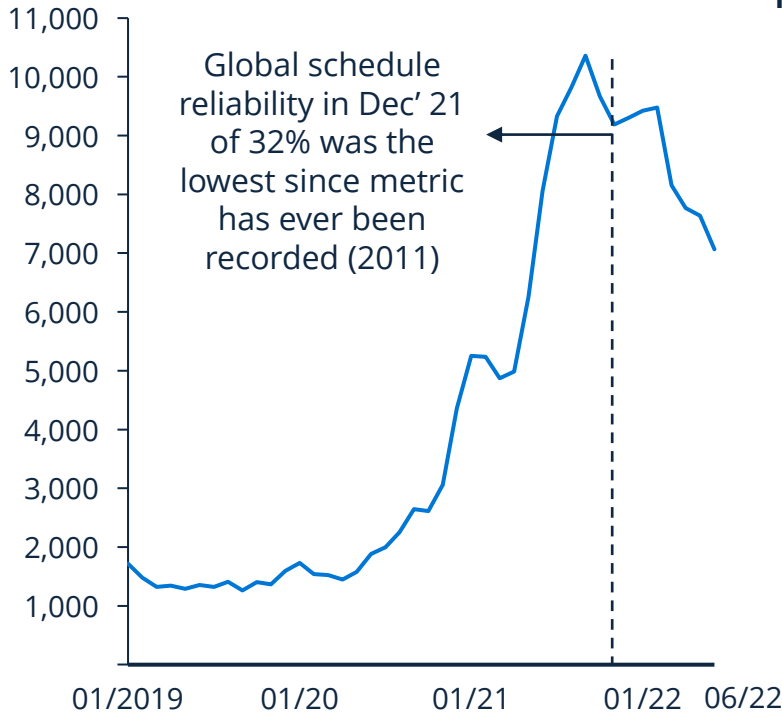
Job openings in the U.S. per industry in thousands in May 2022

Industry	Thousands
Education and health services	2,166
Trade, transportation, and utilities	2,016
Professional and business services	2,002
Leisure and hospitality	1,570
Government	1,042
Manufacturing	809
Financial activities	501
Construction	434
Information	238
Mining and logging	36

Labor shortage for warehousing and logistics (fulfillment)
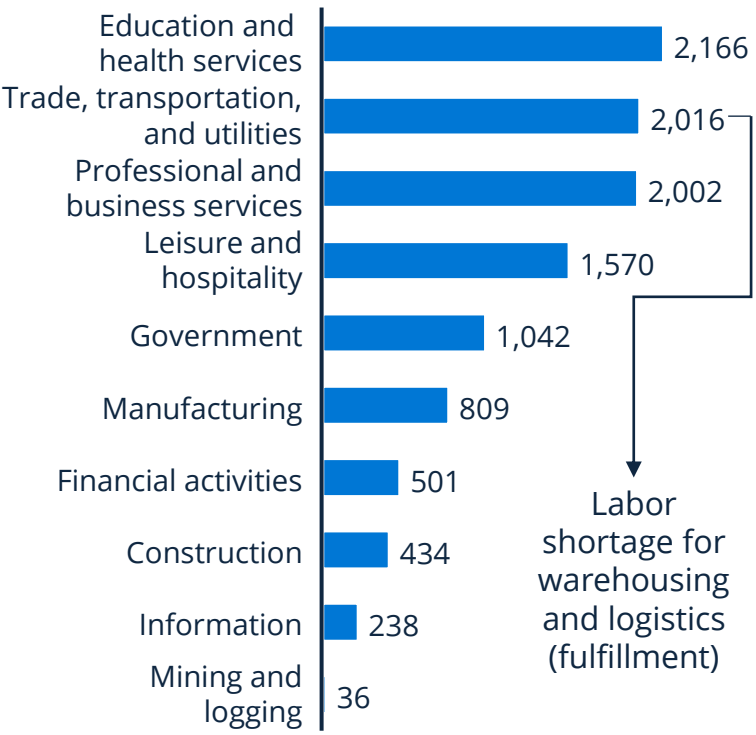
Average CPC for Amazon Ads in the U.S. in 2021

$0.41 — $0.40 — $0.67 — $0.70 — $0.65 — $0.70 — $0.59 — $0.56 — $0.72 — $0.71 — $0.88 — $0.94

Jan. Feb. Mar. Apr. May June July Aug. Sep. Oct. Nov. Dec.
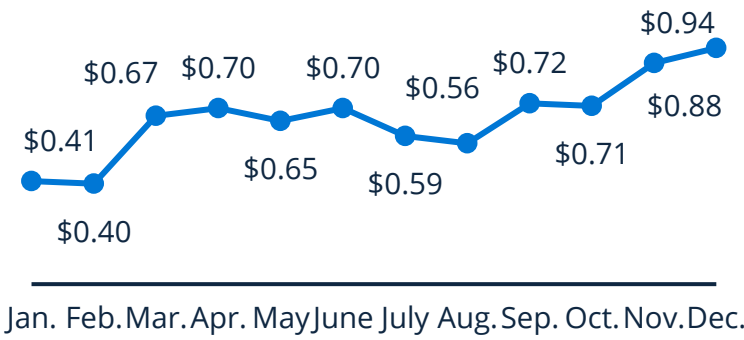
Google paid search CPC growth by selected category YoY in Q3 2021

Category	Growth
Beauty	41%
Home and garden	33%
Apparel	24%
Consumer electronics	21%
Sports and recreation	14%

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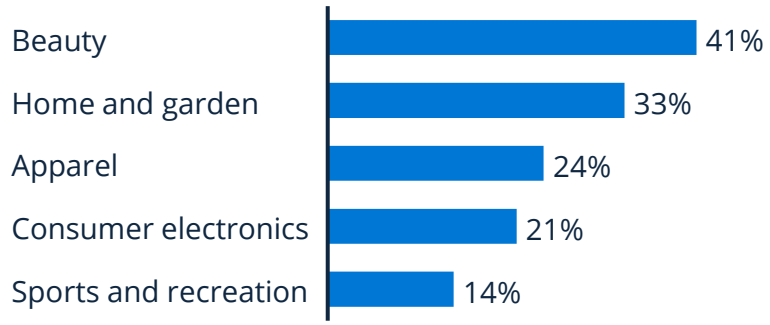
At the beginning of 2022, eCommerce funding as well as unicorn growth started slowing down

Global eCommerce funding in billion US$ and amount of deals

Deals:
349, 402, 379, 288, 299, 352, 356, 365, 333, 307, 359, 376, 390, 462, 468, 435, 384

-14.8%

Funding:
5.1, 5.9, 5.9, 5.9, 5.4, 3.9, 6.1, 5.2, 2.9, 3.6, 6.5, 6.3, 12.8, 14.9, 14.6, 12.8, 10.9

Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
2018				2019				2020				2021				2022

— Deals   ■ Funding
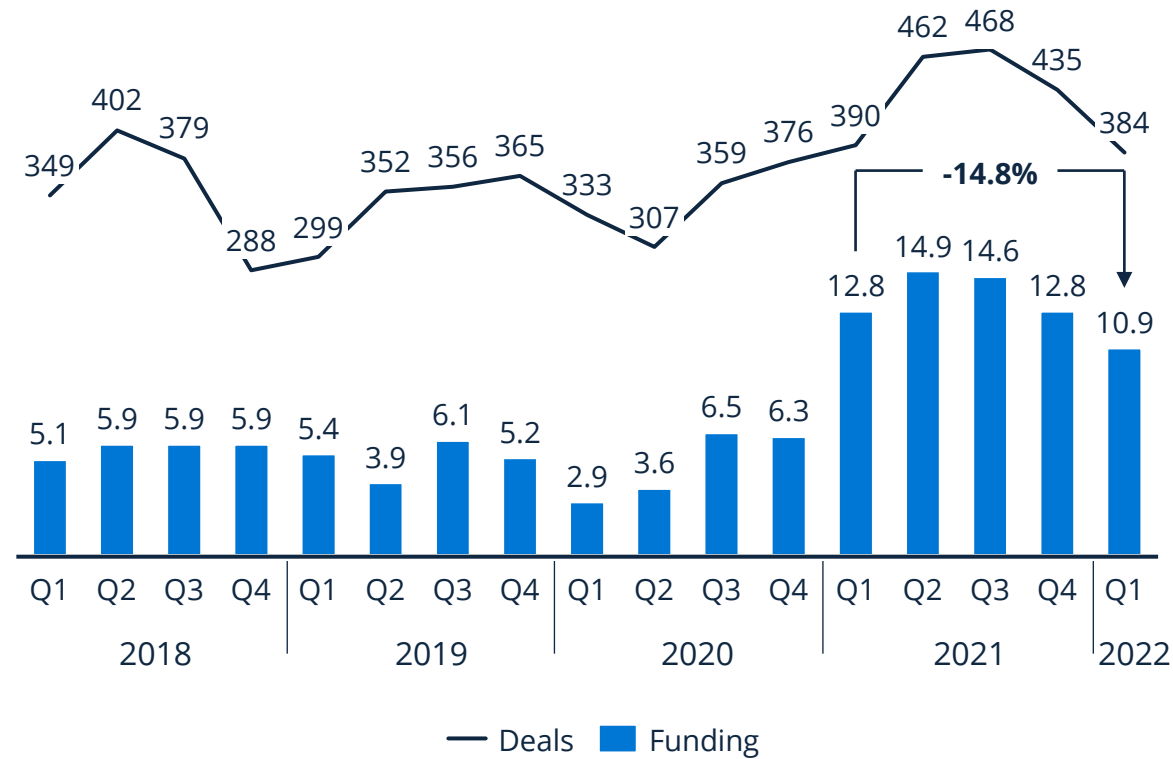
Global number of eCommerce unicorns and new unicorns

Total Unicorns: 73, 79, 84, 101, 108

New Unicorns: 8, 10, 12, 19, 9

-52.6%

Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
2018				2019				2020				2021				2022

— Total Unicorns   — New Unicorns

statista
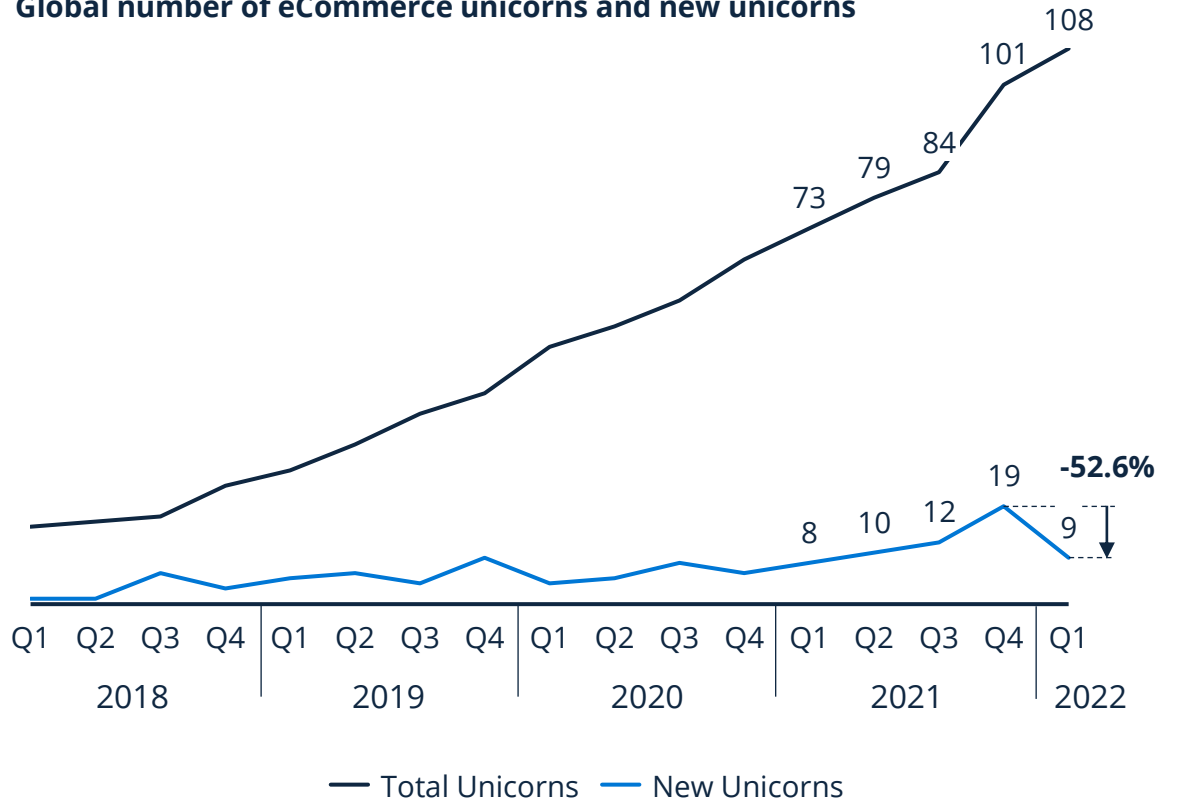
Monthly web traffic of major eCommerce players has been continually declining in the post-lockdown era

MoM[1] web traffic growth of selected eCommerce key player

		Pinduoduo Inc.	Etsy	Alibaba Group	amazon	ebay
Jul	20/21	6%	5%	-7%	2%	-13%
Aug	20/21	-19%	7%	-10%	-1%	-16%
Sep	20/21	-5%	8%	-5%	-3%	-16%
Oct	20/21	3%	6%	-6%	-8%	-17%
Nov	20/21	-2%	-2%	-16%	-7%	-19%
Dec	20/21	20%	-7%	-15%	-7%	-22%
Jan	21/22	97%	-3%	-16%	-4%	-18%
Feb	21/22	55%	-4%	-9%	-6%	-18%
Mar	21/22	-22%	-4%	-12%	-7%	-20%
Apr	21/22	-24%	-5%	-13%	-5%	-18%
Mar	21/22	-34%	-3%	-11%	-7%	-17%
Jun	21/22	-25%	-1%	-9%	-10%	-17%
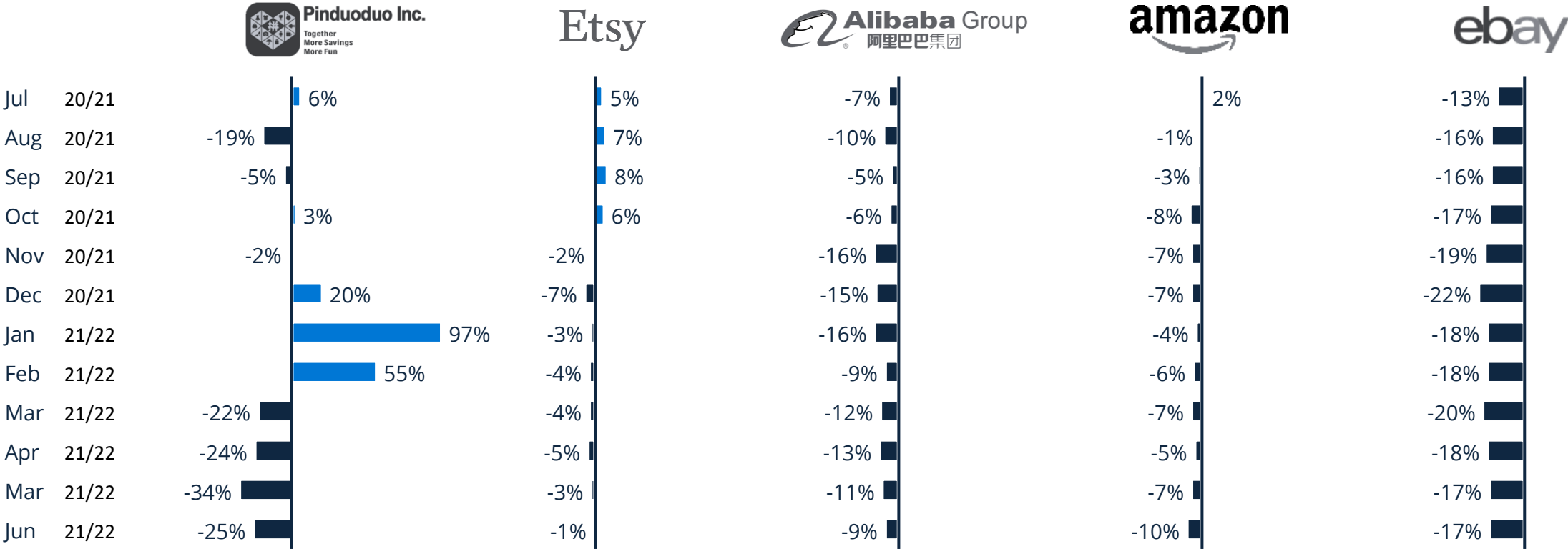
Notes: (1) Month-over-Month

Sources: Similarweb

statista

The Salesforce Shopping Index had indicated particularly low performance for European countries and predicted negative figures as early as Q4 2021

YoY[1] digital commerce (GMV) growth

Q4 21	7%
Q1 22	-2%
Q2 22	-6%
Q4 21	-2%
Q1 22	-20%
Q2 22	-24%
Q4 21	10%
Q1 22	5%
Q2 22	2%
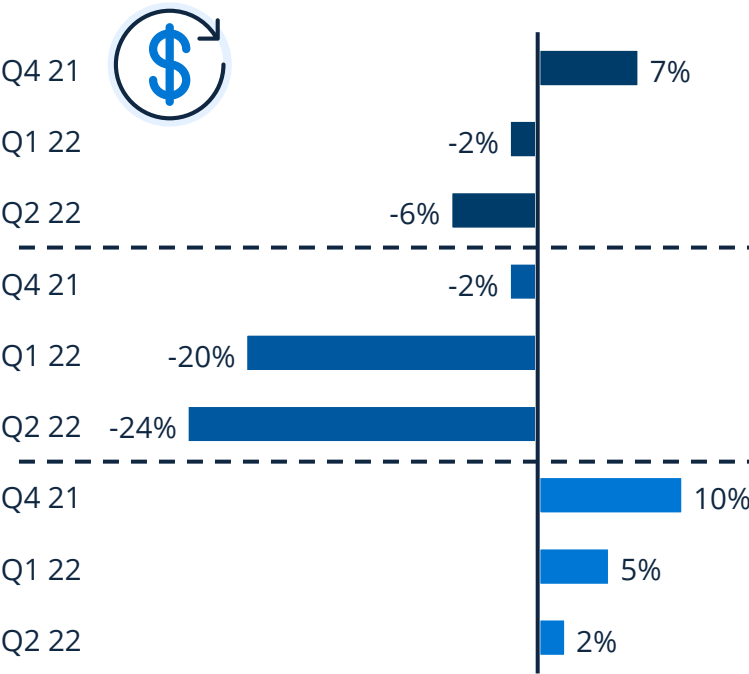
YoY[1] traffic (number of visits) growth

Q4 21	0%
Q1 22	-1%
Q2 22	-2%
Q4 21	-2%
Q1 22	-7%
Q2 22	-7%
Q4 21	-1%
Q1 22	-1%
Q2 22	-3%
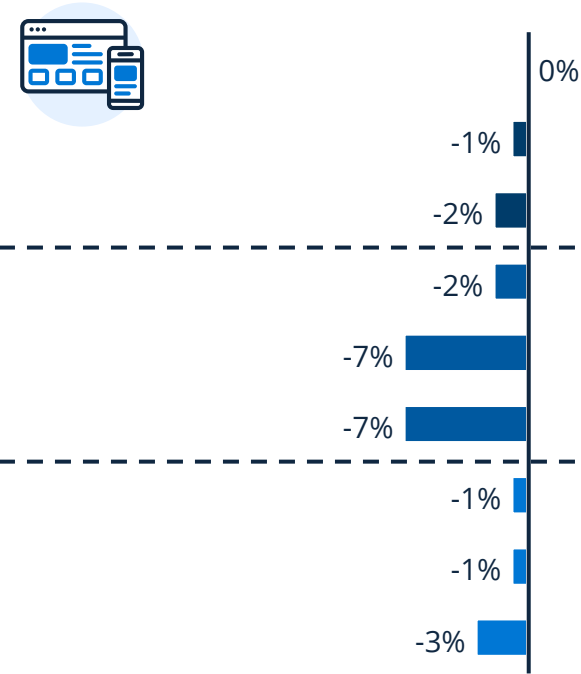
YoY[1] order (number of orders placed) growth

Q4 21	-3%
Q1 22	-11%
Q2 22	-9%
Q4 21	-1%
Q1 22	-16%
Q2 22	-18%
Q4 21	-2%
Q1 22	-6%
Q2 22	-5%

■ Global   ■ Germany   ■ U.S.

statista
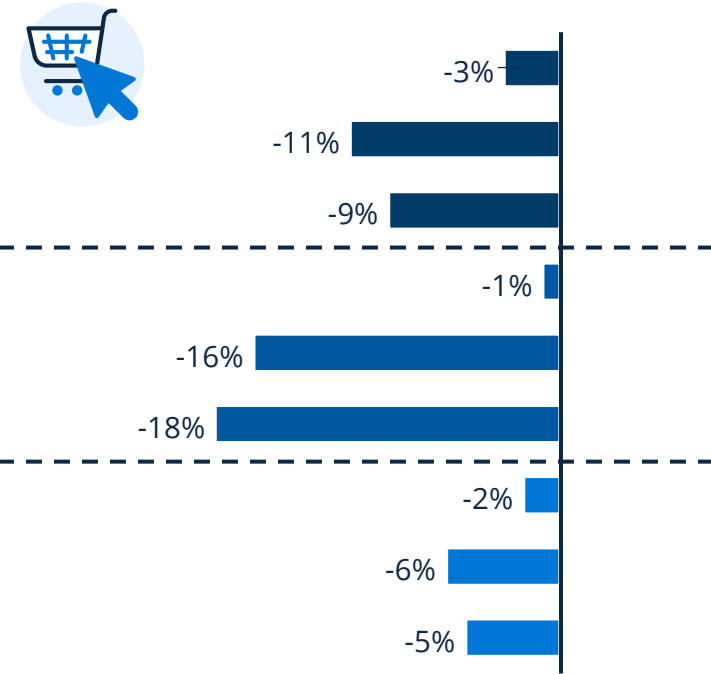
YoY[1] performance for Q1 2022 shows figures below expectations for most key players in contrast to the pandemic-induced growth seen in Q1 2021

Quarterly revenue comparison of selected eCommerce key players for Q1 2021 and Q1 2022 YoY[1]

Online Stores:
- Q1 YoY - 1%
- Q2 YoY - 0%

Third-party seller services:
- Q1 YoY – 9%
- Q2 YoY – 13%

239%
141%
110%
75%
74%
64%
51%
49%
47%
46%
44%
39%
36%
33%
6%

7%
5%
22%
-76%
22%
9%
-11%
-14%
-1%
6%
7%
18%
-9%
-2%
-6%

Pinduoduo Inc. · Etsy · shopify · wish · coupang · Alibaba Group · 唯品会 vip.com · wayfair · zalando · FARFETCH · amazon · JD.COM · BEST BUY · BAOZUN · ebay

■ YoY Q1' 21   ■ YoY Q1' 22

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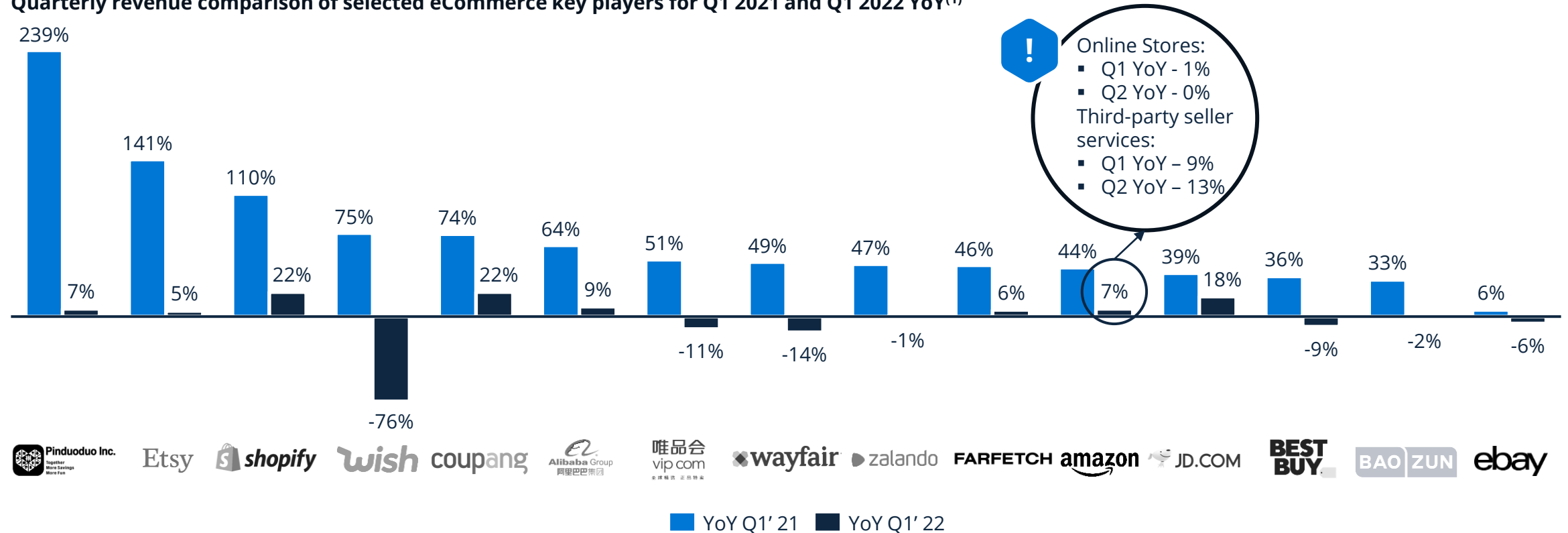
Major players forced to reassess in 2022 from pandemic-driven surge as market capitalization ceased by mid-year for most of them

eCommerce revenue of selected key players in billion US$
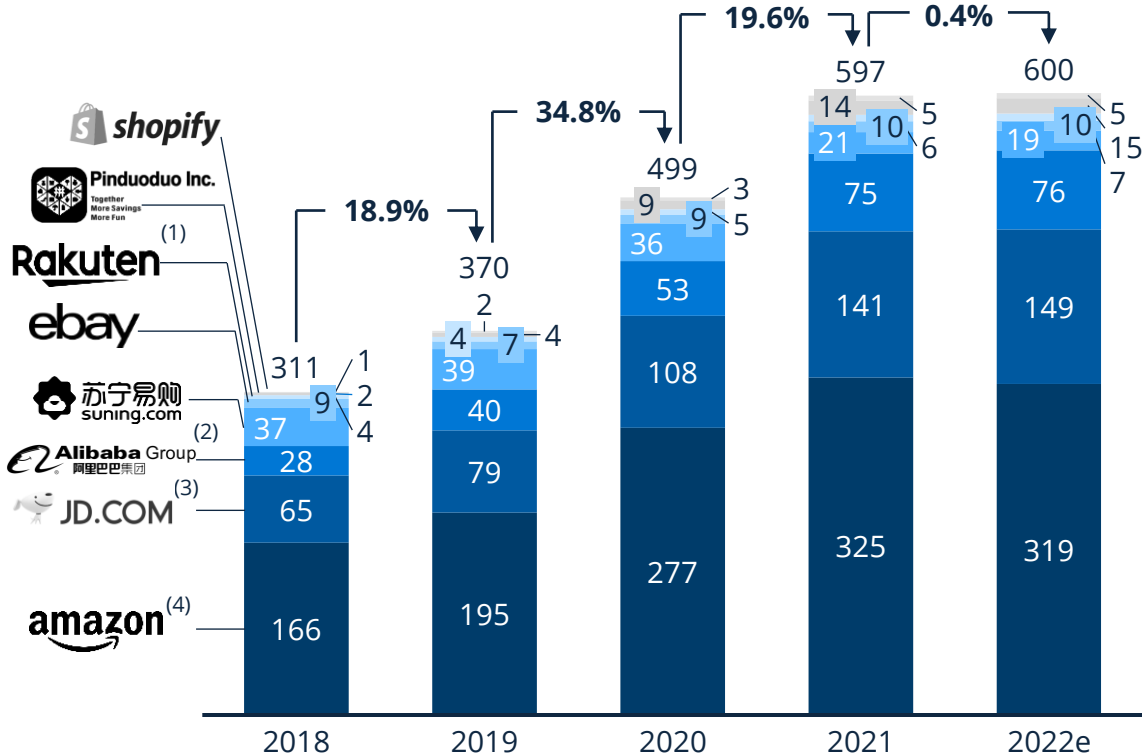
Market caps of selected key players on the 1st of June of the respective year
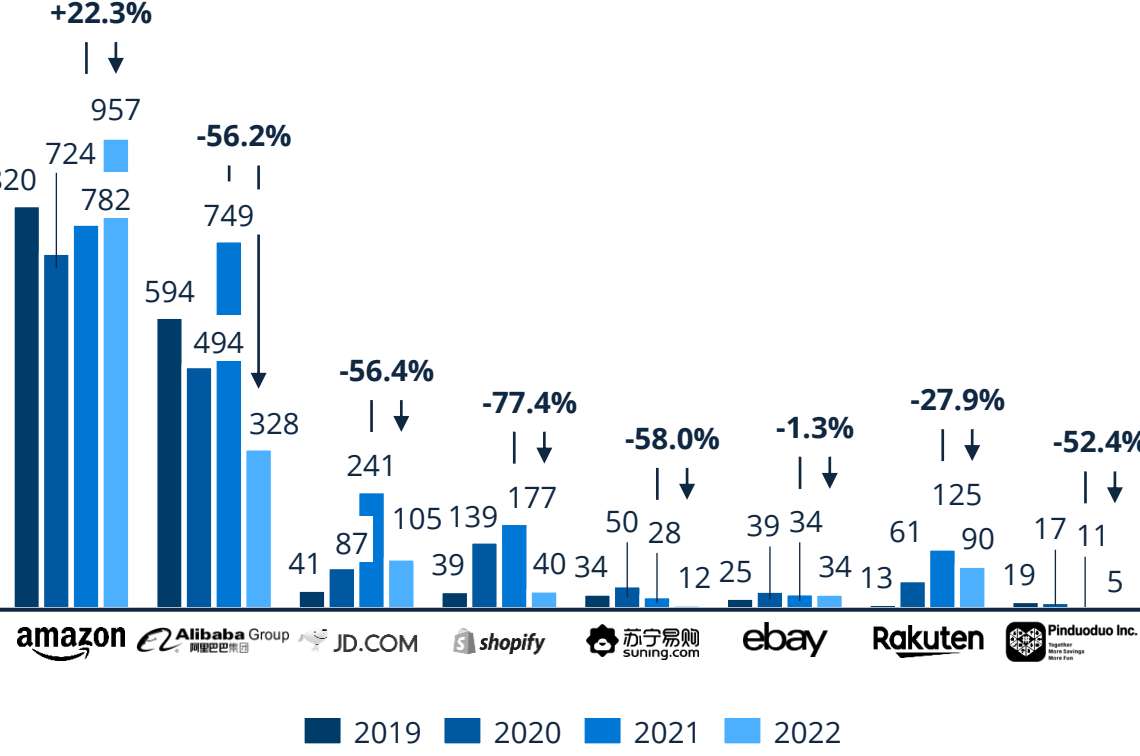
Legend: 2019 | 2020 | 2021 | 2022

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More waves of layoffs are taking place in the industry, whose workforce boomed between 2020 and 2021

Number of employees of selected eCommerce players in thousand

+102%
1,608
1,298
798

+69%
315 385
228

+147%
118 251
102

+41%
20 24 28

+209%
10 16 30

+100%
5 7 10

amazon JD.COM Alibaba Group Rakuten mercado libre shopify

■ 2019 ■ 2020 ■ 2021
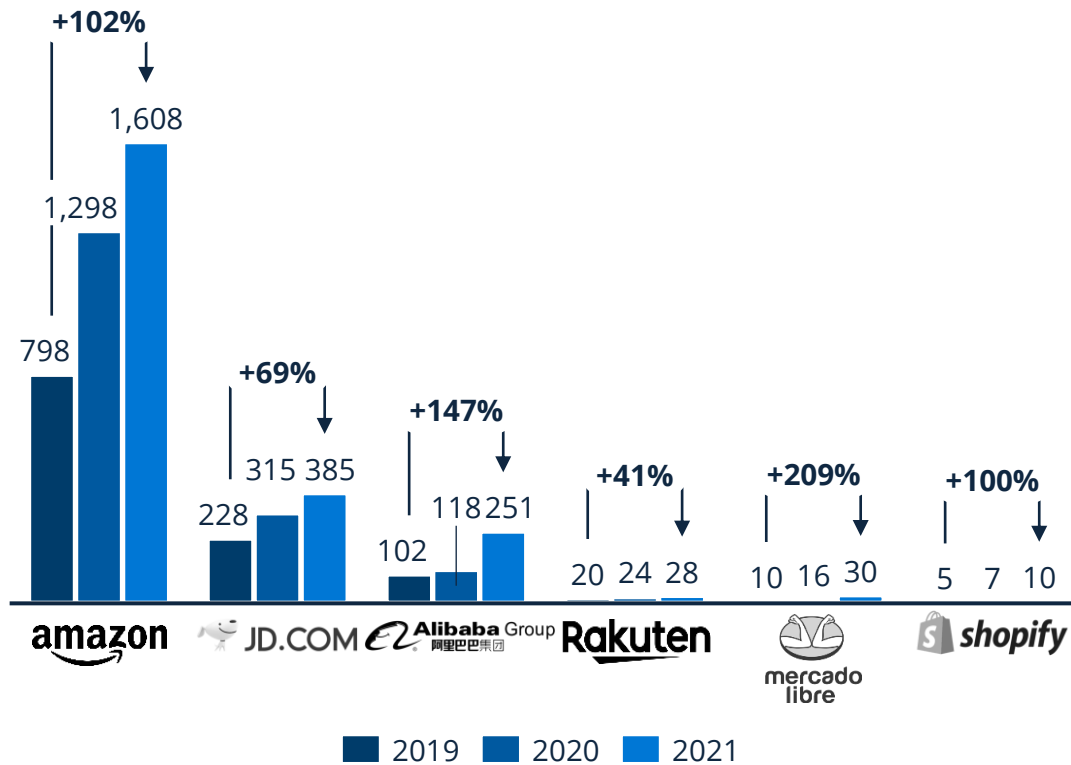
Selected layoffs of eCommerce companies in 2022

~ 8000 layoffs in the broader eCommerce industry so far in 2022

! Especially quick commerce faces a reckoning, with other companies such as Getir, Blinkit or Jiffy having had layoffs and closures in 2022

1st March	wish	190
30th March	Shopee	350
25th May	GORILLAS	300
12th July	goPuff	1,500
27th July	shopify	1,000

statista
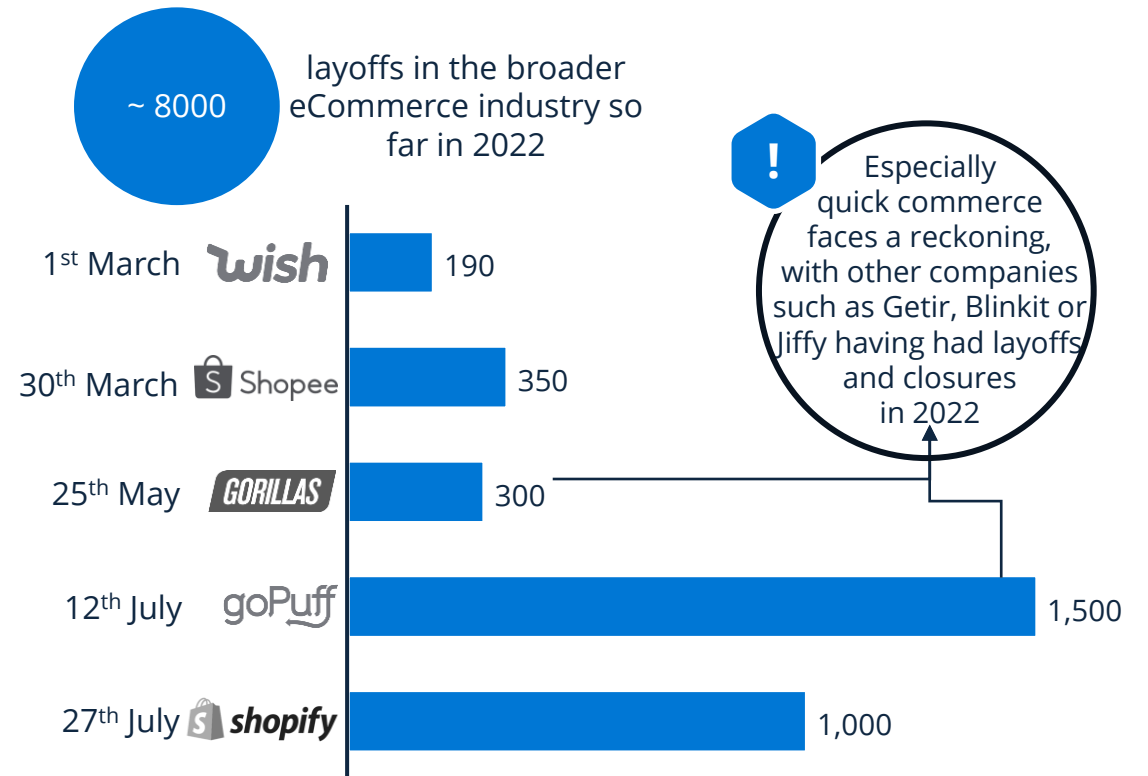
Fintech payment providers strongly connected to eCommerce, particularly BNPL services, are also witnessing mounting losses with their valuations tumbling

Klarna.

BNPL[1] faces numerous hardships

Macroeconomic climate

- Rising costs of borrowing and refinancing due to surging inflation and ensuing interest rate hikes
- Shrinking discretionary spending by consumers
- Fading eCommerce boom
- Looming recession may lead to debt defaults
- BNPL has yet to prove itself profitable

Klarna's outlook for the next years looks bleaker

- Various competitors are entering the market, even big players such as Apple, Inc. and PayPal
- After rapidly expanding in 2021, Klarna is now downsizing and has laid off 10% of its staff

Klarna's GMV[2] vs. net result in billion US$

Year	GMV	Net Loss
2019	35	-0,10
2020	53	-0,15
2021	80	-0,83

■ GMV ■ Net Loss

Klarna's valuation development in billion US$

-86%

Date	Value
08/19	5.5
09/20	10.7
06/21	45.6
07/22	6.5

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Given the current circumstances, eCommerce's already low margins are under even more pressure

Average industry net margins in the U.S in 2022[1]

Value	Industry
32%	Financial Services
29%	Software (Entertainment)
25%	Asset Management
21%	Tobacco
17%	Information Services
15%	Real Estate
13%	Healthcare Products
13%	Insurance
13%	Restaurant/Dining
10%	Broadcasting
8%	Telecom. Services
7%	Retail (Online)
7%	Education
7%	Apparel
3%	Retail (General)
-5%	Coal & Related Energy
-8%	Air Transport
-29%	Hotel/Gaming

Pre-tax profit margins, %

Legend: Total — Pure online

X-axis: 2011–12, 2012–13, 2013–14, 2014–15, 2015–16, 2016–17, 2017–18, 2018–19, 2019–20

Cost margins, % (excluding OGS)

Sale via Amazon: 60.9%
Omni-channel brick-and-mortar: 64.3%

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Even Amazon's eCommerce business demonstrates a trend of sinking and currently negative operating income

Amazon operating income for North America and International in US$ billion

Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022
4.8	3.5	0.0	-1.8	-2.9	-2.4

statista
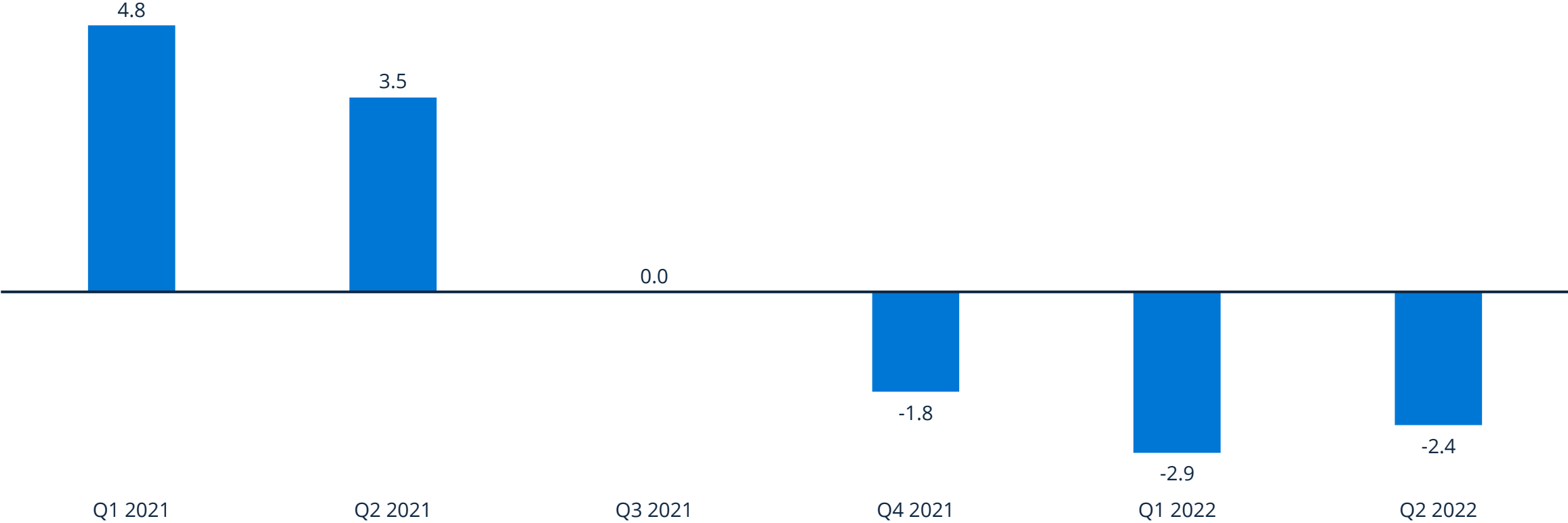
By branching out into other sectors and revenue opportunities, established eCommerce players are attempting to compensate for thin online retail margins

Amazon revenue by segment in billion US$

amazon

	2018	2019	2020	2021
Total	233	282	388	470
Online stores	123	141	197	222
Third-party seller services	43	54	80	103
Physical stores	17	17	16	17
Subscription services	14	19	25	32
AWS	26	35	45	62
Advertising services	10	14	21	31
Other	—	1	2	2

- Online stores
- Third-party seller services
- Physical stores
- Subscription services
- AWS
- Advertising services
- Other
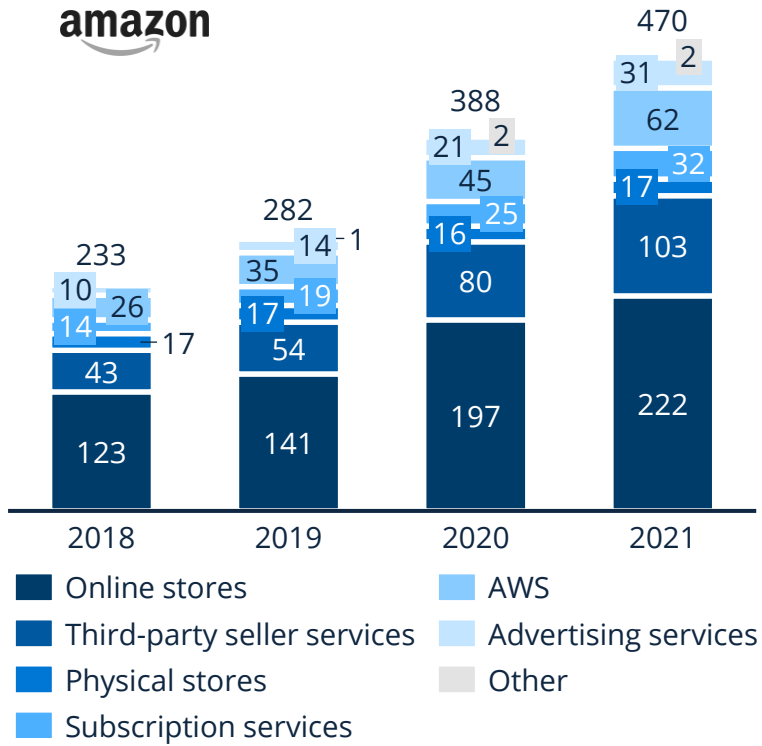
Alibaba Group revenue by segment in billion US$

Alibaba Group 阿里巴巴集团

|	2018	2019	2020	2021
Total	36	51	68	106
China commerce(2)	28	39	52	79
International commerce(3)	3	4	6	6
Cainiao logistics services	2	4	5	7
Cloud computing	3	4	6	9
Digital media		1	1	5
Innovation initiatives	0	1	1	1

- China commerce(2)
- International commerce(3)
- Cainiao logistics services
- Cloud computing
- Digital media
- Innovation initiatives
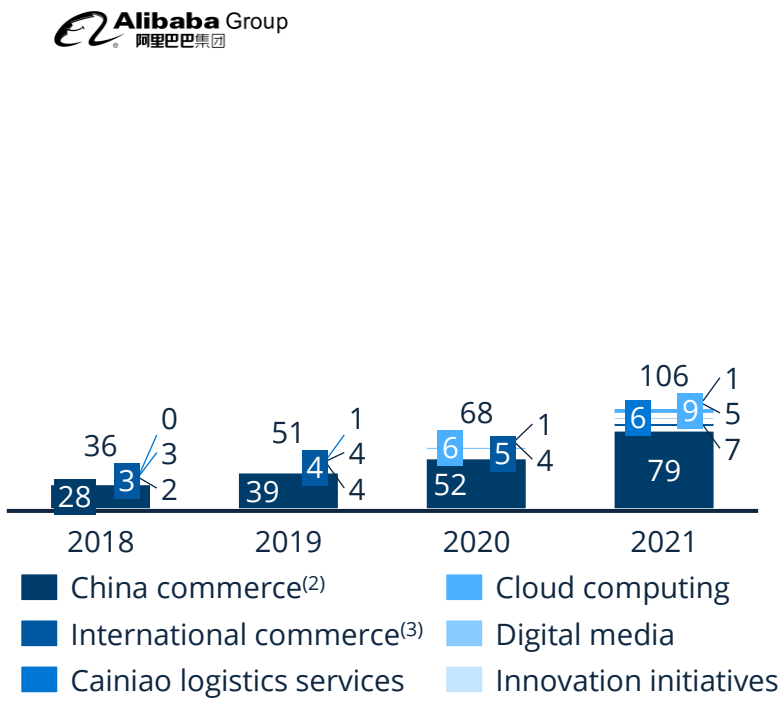
Mercado Libre revenue by segment in billion US$
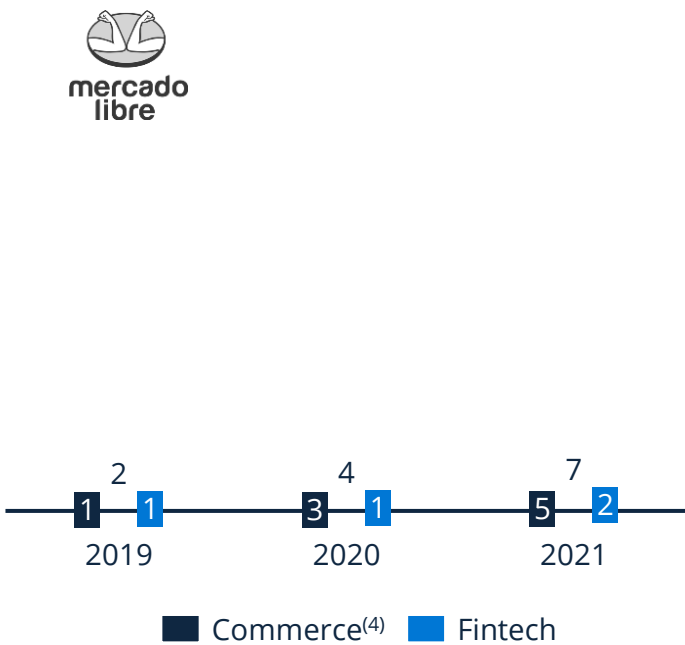
mercado libre

	2019	2020	2021
Total	2	4	7
Commerce(4)	1	3	5
Fintech	1	1	2

- Commerce(4)
- Fintech

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Many large ecommerce players are therefore moving into the higher margin advertising business themselves

Global advertising revenue of selected eCommerce players in billion US$
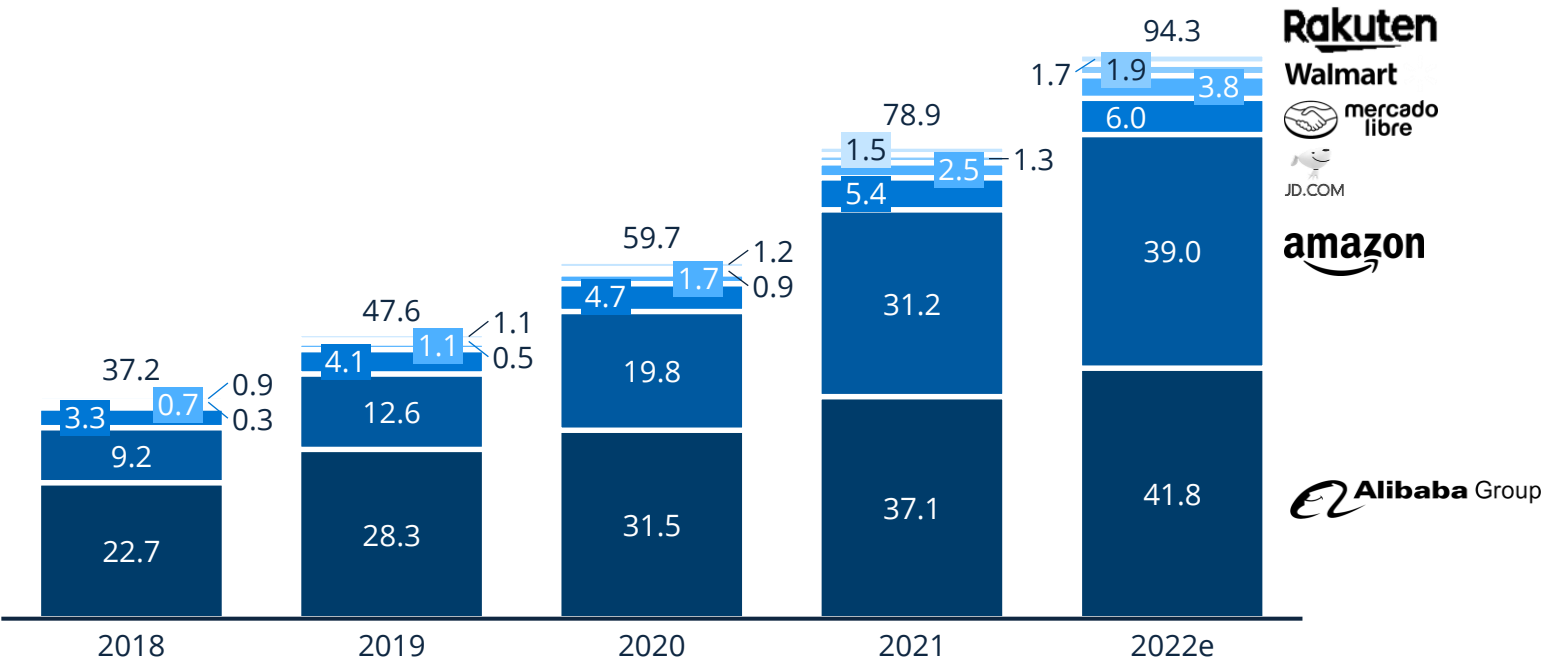
Worldwide print and radio ad spend in billion US$

Print · Traditional Radio · Total

statista
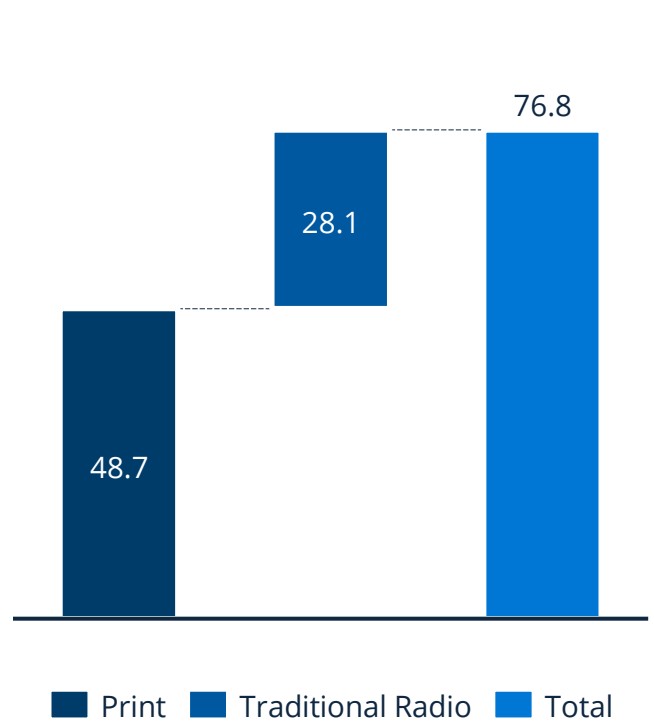
Amazon not only tripled ad revenues in 2022, but also moved beyond its own ad inventory by becoming a DSP and attacking linear TV advertising with Freevee

amazon

Amazon selected segment revenues in US$ billion

+210%

+4%

	2019	2020	2021	2022e
Advertising	13	20	31	39
Third-party seller services	54	80	103	107

■ Advertising ■ Third-party seller services

Amazon's advertising business tripled over the last 3 years (in 2021 being nearly 8x as large as Snapchat), but growth is strongly connected to their own add ecosystem in their marketplace environment. With a slowdown in growth for third-party seller services, revenue opportunities could be limited in the future.

Traditional advertising revenue in US$ billion

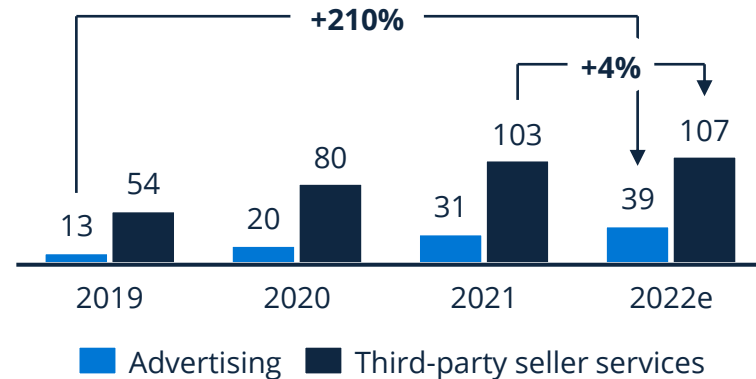|	2019	2020	2021	2022
Total	278	240	247	243
Print	65	54	53	49
Out-of-Home	24	17	19	21
Radio	31	27	28	28
TV	158	143	148	145

■ TV ■ Radio ■ Out-of-Home ■ Print
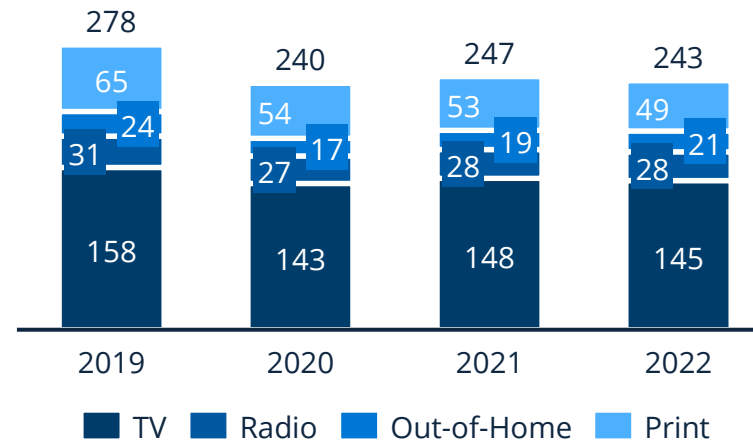
Even though with all formats in decline, in 2021 30% of all ad spending still came from traditional (non-digital) segments. TV advertising being the biggest one of it, still accounting for a lot of revenues that could be captured from digital players.

Amazon's ad supported streaming offer

freevee

Amazon has launched its free, ad-supported streaming channel Freevee in 2022. Originally launched as IMDb TV in the U.S., the UK and Germany are the second and third country worldwide in which Freevee was launched. Freevee offers classic series and movies as well as in-house productions. Commercial breaks interrupt the content, as with linear TV.

With this strategy, Amazon is not only giving a cost-free opportunity to customers next to prime video, but also eating into the linear TV ad spend ecosystem.

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Besides advertising, direct selling gains global traction during the pandemic particularly in the APAC region

What are DTC[1] brands?

DTC brands sell their products or services directly to consumers without using intermediaries such as third-party retailers, wholesalers, and/or agents. Typically, sales are conducted online, but pop-up stores or other physical locations sometimes appear to meet consumer desire for the omnichannel experience.

The advantages of the DTC route are:

- Higher revenue margin per product

- Direct access to consumer data and insights for decision making

- Better customer engagement that establishes brand loyalty

Global distribution on the number of direct selling independent representatives[2] in millions

	2019	2020	2021
Asia/Pacific	72.3	72.7	74.5
North America	17.5	18.1	17.5
Europe	14.2	14.5	15.7
South & Central America	13.4	14.4	14.9
Africa/Middle East	6.5	7.6	5.5

Asia/Pacific | South & Central America
North America | Africa/Middle East
Europe
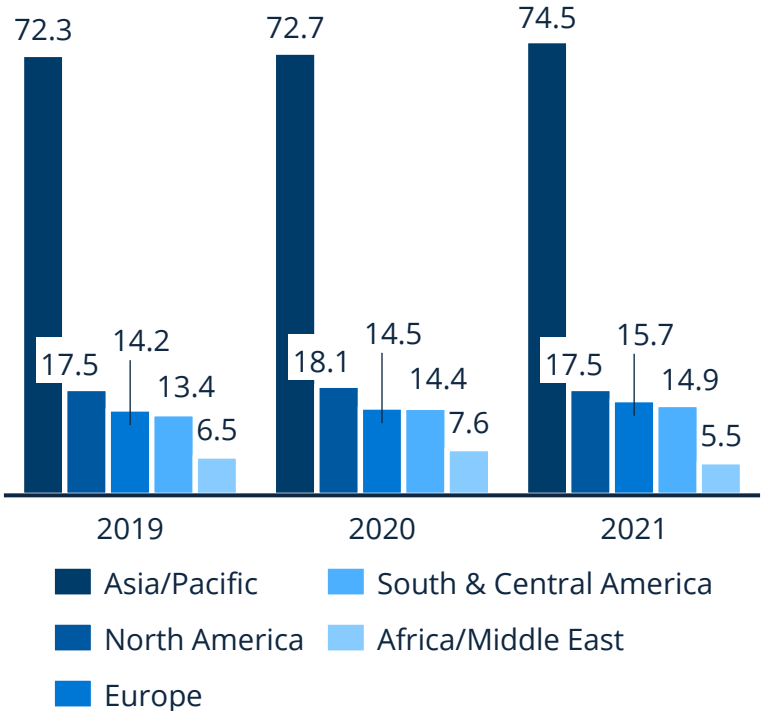
Number and distribution of eCommerce platforms in the U.S.

800,000
110,000
690,000

2022

Amounts to about 13% of all eCommerce businesses in the U.S.

DTC businesses
Traditional eCommerce platforms

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Being hyper focused on empowered consumers is the mantra for establishing a successfully DTC[1] brand

Casper: The Sleep Company

Founded in 2014, this a mattress company achieved US$100 million in sales in under two years. From the start, Caspar's magic formula was in its simplicity: it produced one mattress that was **affordable, top quality,** and **delivered to the customer's doorstep**. By doing so, Casper provided a great shopping experience and eliminated confusion by offering a single product to consumers.

Care/of: Personalized vitamins is one quiz away

Care/of was founded in 2016 aimed to transform the vitamin buying experience into a smooth digital journey. Website visitors take a **quiz** to provide key health information. With the help of an algorithm, a **personalized and clinically based regimen of vitamins** is put together and delivered by subscription to the customer. In 2020, **Bayer** acquired a 70% stake in the company that was valued at US$225 million.
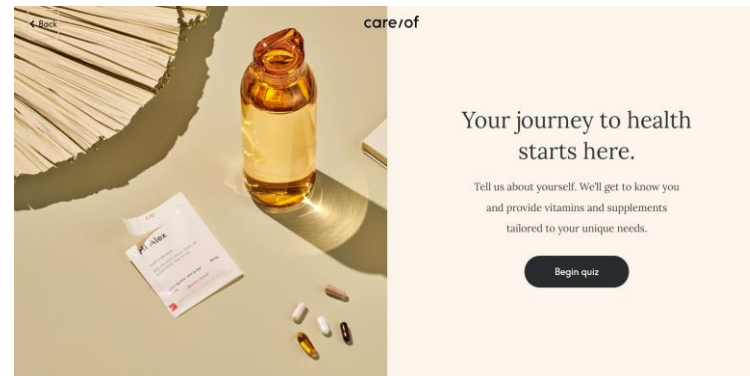
BarkBox: Taps into an unmet millennial market

BarkBox was founded in 2011 and targeted the niche demographic of millennial **die-hard dog lovers**. BarkBox provides them with a **monthly themed box of toys and treats** designed to please and includes a surprise gift in every shipment. BarkBox achieved a revenue of US$250 million in 2019.

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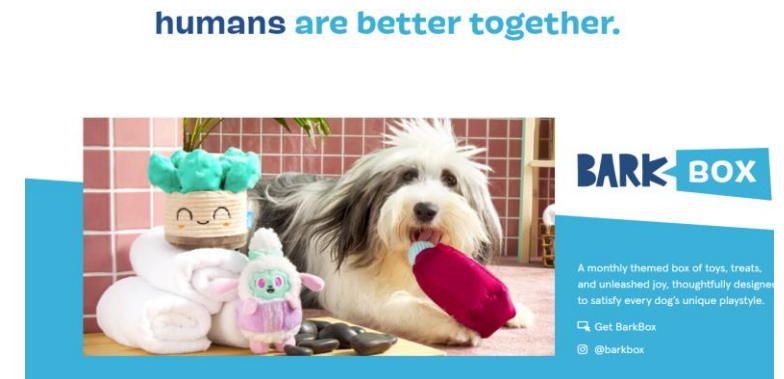
By incorporating DTC[1] into their sales channels, retail juggernauts such as Nike have redefined their company strategy and successfully generated revenues

NIKE DTC sales in billion US$

38.7% of total revenue

Years: 2016 (30), 2017 (32), 2018 (34), 2019 (37), 2020 (36), 2021 (42)

Wholesale customers: 2016 (23), 2017 (23), 2018 (24), 2019 (25), 2020 (23), 2021 (26)

NIKE Direct: 2016 (8), 2017 (9), 2018 (10), 2019 (12), 2020 (12), 2021 (16)

- Wholesale customers
- NIKE Direct
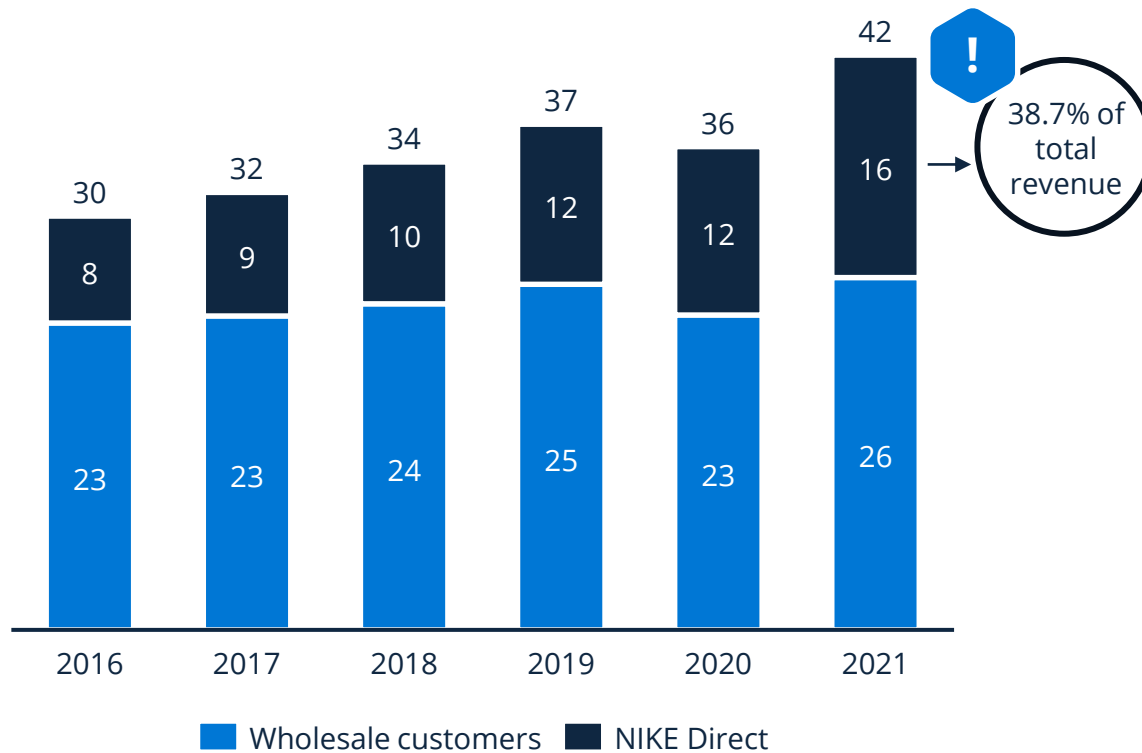
Nike's journey from traditional marketing-first retailer to D2C juggernaut

Over the years, Nike has generated high revenues from its DTC channel by incorporating the design and execution of two key strategies into its business, Consumer Direct Offense and Consumer Direct Acceleration.

Consumer Direct Offense the triple-double strategy is based on three concepts: **Double innovation** offers an in-depth selection to its franchises, **Double speed** minimizes the time incurred between production and selling, and **Double direct connection** focuses on selling more products via digital channels.

Consumer Direct Acceleration, which is the most recent phase of the **Consumer Direct Offense** strategy, focuses on three areas: creating a digital marketplace of the future, offering its products to all consumer demographics, and assertively investing in its digital transformation process.

These strategies have not only helped Nike effectively address the changing consumers behaviors but have also successfully optimized its costs.

statista

Although many brands are aggressively shifting towards DTC[1] to generate higher profit margins, its underlying profitability remains questionable

DTC books high revenue per unit, but is the shift profitable for brands?

There are many benefits company would have by shifting to DTC: it has better control of its overall brand, able to collect detailed consumer insights and achieves higher revenue per item sold. However, three factors affect its profitability:

Although revenue per item may seem to grow by using the DTC model, the overall revenue of the company does not because the abandonment of the wholesale channel leads to a loss in revenue units.

eCommerce platforms generate significant profitability by saving rent and labor costs. However, ecommerce creates its own set of expenses, including fulfillment, logistics, heavy marketing, technology, and return policies.

DTC brands spend on digital advertising in order to acquire customers but without a physical infrastructure, its goals are not necessarily clear. Customer Lifetime Value CLV[2] is one such matrix often overlooked but potentially beneficial for DTC brands.

Revenue vs. net results of Casper in US$ million

The success of Casper Sleep, Inc. depended largely on its investment in marketing, but its path to profitability appeared rocky as a result.

	2019	2020	2021 (Sep)
Revenue	439	497	436
Net loss	-93	-90	-80

■ Revenue ■ Net loss

statista
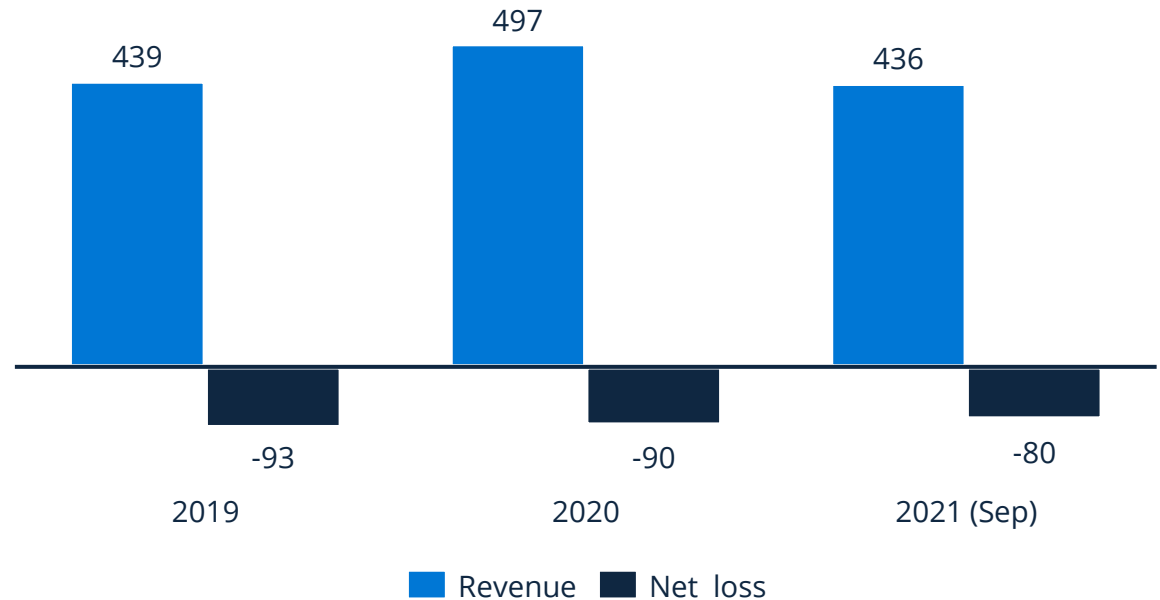
Frictionless social and metaverse commerce: the future of eCommerce?

The eCommerce market is evolving just as quickly as it is expanding. One consequence of rapid innovation in this space is the emergence of an ecosystem that reduces friction within the value chain. These interconnected platforms, which are still being developed by several companies, continue to generate interest among VCs. In particular, social commerce and payment platforms have significant potential to shape the future of eCommerce. With the line between the physical and digital world blurring day by day, technologies such as blockchain, artificial intelligence, augmented and virtual reality, cryptocurrency payment platforms, and 5G are shaping consumer shopping into an increasingly seamless experience in the metaverse.

A short-term development of the broader eCommerce ecosystem is increased connectedness that removes friction along the value chain

Overview of the broader eCommerce marketplace stack

Fintech

Buy now, pay later

D2C banking, trading

Lending

Insurance

Revolut N̄26 **Klarna.** Lendo Money Super Market alan wefox

robinhood

Advertising

Google
amazon

Moving into vertical search

Focusing on advertising platform

Creating marketplaces

Logistics

Potentially levelling the playing field by enabling asset-light players to have full-stack capabilities

Lineage LALAMOVE

Software

Software directly competing with Amazon's platform

SaaS with add-on marketplace for doctors

WIX shopify Doctolib

Own Product

Competing directly with marketplaces & eCommerce

WARBY PARKER BEYOND MEAT

Marketplace stack

- Fintech
- Advertising
- Logistics
- Software
- Own Product

Sources: Speedinvest, Adevinta Ventures, dealroom.co

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Several eCommerce connected platforms that can leverage certain aspects of frictionless commerce continue to gain much attention from investors in 2022

Global top eCommerce equity deals in 2022

	Round amount in Q1 2022 in million US$	Valuation in US$ million	Series	Country
Fanatics	1,500	40,000	Series D	🇬🇧
checkout.com	1,000	27,000	Series H	🇺🇸
BackMarket	510	11,000	Series E	🇺🇸
Bolt	355	5,700	Series E	🇫🇷
INXEPTION	275	3,000	Series E	🇺🇸
moglix	250	2,600	Series E	🇸🇬
ankorstore	282	2,200	Series C	🇫🇷
CARSOME	290	1,700	Series E	🇲🇾

statista
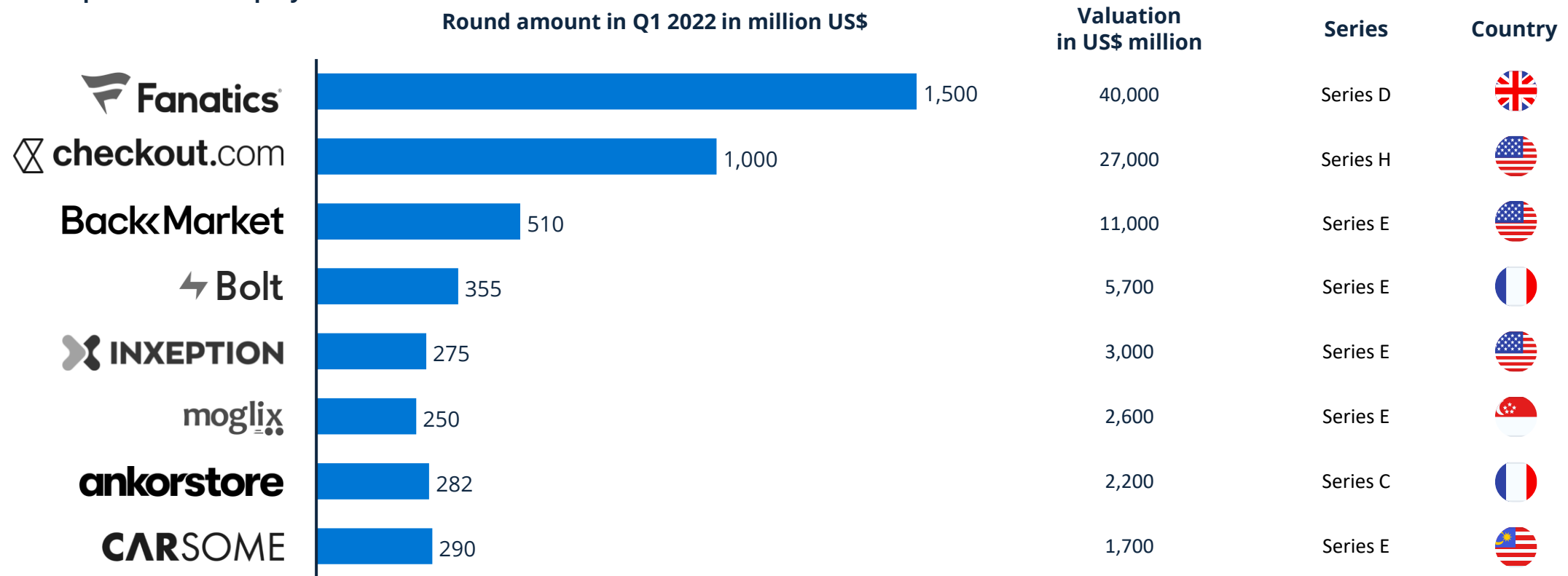
In addition to selling classic sports apparel, Fanatics offers sports collectibles, NFTs, trading cards, and merchandise, as well as sports betting and iGaming

Fanatics, a global leader in licensed sports merchandise, has drawn the attention of investors from various industries. The company transforms the digital sports experience by becoming a real-time, on-demand platform for a broad array of sports products fans. The company currently has a database of more than 80 million sports fans, which gives Fanatics the advantage of being able to provide personalized offers and acquire/generate customers for its new businesses.

Fanatics's funding from 2018 – 2022 in million US$

Year	Value
2012	225
2013	170
2015	300
2017	1,000
2020	350
2021	645
Q1 2022	1,500
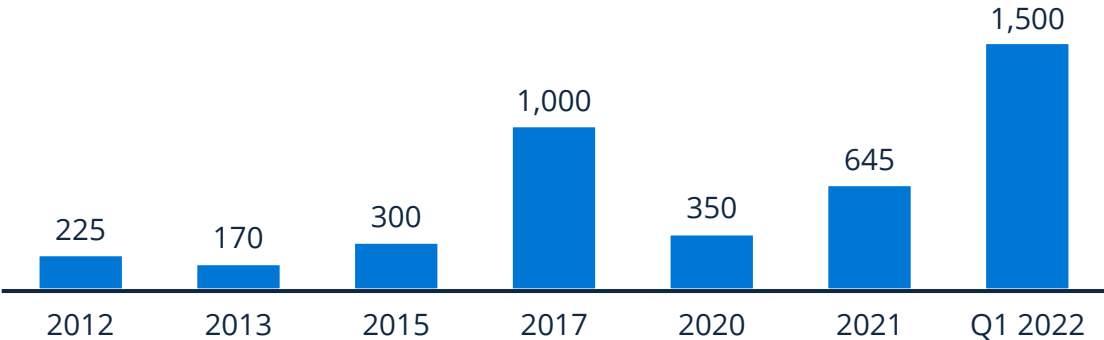
Diversity of Fanatics investors

Financial Institutions
- SoftBank Group
- Thrive Capital
- Blackstone Group
- Fidelity Management

Athletic Organizations
- National Football League
- Major League Baseball
- Sliver Lake

Entertainment
- Jay-Z
- Roc Nation

Fanatics
Innovative vertical commerce model that distributes and manufactures on-demand licensed products to fans

Topps / zerocool
Manufacturers of trading sport cards, collectibles, and arts

Family of companies

CANDY
Official NFT ecosystem that buys and trades digital assets

Coming Soon:
Betting and Gaming platform

statista
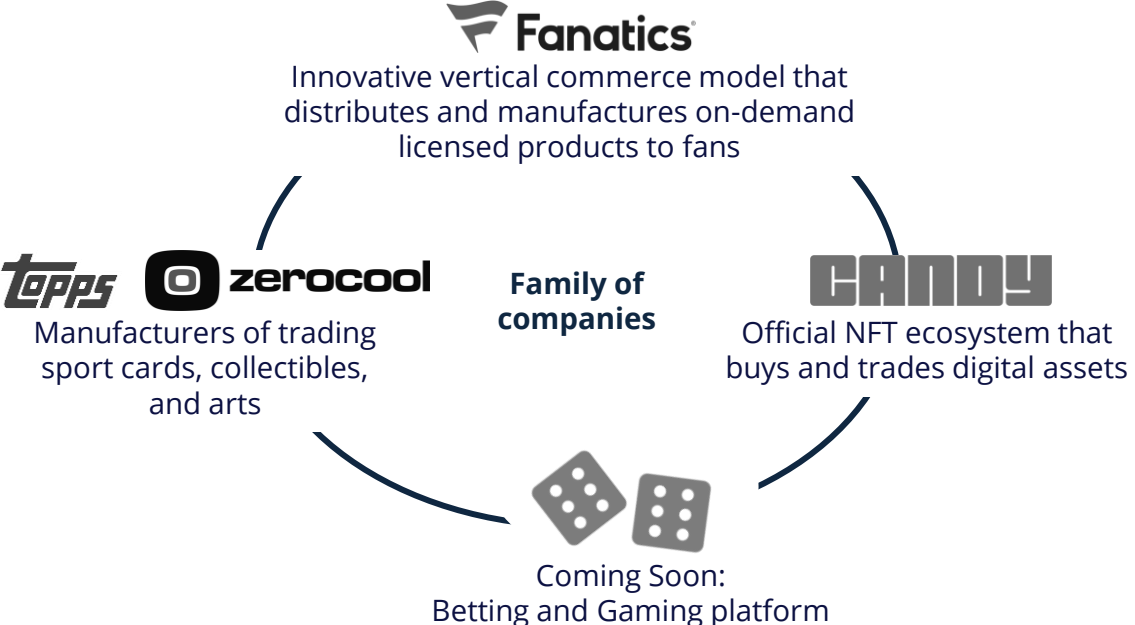
Checkout.com has become Europe's top valuable payment provider with a US$40 billion valuation in 2022

checkout.com

Checkout.com, a cloud-based payment solution for marketplaces, has raised US$1 billion in a funding round that makes it the UK's most valuable private tech company. The company almost tripled its valuation to US$40 billion in a year. The company succeeded in catching up to the online shopping trend after several years of profitability and expanded its business to over 1700 employees in 19 global offices in just ten years.

Checkout.com timeline

Funding amount in million US$

Checkout.com established

Authorized as an electronic money institution in the U.K.

1,000

450

230

150

| 2012 | 2013 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |

Partner with major payment institutions

VISA MasterCard JCB
Diners Club International UnionPay 银联 AMERICAN EXPRESS

- 200+ employees
- 8 global offices

- 1000+ employees
- 17 global offices

- 500+ employees
- Authorized as an electronic money institution in France

- 1700+ employees
- 19 global offices

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Ankorstore, a wholesale marketplace that connects shop owners and specialist brands with neighborhood retailers, reached unicorn status in three years

ankorstore

Ankorstore, founded in July 2019, is the fastest growing online wholesale marketplace that has reached unicorn status in three years. Ankorstore connects 20,000 authentic brands and 250,000 local retails across 33 countries in Europe. Unlike other major commercial marketplaces, Ankorstore has focused on localization and has been successful with this strategy.

Comparison of Ankorstore's and Amazon's pages in the beer category
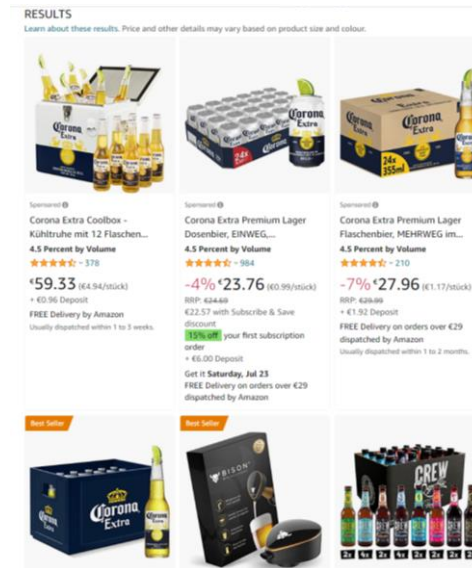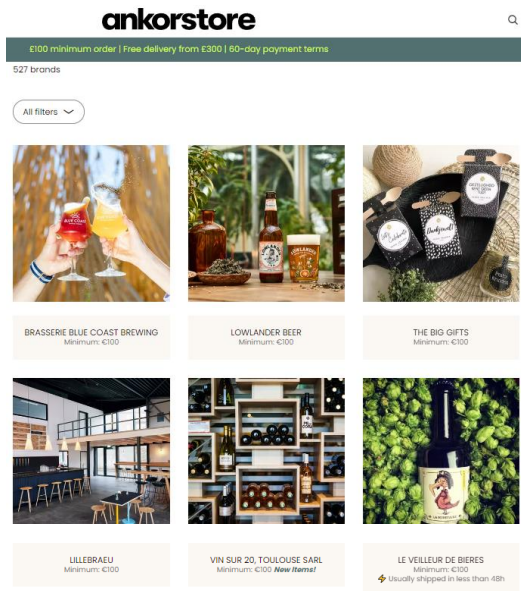
Ankorstore's funding amount in US$ million

The beginning of Ankorstore, a European wholesale marketplace for local products

3 Years

Reached unicorn status with a valuation of US$1.75 billion

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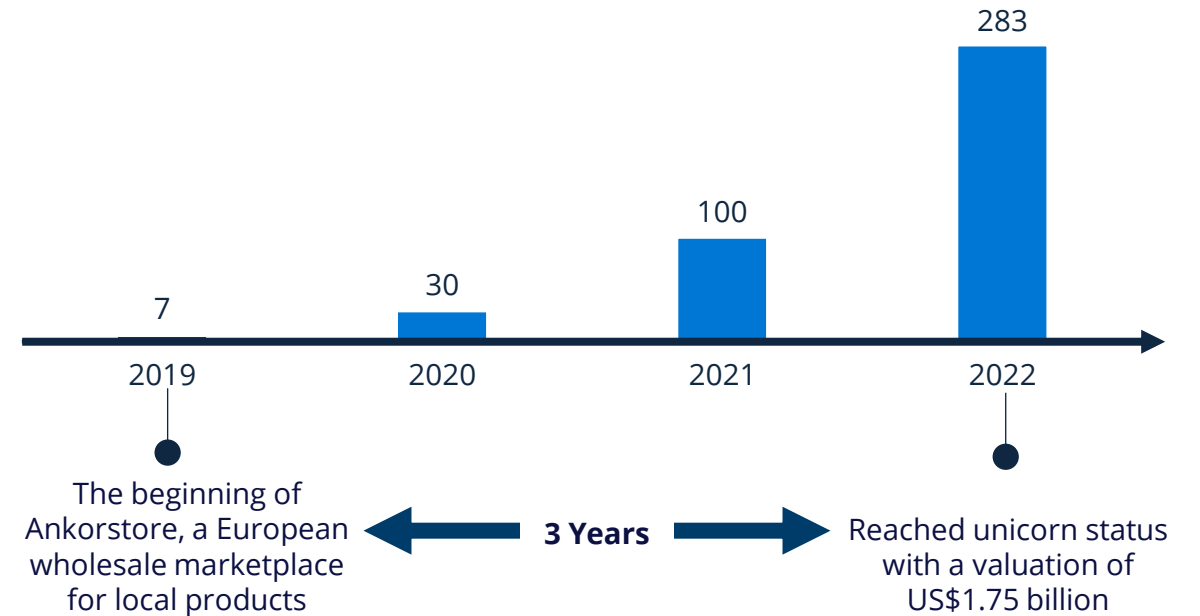
Long-term topics such as social commerce will lead to the next wave in online shopping: leveraging convenience and network effects of social media

Global social and influencer ad revenue in US$ bn

Influencer Advertising
- 28 (2022)
- 51 (2027) **+86%**

Social Media Advertising
- 226 (2022)
- 385 (2027) **+70%**

■ 2022 ■ 2027
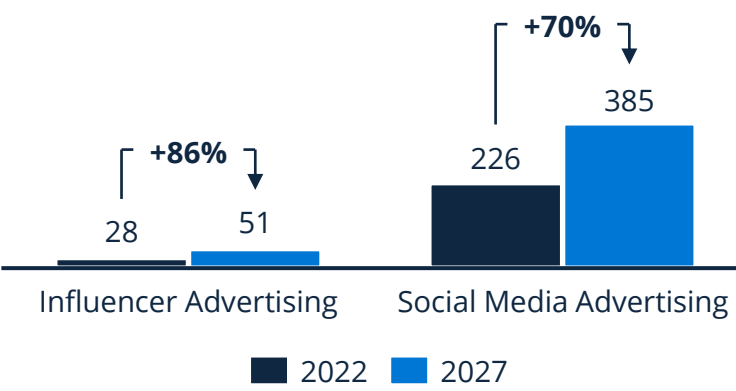
Global number of social media users in million

2022	2023	2024	2025	2026	2027
4,594	4,898	5,174	5,423	5,649	5,852
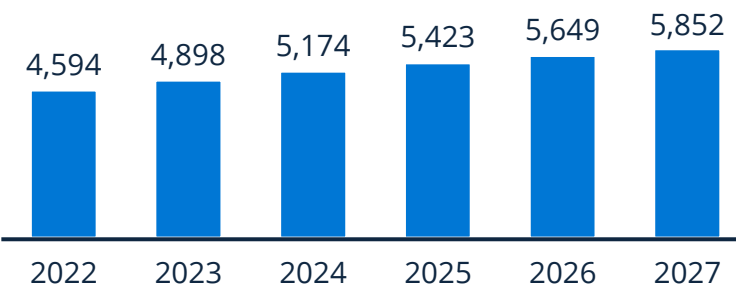
Users purchasing from social networks in 2021

Country	%
China	46%
U.S.	36%
Australia	30%
Canada	26%
Russia	26%
Brazil	25%
UK	24%
France	23%
Italy	23%
Spain	22%
Mexico	21%
Germany	18%
Japan	18%
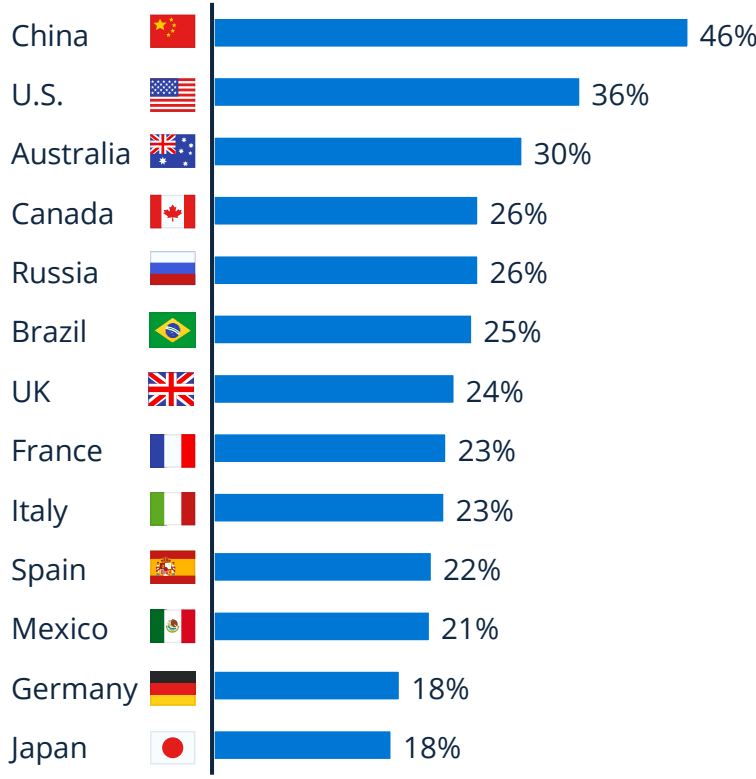
Global social commerce revenue in bn US$

+249%

2022	2023	2024	2025	2026	2027
751	964	1,240	1,590	2,040	2,620

statista
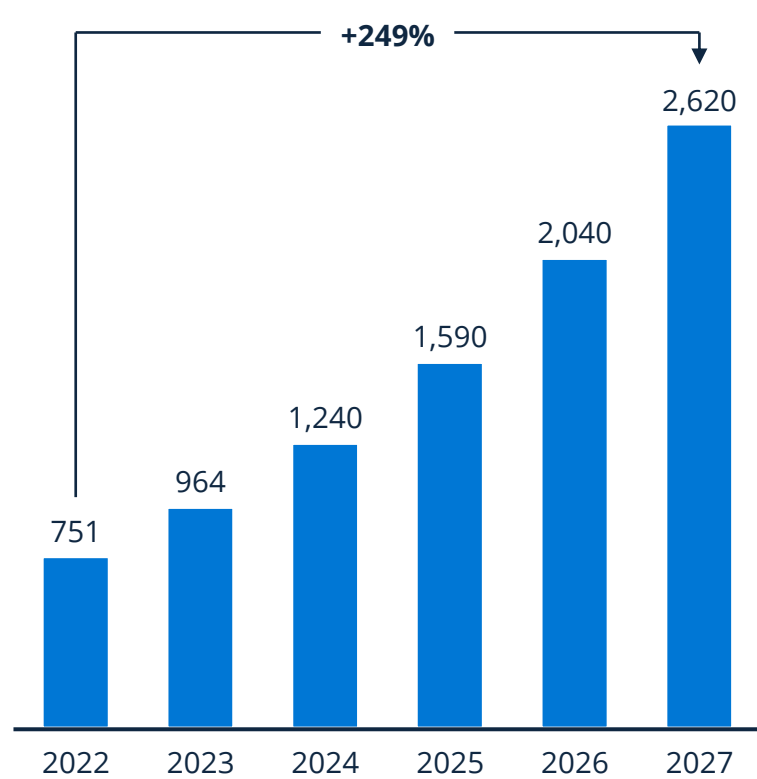
As the line between the physical and digital world becomes increasingly blurry, the metaverse will reimagine the path to omnichannel shopping experiences

Overview of future next-level commerce

3D assets (NFTs[1]**)** and **virtual try-ons** supported by **AR**[2] and **blockchain** will pave the way to customized on-demand apparel-making and products

In **conversational commerce,** brands and retailers leverage **direct messaging platforms** to interact on a personal level with shoppers

In **Headless Commerce,** brands optimize their approaches for reaching customers via maximum interfaces such as smartphones, smart speakers, apps, and social media

As brands seek ways to improve customer engagement, **virtual stores** in the **metaverse** present a unique opportunity for retailers to provide their shoppers with an **immersive** experience

Brands that integrate **cryptocurrency** options into their eCommerce platforms can enable faster payments with a broader (global) customer reach

Retailer websites that leverage **AI** technology can provide **individualized recommendations** to customers based on their shopping profiles

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The ascent of the crypto economy

Originally released in May 2022 (as Chapter 1)

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Table of contents

The ascent of the crypto economy

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Cryptocurrencies with their disruptive potential have gone mainstream

The ascent of cryptocurrencies has been turbulent, accompanied by many advances and setbacks. In 2009, the first Bitcoin block was mined; in 2015, Ethereum introduced the first programmable blockchain; in 2018, 80% of the market was erased by a speculative bubble; and most recently, Bitcoin has even become a legal tender in some countries. The industry has moved on from concepts and whitepapers to real-life applications, adding over 10,000 different cryptocurrencies with a market capitalization of over US$2 trillion (end of 2021), creating an entire ecosystem of use cases. Despite significant advancements, cryptocurrencies remain highly controversial due to high volatility, increasing numbers of cyberattacks, and issues related to energy consumption and scalability. Nevertheless, many startups and companies are entering the sector, and more and more governments, investment funds, and corporations are formulating their crypto strategies, transforming the sector into a mainstream industry.

A cryptocurrency is a tradable and decentralized digital asset built on blockchain technology

Simplified explanation of how cryptocurrencies work[1]

Someone initiates a **transaction**.

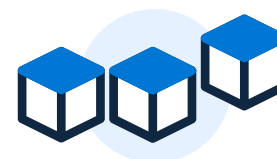The transaction is broadcasted to all nodes of a **peer-to-peer network**.

Nodes attempt to validate the transactions based on **embedded algorithms** (PoW, PoS[2]).

The transaction is **verified**! Nodes continue to work on the next block.

Once validated, the signed block is **broadcast** to the other network nodes, which then accept it.

The validated transactions are bundled as a block and added to the **blockchain**.
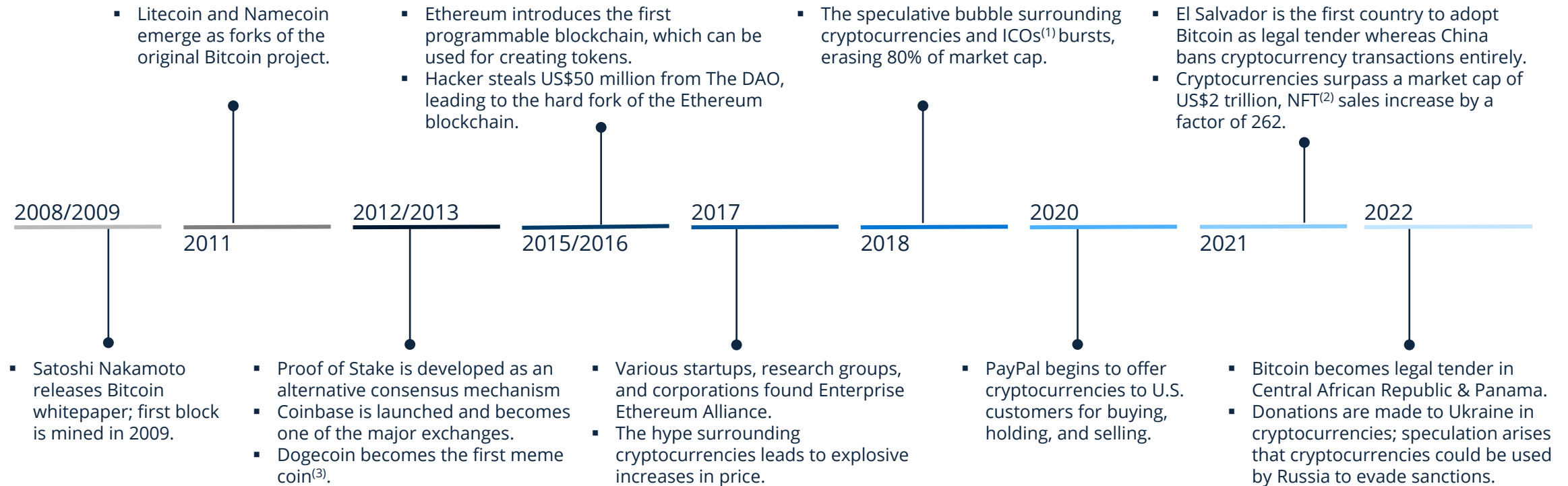
What is a cryptocurrency?
A cryptocurrency is a digital currency. Each coin consists of cryptographic signatures definitively proving individual ownership.

What is a blockchain?
A blockchain is a distributed ledger that records all transactions by gathering them in blocks, which are then immutably chained together.
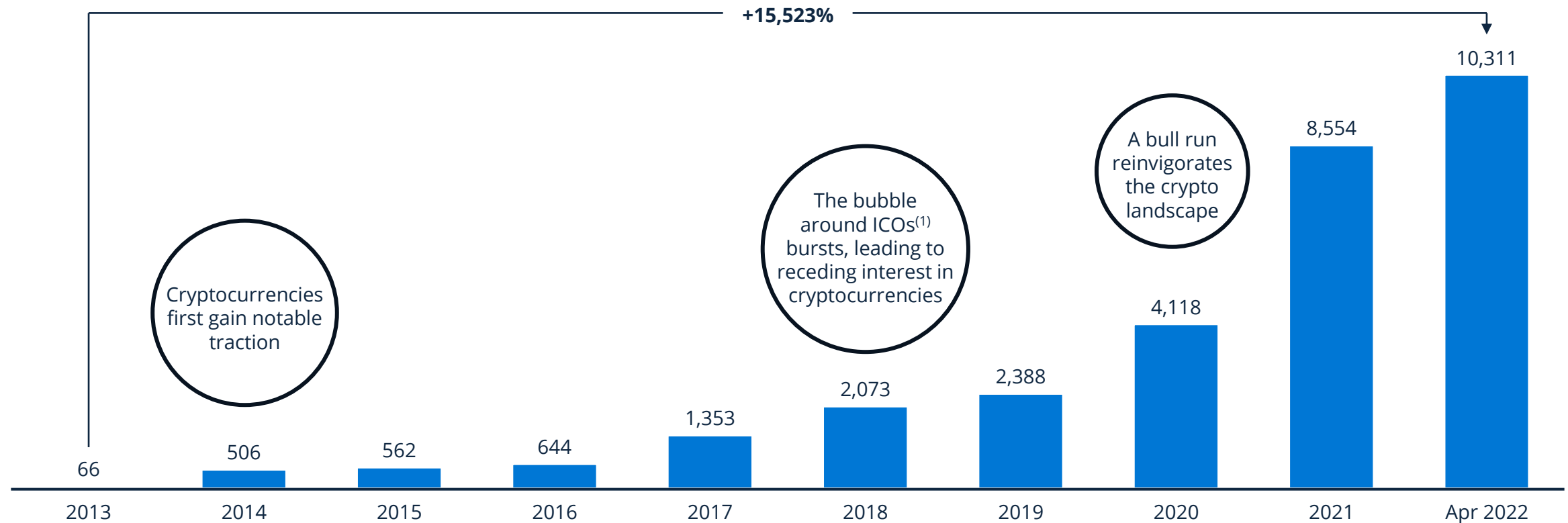
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The ascent of cryptocurrencies has been turbulent, accompanied by many advances and setbacks

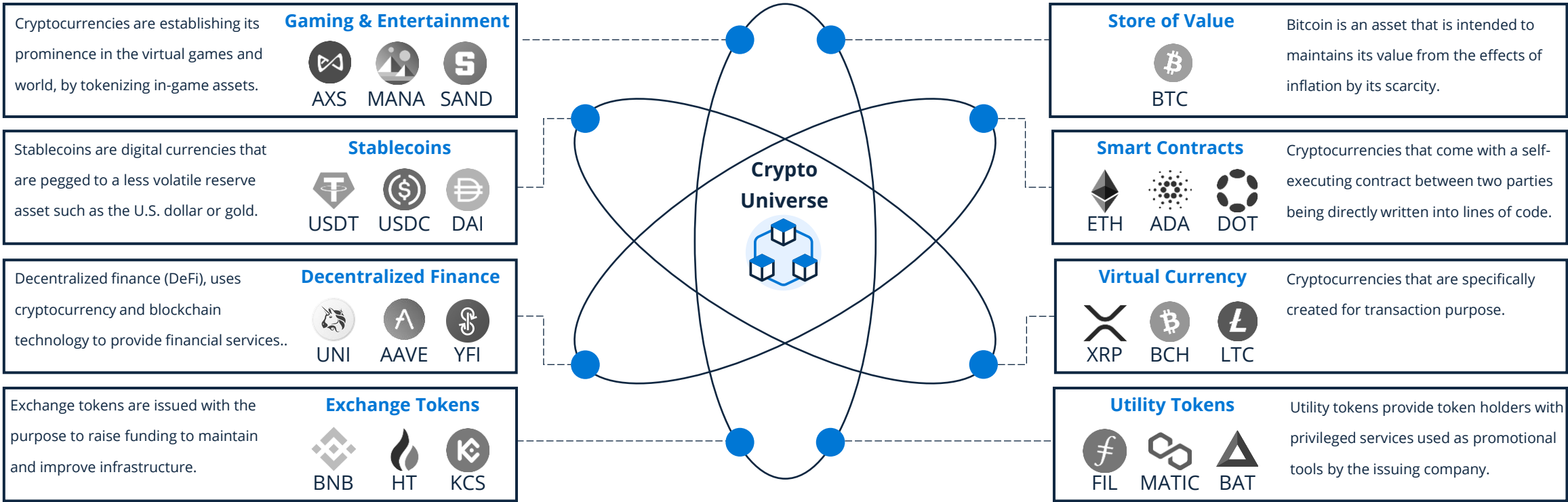**Timeline of selected events leading to the rise of cryptocurrencies**

- Litecoin and Namecoin emerge as forks of the original Bitcoin project.

- Ethereum introduces the first programmable blockchain, which can be used for creating tokens.
- Hacker steals US$50 million from The DAO, leading to the hard fork of the Ethereum blockchain.

- The speculative bubble surrounding cryptocurrencies and ICOs[1] bursts, erasing 80% of market cap.

- El Salvador is the first country to adopt Bitcoin as legal tender whereas China bans cryptocurrency transactions entirely.
- Cryptocurrencies surpass a market cap of US$2 trillion, NFT[2] sales increase by a factor of 262.

2008/2009   **2012/2013**   **2017**   **2020**   **2022**

2011   **2015/2016**   **2018**   **2021**

- Satoshi Nakamoto releases Bitcoin whitepaper; first block is mined in 2009.

- Proof of Stake is developed as an alternative consensus mechanism
- Coinbase is launched and becomes one of the major exchanges.
- Dogecoin becomes the first meme coin[3].

- Various startups, research groups, and corporations found Enterprise Ethereum Alliance.
- The hype surrounding cryptocurrencies leads to explosive increases in price.

- PayPal begins to offer cryptocurrencies to U.S. customers for buying, holding, and selling.

- Bitcoin becomes legal tender in Central African Republic & Panama.
- Donations are made to Ukraine in cryptocurrencies; speculation arises that cryptocurrencies could be used by Russia to evade sanctions.

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Today, there are just over 10,000 cryptocurrencies, indicating a dramatic increase from just a handful of digital coins in 2013

Global number of cryptocurrencies

+15,523%

Cryptocurrencies first gain notable traction

The bubble around ICOs[1] bursts, leading to receding interest in cryptocurrencies

A bull run reinvigorates the crypto landscape

2013	2014	2015	2016	2017	2018	2019	2020	2021	Apr 2022
66	506	562	644	1,353	2,073	2,388	4,118	8,554	10,311

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Cryptocurrencies from its infancy in 2009 have evolved into an entire ecosystem with several use cases

Selected categories of cryptocurrencies based on their use cases

Gaming & Entertainment

Cryptocurrencies are establishing its prominence in the virtual games and world, by tokenizing in-game assets.

AXS   MANA   SAND

Stablecoins

Stablecoins are digital currencies that are pegged to a less volatile reserve asset such as the U.S. dollar or gold.

USDT   USDC   DAI

Decentralized Finance

Decentralized finance (DeFi), uses cryptocurrency and blockchain technology to provide financial services..

UNI   AAVE   YFI

Exchange Tokens

Exchange tokens are issued with the purpose to raise funding to maintain and improve infrastructure.

BNB   HT   KCS

Crypto Universe

Store of Value

Bitcoin is an asset that is intended to maintains its value from the effects of inflation by its scarcity.

BTC

Smart Contracts

Cryptocurrencies that come with a self-executing contract between two parties being directly written into lines of code.

ETH   ADA   DOT

Virtual Currency

Cryptocurrencies that are specifically created for transaction purpose.

XRP   BCH   LTC

Utility Tokens

Utility tokens provide token holders with privileged services used as promotional tools by the issuing company.

FIL   MATIC   BAT

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The crypto segment reached an average market capitalization of US$2 trillion in 2021 with Bitcoin and Ethereum constituting more than half the entire sector

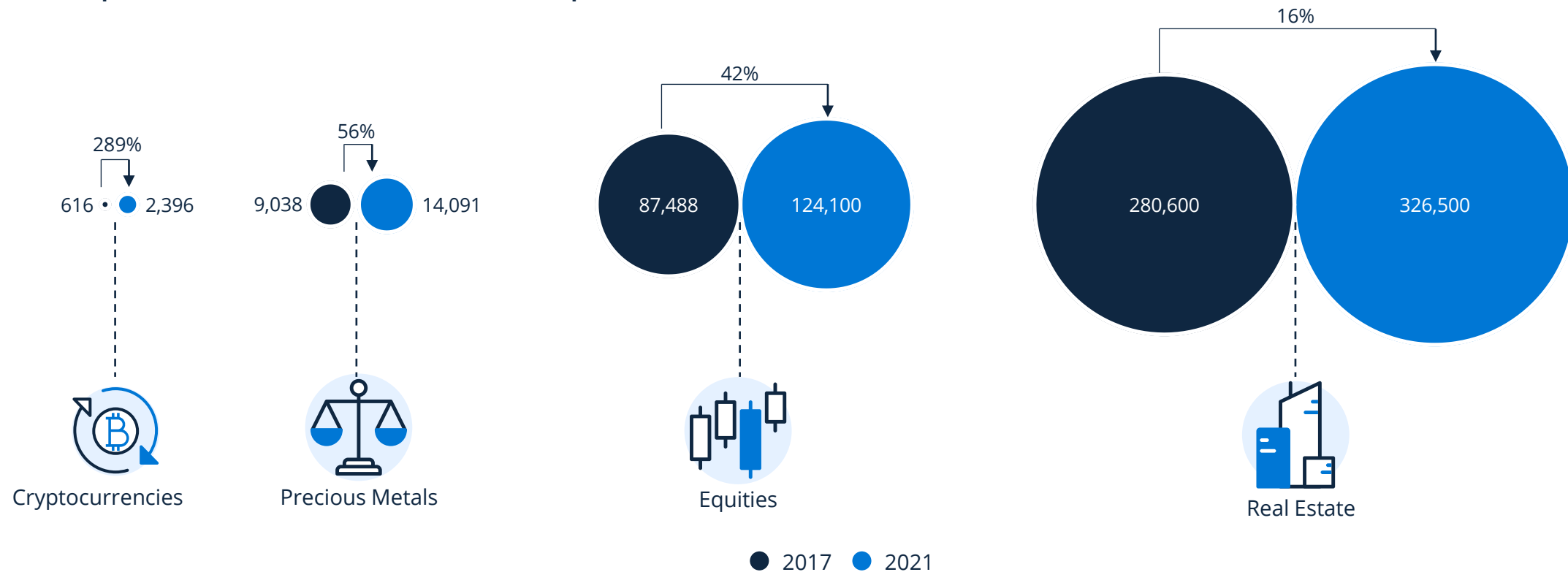**Average market capitalization of the crypto segment in US$ billion in 2021**
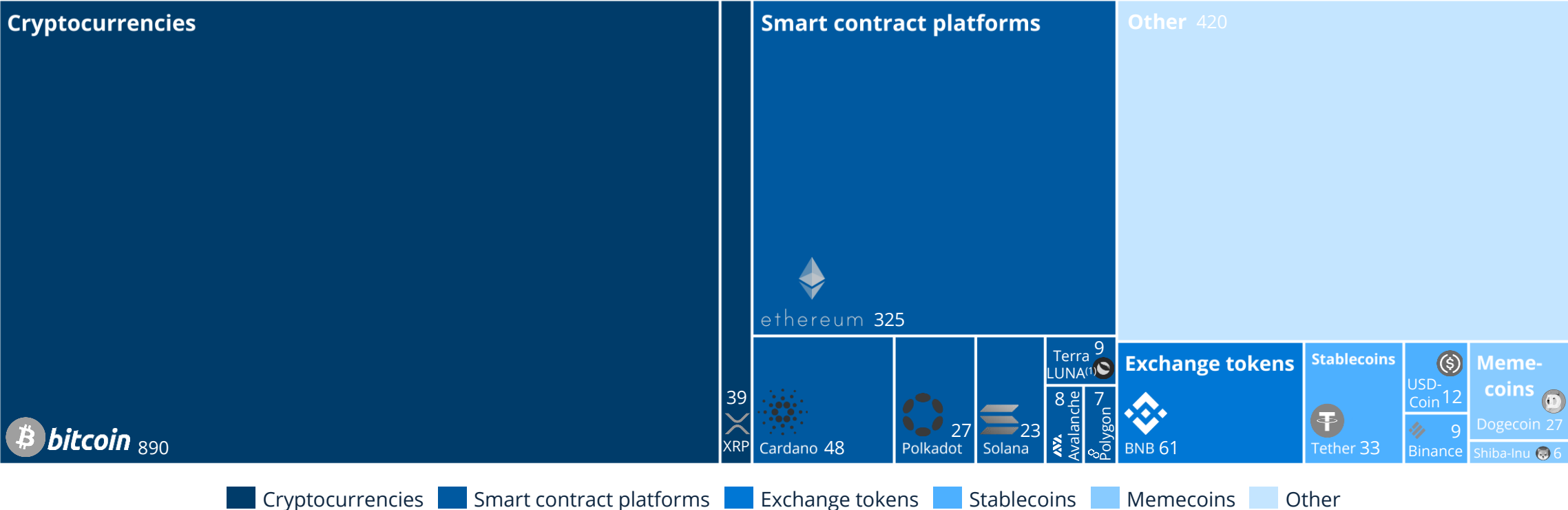
Legend: Cryptocurrencies | Smart contract platforms | Exchange tokens | Stablecoins | Memecoins | Other

Chart labels:
- Cryptocurrencies — bitcoin 890
- Smart contract platforms — ethereum 325; XRP 39; Cardano 48; Polkadot 27; Solana 23; Avalanche 8; Polygon 7; Terra LUNA(1) 9
- Other 420
- Exchange tokens — BNB 61
- Stablecoins — Tether 33; USD-Coin 12; Binance 9
- Memecoins — Dogecoin 27; Shiba-Inu 6

Compared to other popular asset classes, cryptocurrencies are still small in terms of market capitalization

Market capitalization of different asset classes in comparison in US$ billion

Cryptocurrencies

289%

616 • 2,396

Precious Metals

56%

9,038 • 14,091

Equities

42%

87,488 • 124,100

Real Estate

16%

280,600 • 326,500

● 2017   ● 2021

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The pandemic triggered a significant increase in revenues made in the crypto sector with growth of 481% from 2019 to 2020

Global cryptocurrencies revenue forecast in US$ billion
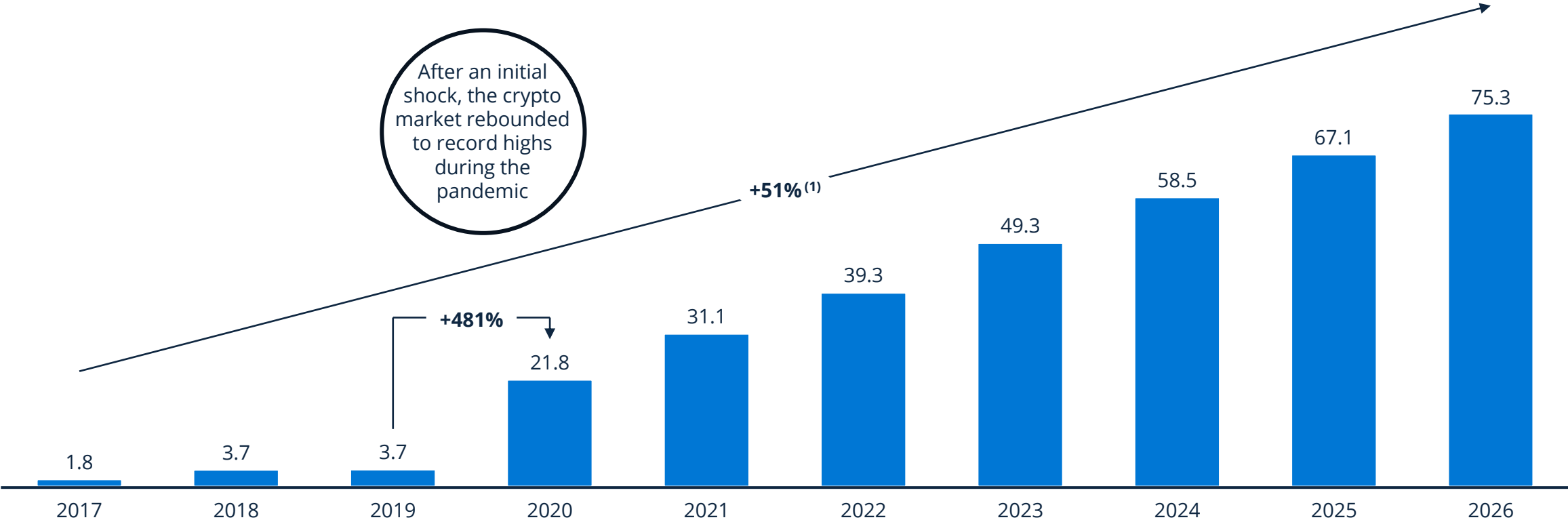
After an initial shock, the crypto market rebounded to record highs during the pandemic

+51% [1]

+481%

Year	Value
2017	1.8
2018	3.7
2019	3.7
2020	21.8
2021	31.1
2022	39.3
2023	49.3
2024	58.5
2025	67.1
2026	75.3

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As cryptocurrencies grow in value, transaction volumes have also increased, nearly catching up to network volumes to that of Visa and Mastercard

Total transaction volume for 2021 in US$ trillion

US$10.8tn — VISA

US$7.7tn — MasterCard

US$4.6tn — bitcoin

US$3.6tn — ethereum

Legend: Ethereum[1] · Bitcoin[1] · MasterCard[2] · Visa[2]

X-axis: Jan '21 · Jun '21 · Oct '21 · Dec '21

Y-axis: 0 to 11
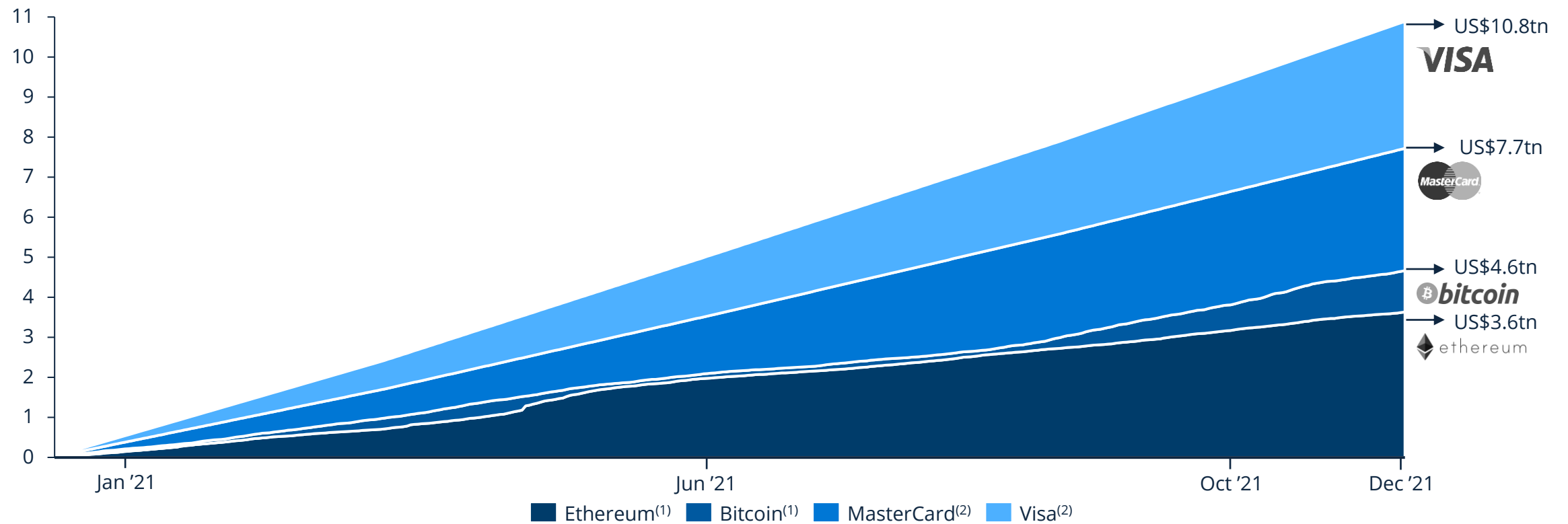
Notes: (1) Ethereum and Bitcoin payment volume corrected to account for non-meaningful transactions (2) VISA and MasterCard payment volume extrapolated from quarterly reports

Sources: Company information, CoinMetrics

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Notably, the total transaction volume is still limited due to transaction delays and scalability issues with cryptocurrencies

Transaction finality[1] of different cryptocurrencies in minutes in January 2022[2]

Cryptocurrency	Value
bitcoin	40
Dogecoin	40
Cardano	10
Shiba Inu	5
ethereum	5
tether	5
USD Coin	5
Polkadot	2
Avalanche	1
ripple	near-instant
Solana	near-instant
Terra	near-instant

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Because all cryptocurrencies inevitably experience huge fluctuations in their valuation, they remain a high-risk investment

Annualized and average daily price volatility of top eight coins by market capitalization in 2021

	Dogecoin	Solana	XRP	bnb	Polkadot	Cardano	Ethereum	Bitcoin
Annualized Price Volatility	421%	162%	153%	148%	148%	131%	107%	81%
Avg. Daily Volatility	22%	8%	8%	8%	8%	7%	6%	4%

■ Annualized Price Volatility ——●—— Avg. Daily Volatility

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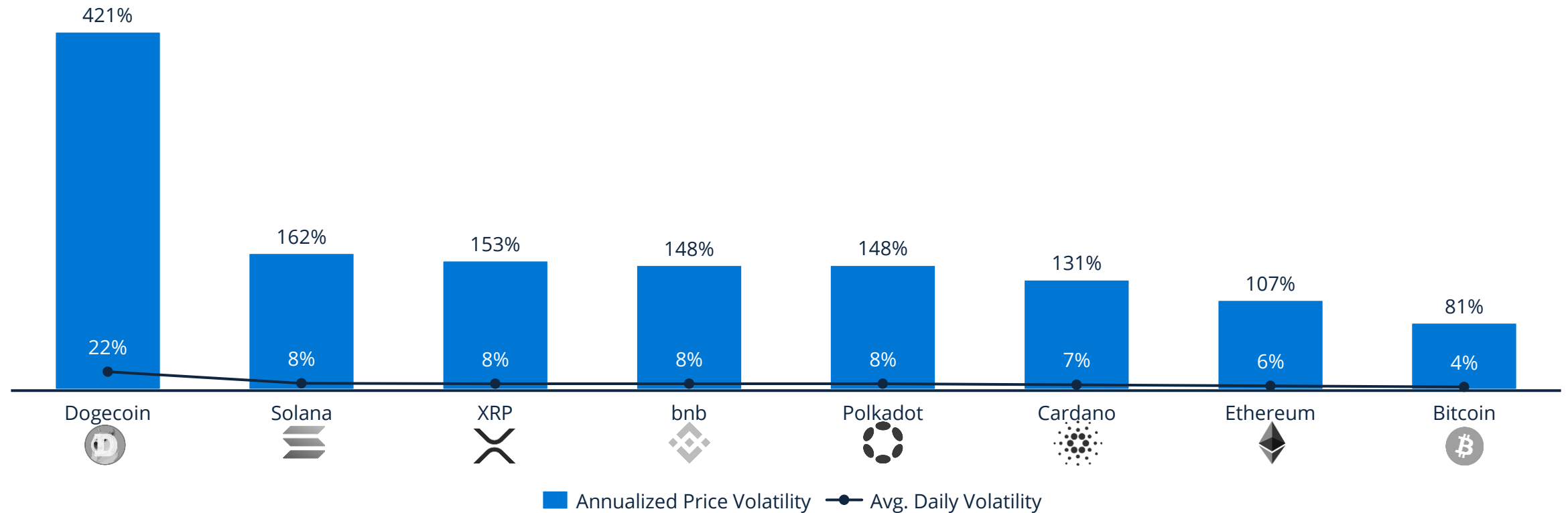
Volatility and risks are becoming significantly evident since beginning of 2022 when a market-wide extreme loose in value started

Cryptocurrencies total market capitalization in US$ trillion
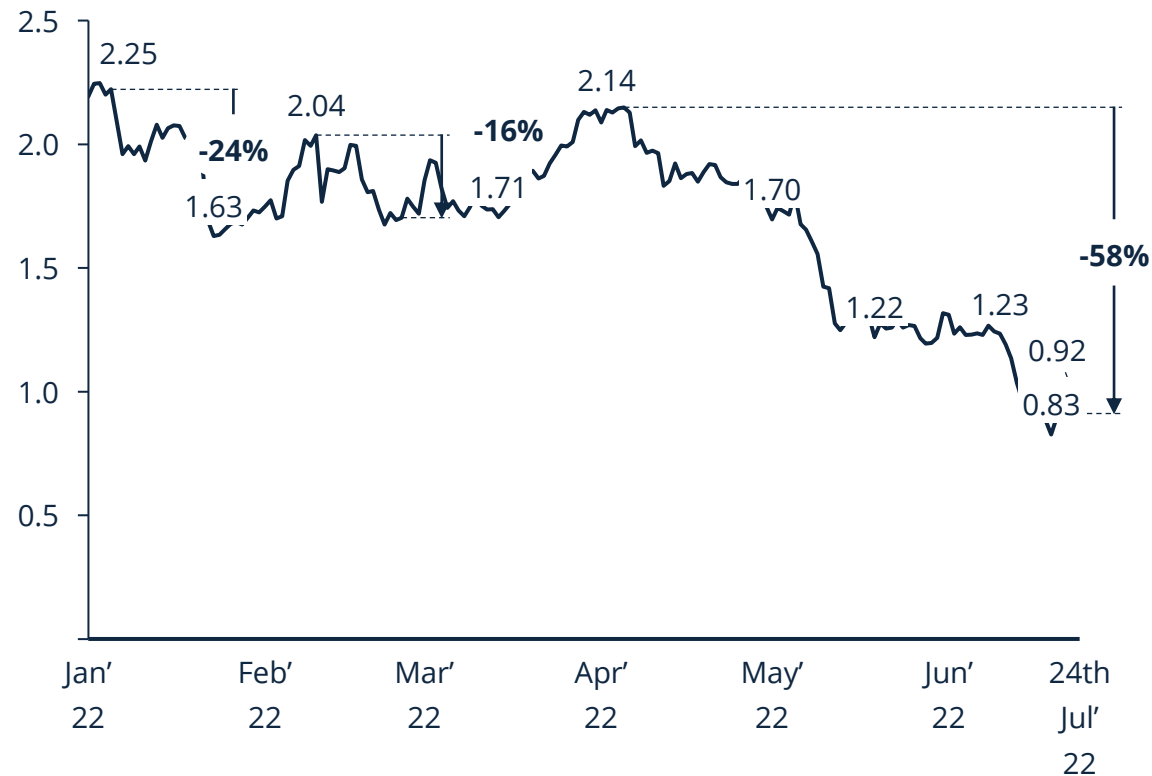
Bitcoin price in US$

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Stablecoins are one way to deal with the volatility problem of cryptocurrencies because they are designed to preserve the value of digital assets

How Stablecoins work?

A Stablecoin is a digital currency that is pegged to a less volatile reserve asset such as the U.S. dollar or gold. Stablecoins were introduced to minimize volatility relative to unpegged cryptocurrencies like Bitcoin.

Sender

Receiver

Miners validate the transfer of bitcoin

3

4

2

6

Sender buys
Bitcoin with fiat[2]

Receiver exchanges
Bitcoin with Stablecoin

1

Exchange
facilitates
trading

5

Bank

Crypto company issues
Stablecoins pegged to US$
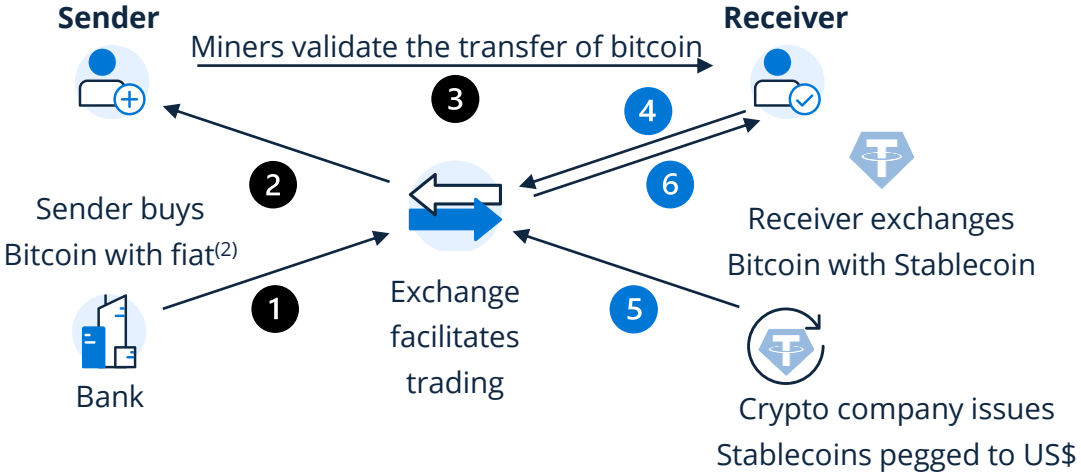
Top-5 coins by market capitalization[1] in US$ billion in 2022
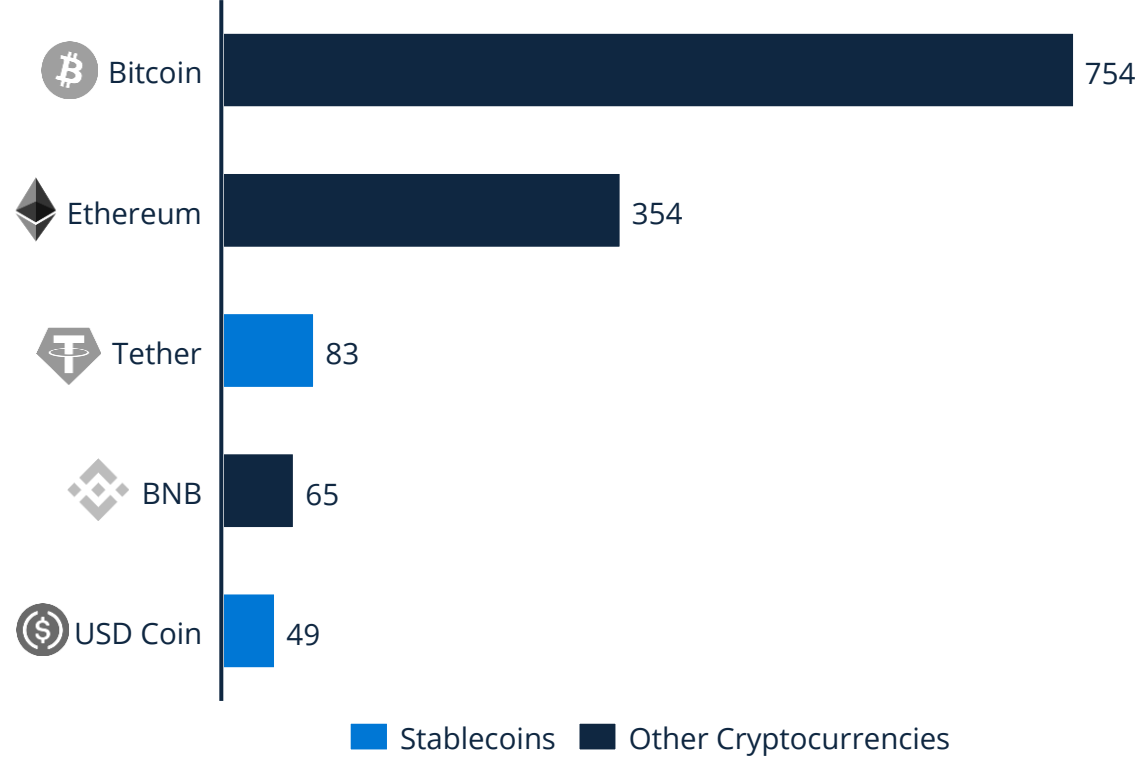
Coin	Value
Bitcoin	754
Ethereum	354
Tether	83
BNB	65
USD Coin	49

■ Stablecoins   ■ Other Cryptocurrencies

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Terra fails to establish the working concept of algorithmic Stablecoins with the prices of LUNA[1] nose-diving and UST[2] losing its peg in May 2022

What are the different types of Stablecoins?

Collateralized Stablecoins

Collateralized Stablecoins are minted or burned when assets such as fiat currencies, gold or cryptocurrencies are deposited to or withdrawn from their reserves

To maintain the stability of the Stablecoins peg there is a need for large volumes of liquid reserves

Algorithmic Stablecoins

Algorithmic Stablecoins do not use the concept of depositing collaterals. They leverage algorithms and smart contracts to manage supply and demand of tokens, thereby, maintaining their price stability

When Stablecoins (UST) price is <US$1, the protocol incentivizes users to burn Stablecoins and mint the linked cryptocurrency (LUNA)[1] in the protocol

The collapse of the Terra protocol

Terraform Labs designed the Terra protocol that issued the first algorithmic Stablecoin UST and LUNA[1], the latter of which algorithmically backs the former
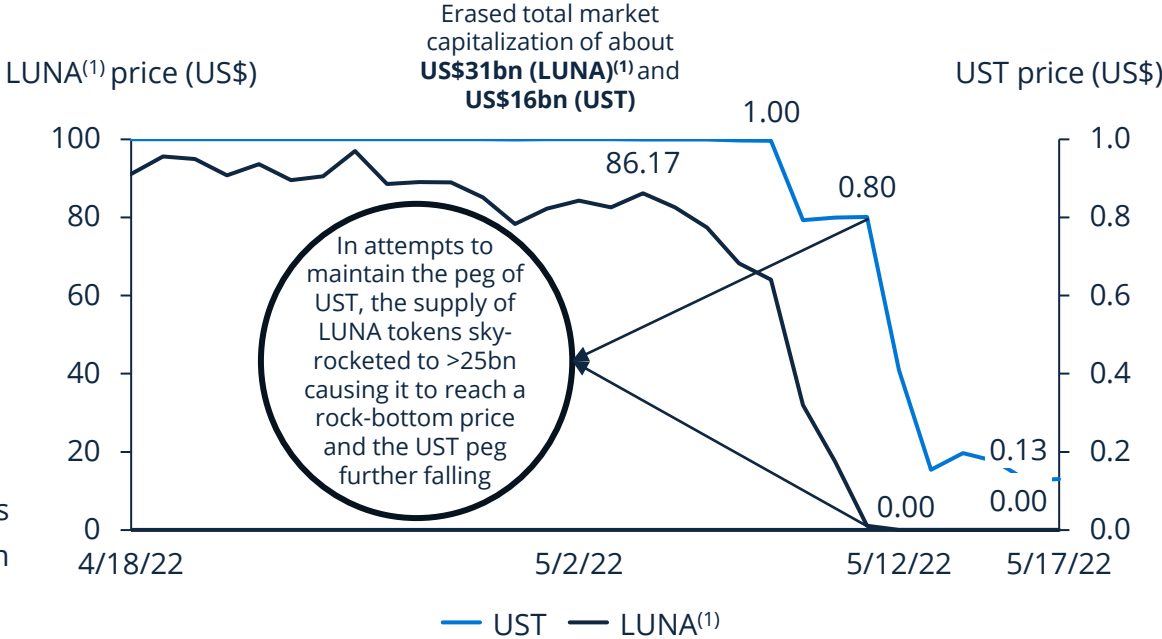
LUNA[1] price (US$)

Erased total market capitalization of about **US$31bn (LUNA)[1]** and **US$16bn (UST)**

UST price (US$)

In attempts to maintain the peg of UST, the supply of LUNA tokens sky-rocketed to >25bn causing it to reach a rock-bottom price and the UST peg further falling

1.00

86.17

0.80

0.13

0.00

0.00

100

80

60

40

20

0

1.0

0.8

0.6

0.4

0.2

0.0

4/18/22   5/2/22   5/12/22   5/17/22
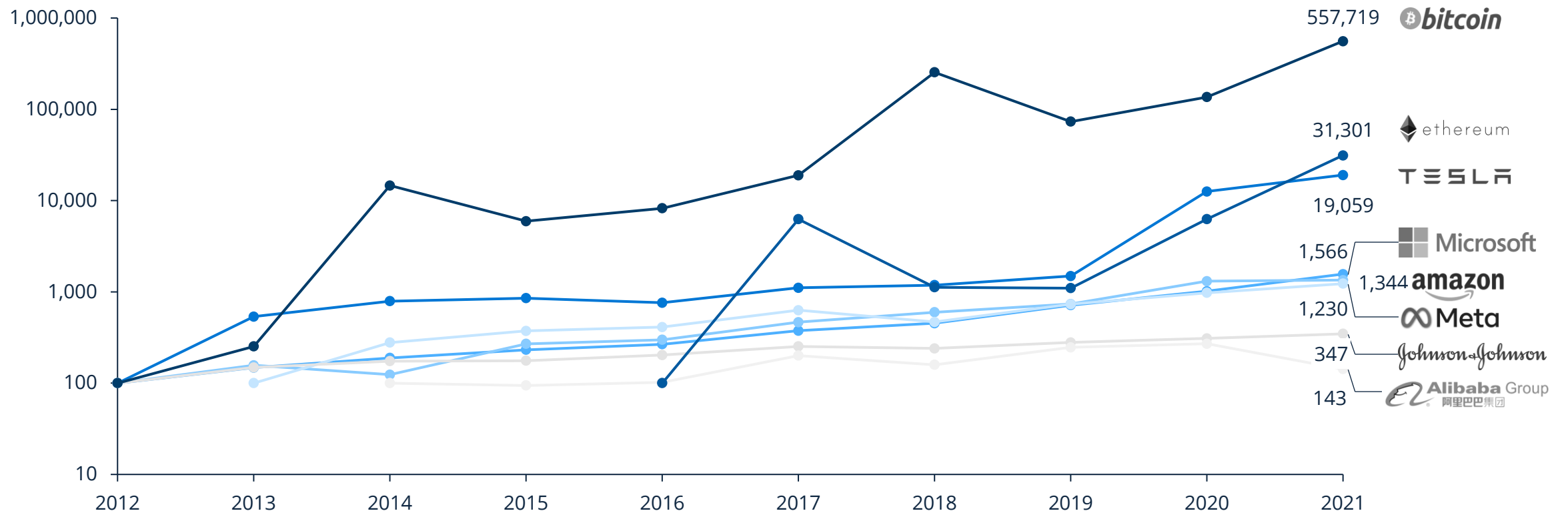
— UST   — LUNA[1]

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Despite significant advancements, cryptocurrencies remain highly controversial due to increasing cyberattacks within the past few years

The biggest crypto heists of all time in US$ million

Exchange/Platform (Year)	Amount
Ronin (2022)	625
PolyNetwork (2021)	610
Coincheck (2018)	532
MT.GOX (2014)	470
wormhole (2021)	326
KUCOIN (2020)	275
BitMart (2021)	200
BITGRAIL (2018)	170
BITFINEX (2016)	72
niceHASH (2017)	64
Zaif (2018)	62

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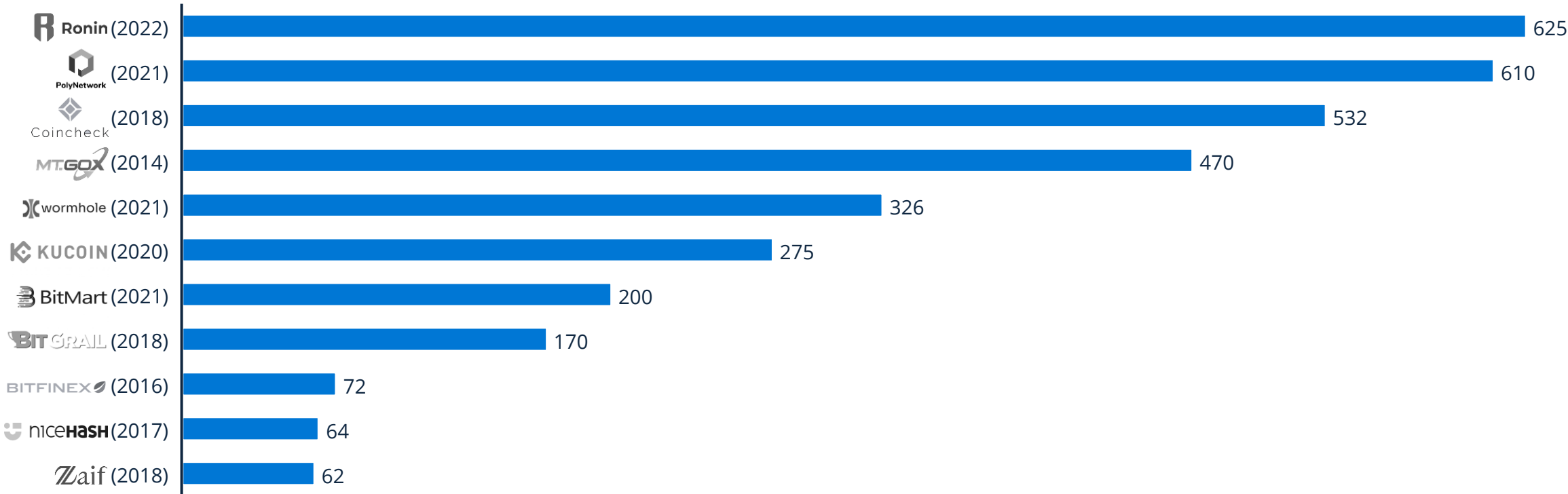
Although Bitcoin received its fair share of negative attention, early-stage investments would have yielded an extremely high return

US$100 of investment in shares of Bitcoin and Ether compared to mega corporations' stocks in 2012 and its respective yield in 2021 in US$[1]

Legend/end values:
- 557,719 — bitcoin
- 31,301 — ethereum
- 19,059 — TESLA
- 1,566 — Microsoft
- 1,344 — amazon
- 1,230 — Meta
- 347 — Johnson & Johnson
- 143 — Alibaba Group

X-axis: 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021

Y-axis (logarithmic): 10, 100, 1,000, 10,000, 100,000, 1,000,000

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While Bitcoin is often described as an alternative to gold, its historical price action suggests it is more closely related to stocks

52-week rolling correlation between Bitcoin (BTC) with S&P500, NASDAQ and Gold

Correlation coefficient [r][1]

— S&P500 - BTC — NASDAQ - BTC — Gold - BTC

28th April 2022
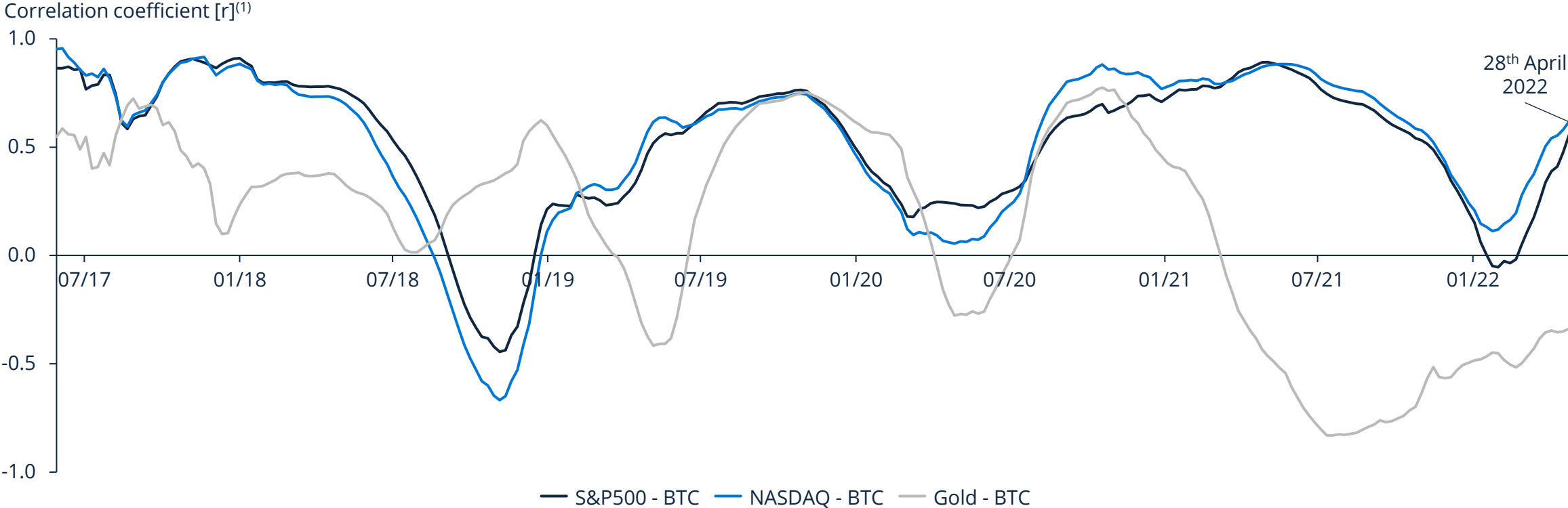
Notes: (1) 1.0 = very strong relation two each other; 0 = no relation to each other; -1.0 = strong negative relation to each other - Chart shows correlation in 52-week sliding window preceding the date; the correlation coefficient changes as market conditions change

Sources: Yahoo Finance

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So far, there is a high rate of consumer adoption for cryptocurrencies in the US as well as in emerging economies

Top ten countries by cryptocurrency users in 2021

Country		Users (millions)
India	🇮🇳	107.0
United States	🇺🇸	26.3
Russia	🇷🇺	11.4
Indonesia	🇮🇩	7.4
Nigeria	🇳🇬	6.6
Brazil	🇧🇷	6.5
Vietnam	🇻🇳	4.2
Japan	🇯🇵	4.0
Thailand	🇹🇭	4.0
Pakistan	🇵🇰	3.7

Cryptocurrency user penetration rate[1] in 2021
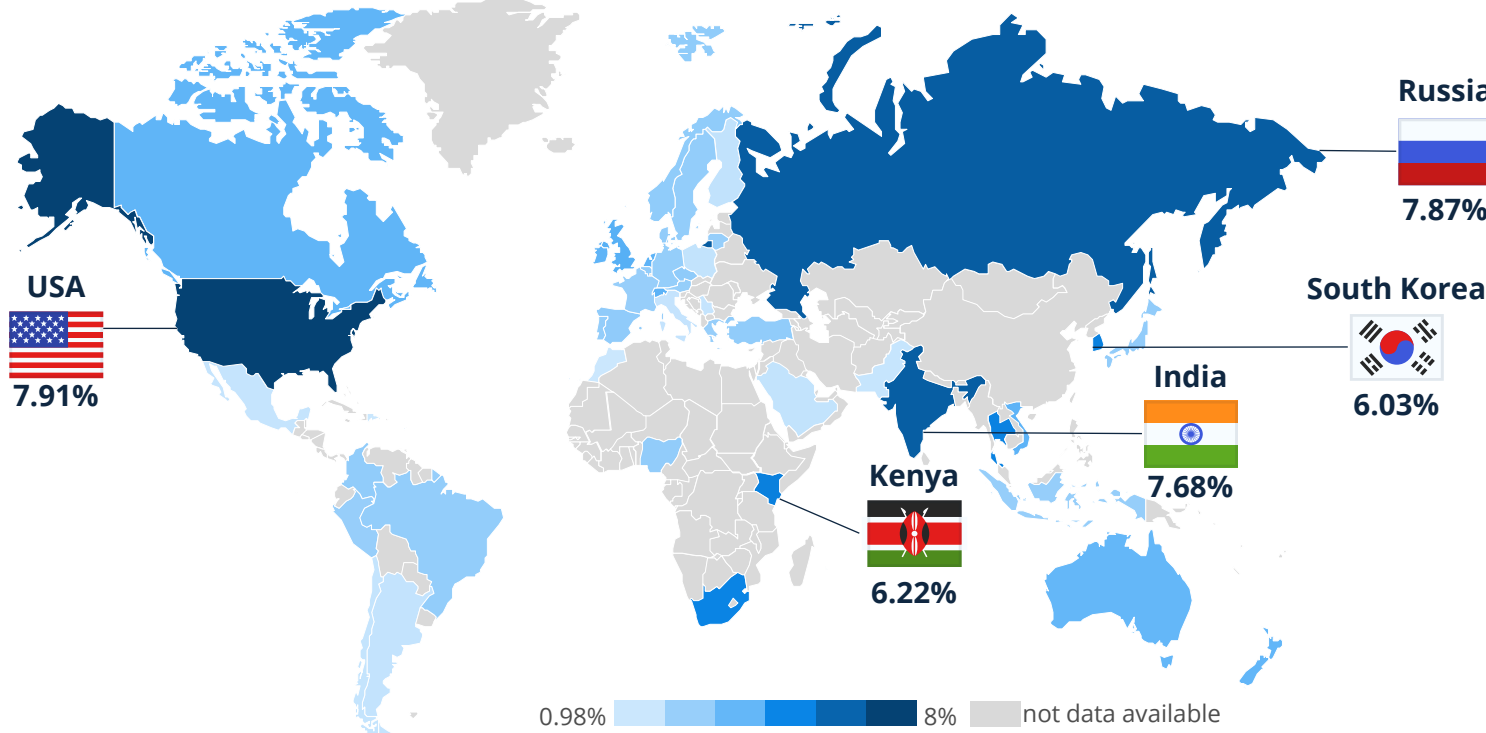
Russia **7.87%**

USA **7.91%**

South Korea **6.03%**

India **7.68%**

Kenya **6.22%**

0.98% ▬▬▬▬ 8%   not data available

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Based on the off-chain activities of the exchange locations, Asia-Pacific and Europe are heavily involved in the trading of cryptocurrencies

Share of transaction type based on the off-chain activities[1]

	Asia-Pacific	Europe	Latin America	North America	Middle East & Africa
External wallet[4]	6%	24%	28%	38%	47%
Internal account[3]	25%	24%	27%	17%	20%
Open market[2]	69%	52%	45%	45%	33%

■ Open market[2]   ■ Internal account[3]   ■ External wallet[4]

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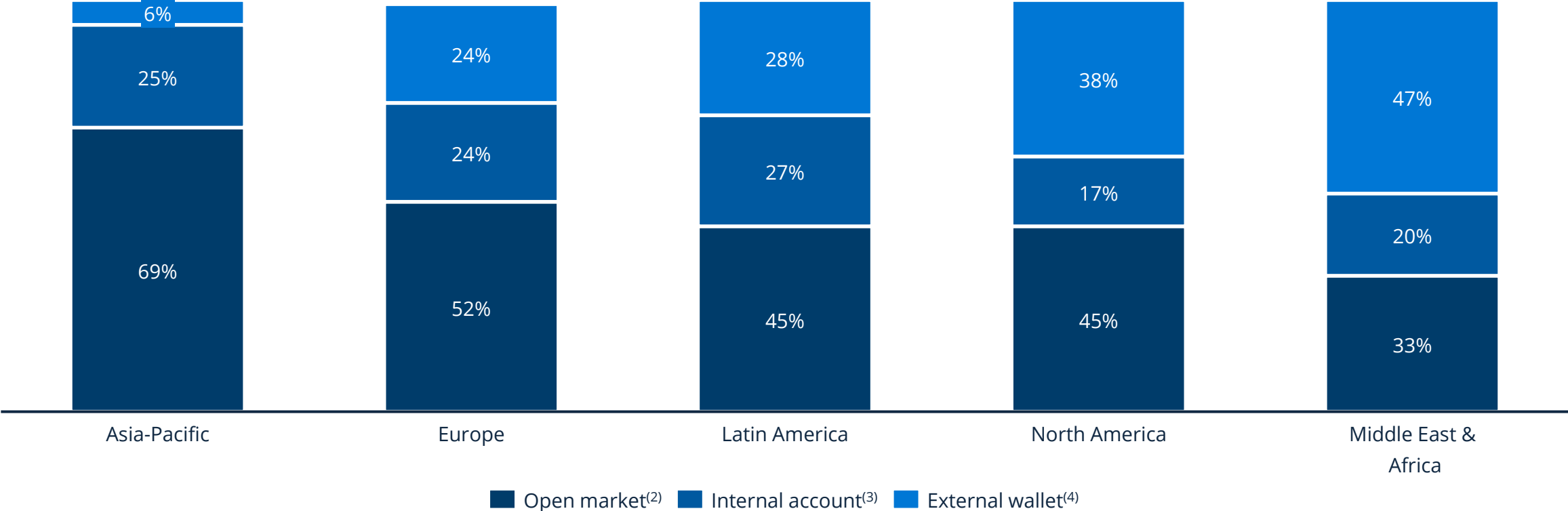
In rare cases, Bitcoin made its way to the national treasury of some countries because of new regulations, crackdowns on cybercrime and donations

Bitcoin equivalent in US$ million held by governments of different countries

Bulgaria	Ukraine	El Salvador	Finland	Georgia
8,847	1,920	394	82	3
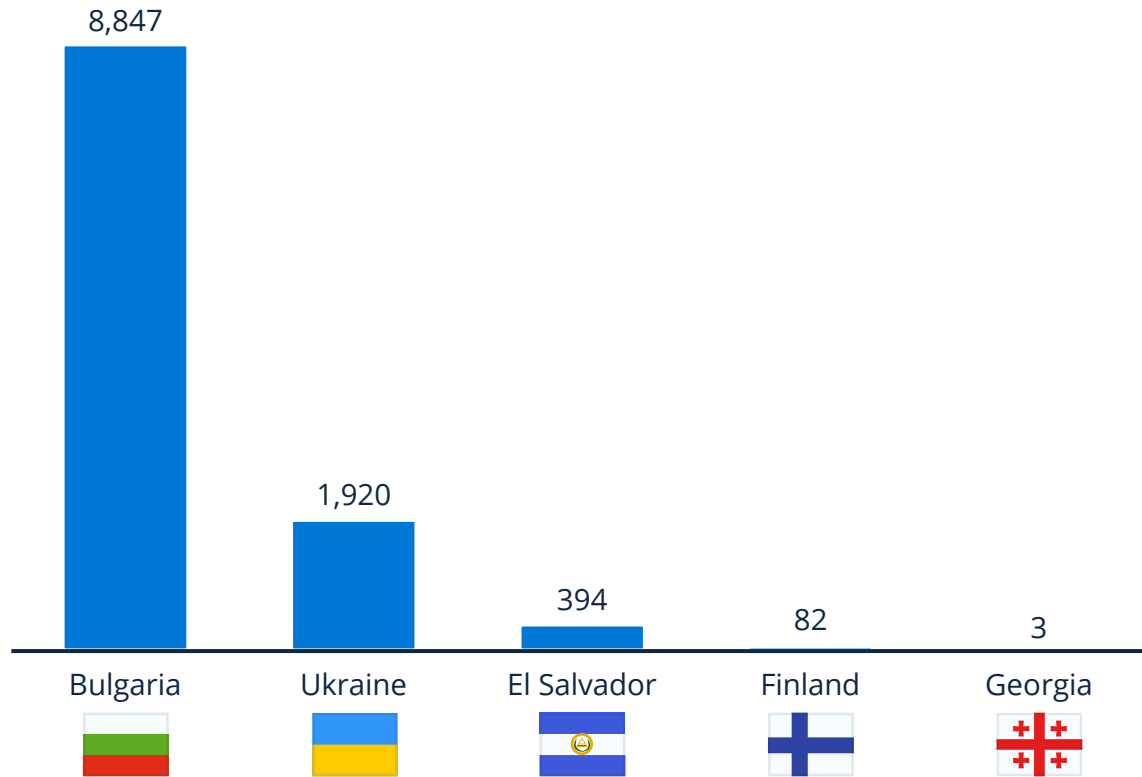
Bulgaria has more bitcoins than gold in its treasury. The country holds 213,519 Bitcoins, which is US$8.8 billion compared to its US$2.5 billion gold reserve. This staggering number of Bitcoins was confiscated by Bulgarian authorities as part of a law enforcement operation in 2017.

Ukraine's government is raising donations via cryptocurrencies and using them to aid purchases of critical supplies. As of April 05, 2022, Ukraine has raised more than US$60 million through digital coin donations, of which US$41 million has been spent on acquiring bulletproof vests, helmets, and medical supplies.

El Salvador officially made Bitcoin legal tender in September 2021 as an attempt to reduce costs in international remittances, lower the percentage of underbanked people, and minimize the reliance on the U.S. dollar. Bitcoin was declared as legal tender in Central African Republic & Panama in April 2022.

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In addition to adopting regular cryptocurrencies, some countries have taken the initiative to create their own central bank digital currencies (CBDCs)

How do CBDCs work?

Central bank digital currencies are digital tokens that are very similar to cryptocurrencies but are issued by a centralized authority (central banks and government institutions). They are pegged to the value of that country's fiat currency.

Sender   **Receiver**

2. Banks validate the transfer

1. Sender transfers fiat to digital currency

3. Receiver exchanges the digital currency to local fiat

Bank issues, validates & redeems
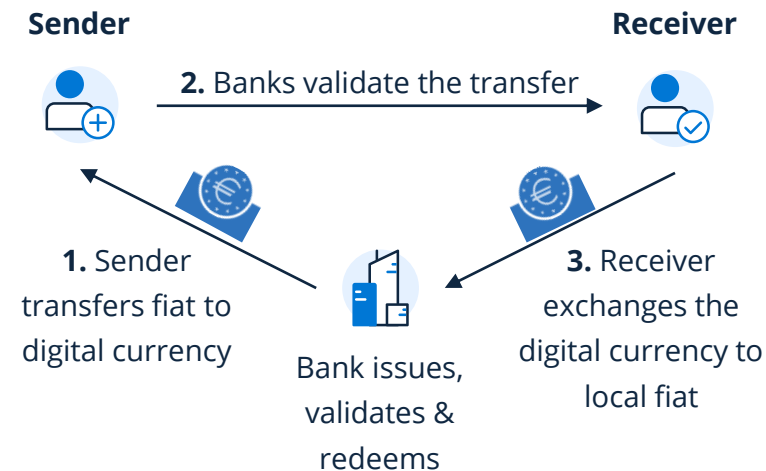
State of selected CBDCs[1]

EU

In July 2021, the European Central Bank (ECB) decided to develop a digital euro. A digital euro would not replace cash, but rather complement it and thus would give consumers an additional payment option.

China

The People's Bank of China is in the test phase of the digital yuan, also known as e-CYN. China has already distributed 200 million yuan (US$30.7 million) in digital currency as part of pilot projects across the country. A digital yuan app was also launched in 2022.

Sweden

The Swedish Central Bank, has undertaken a digital currency piloting project. It focuses on issuing e-krona as a digital currency by the Riksbank. Like bills and coins, e-krona would be guaranteed by the state.

Canada

The Canadian project Jasper started in 2017 and marks a milestone in the payments industry. It is the first time that a central bank cooperates with the private sector to realize a distributed ledger technology (DLT) experiment.

Bahamas

Project Sand Dollar was launched in October 2020 to support access to financial services in the Bahamas, whose archipelago of 700 islands makes cash distribution difficult.

South Korea

In May 2021, the Bank of Korea (BOK) stated its intent to select a technology supplier through an open bidding process to research the practicalities of a CBDC. The first pilot phase has been successfully completed and the second phase will continue until June 2022.

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Mainstream companies across multiple industries took interest and have a positive stance on cryptocurrencies

What can organizations do with cryptocurrencies?

Gartner predicts that by 2024, at least 20% of large enterprises will use digital currencies for payment, stored value or collateral.[1]

Value
- Management reporting
- Treasury and accounting
- Security wallet and custody services

Payments
- Stablecoins and other cryptocurrencies for payments
- Cooperation with payment processors offering cryptocurrencies such as Square, PayPal, BitPay, and Coinbase

Leverage
- Cryptocurrency and stablecoin holdings as collateral for income generation (e.g., lending, liquidity provision)
- Cooperation with companies that bridge centralized and decentralized finance

Selected companies having a positive stance on cryptocurrencies[2]

TESLA · SAMSUNG · shopify · Meituan · prosus
TOYOTA · 中国建设银行 China Construction Bank · Walmart · VISA · MasterCard
tsmc · JPMorganChase · Qualcomm · AT&T · WELLS FARGO
NVIDIA · BANK OF AMERICA · PayPal · RBC · STARBUCKS COFFEE
BLACKROCK · CISCO · Coca-Cola · COMCAST
TATA CONSULTANCY SERVICES · intel · Reliance Industries Limited · Morgan Stanley · amazon
citigroup · 招商银行 CHINA MERCHANTS BANK

Positive stance:
- Accepting crypto as payment method
- Offering cryptocurrency-related products or services
- Hiring for crypto products or services
- Having cryptocurrencies in treasury

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In 2021 investments into the cryptocurrency and blockchain sector skyrocketed to over US$25 billion

Venture and private investment into crypto and blockchain sub verticals in US$ billion

+710%

Year	Value
2015	0.6
2016	0.9
2017	1.1
2018	5.8
2019	3.0
2020	3.1
2021	25.1

Notes: Includes some Data Management, SaaS and Business Intelligence Platforms

Sources: The Block Research, Pitchbook, Crunchbase

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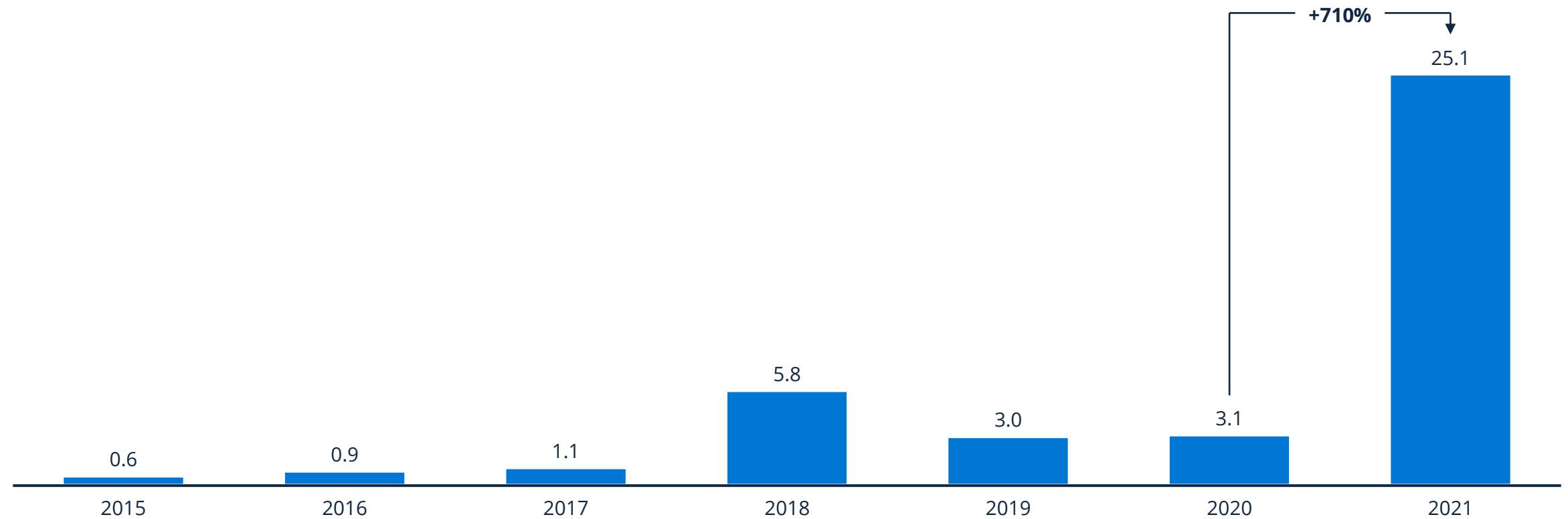
Some companies take an active approach by buying or accepting direct crypto payments, predominantly with Bitcoin

Public companies with highest number of Bitcoins on their balance sheet

129,218

Amounts to US$ 5,348,087,506[1]

43,200

8,133   8,027   5,243   5,242   4,487   4,464   4,032   4,000   3,673   2,317   1,717   1,170   941

MicroStrategy   TESLA   Marathon Digital   BLOCK   Bitfarms   HUT 8   coinbase   RIOT   HIVE   GALAXY DIGITAL   BITCOIN GROUP SE   argo blockchain   NEXON   Seetee   meitu 美图
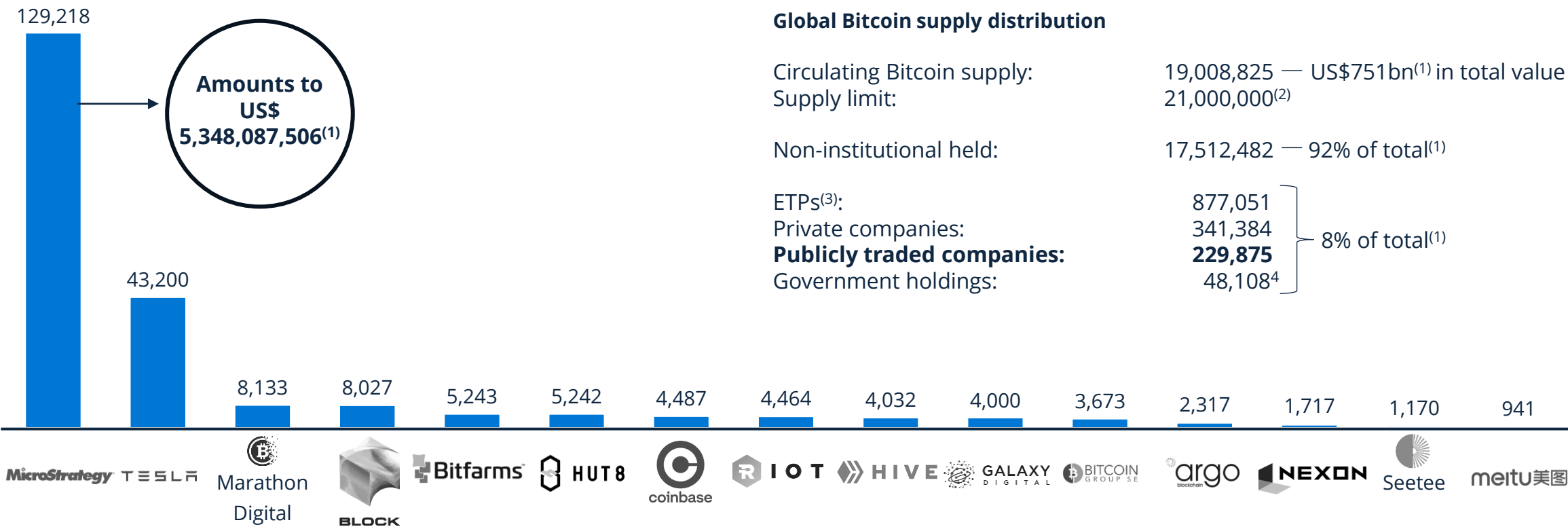
Global Bitcoin supply distribution

Circulating Bitcoin supply:	19,008,825 — US$751bn[1] in total value	
Supply limit:	21,000,000[2]	
Non-institutional held:	17,512,482 — 92% of total[1]	
ETPs[3]:	877,051	
Private companies:	341,384	8% of total[1]
Publicly traded companies:	**229,875**	
Government holdings:	48,108[4]	

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After prices hit an all-time high for Bitcoin and institutions invested heavily in crypto at the end of 2021, prices and inflows have leveled off

Average weekly Bitcoin price compared to net crypto asset institutional inflow and outflow

Average Bitcoin price per week in US$

Net crypto asset inflows/outflows per week in US$ million

Sources: Coingeko, CoinShares, ETCGroup

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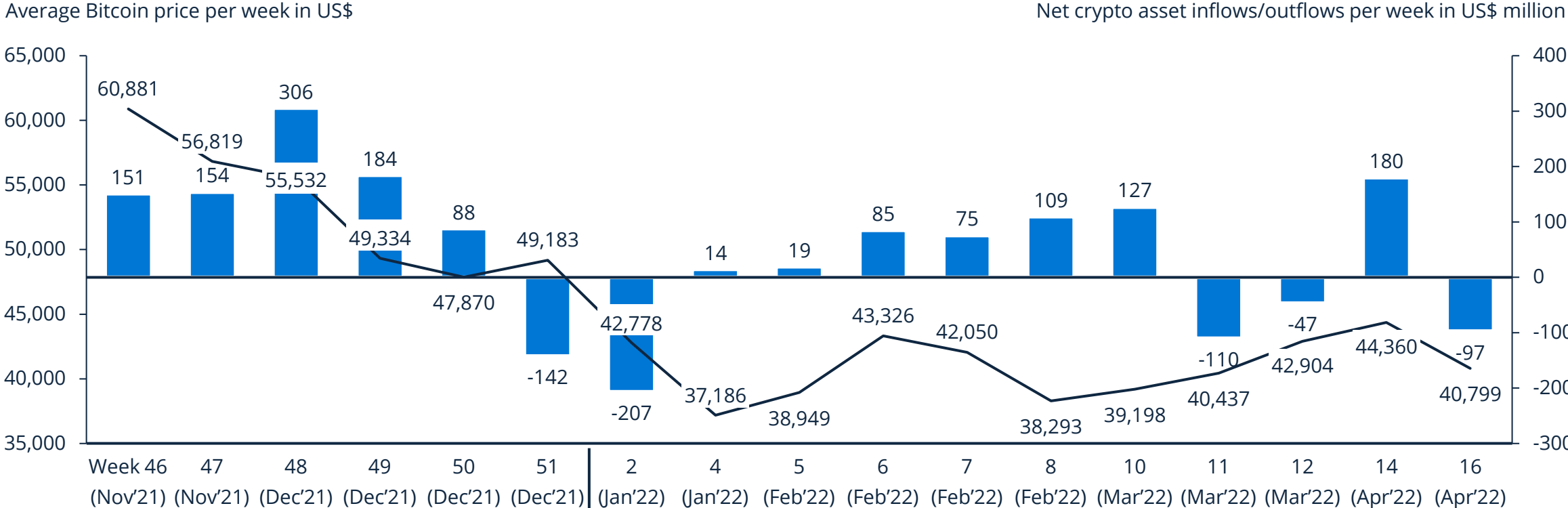
Many startups and companies are entering the crypto sector to make money with all kinds of new solutions, resulting in the creation of a diverse ecosystem

Selected key players per segment in the crypto space

Exchanges

CeFi
Bitstamp, coinbase
eToro
FTX, BINANCE
kraken
GEMINI
Blockchain.com

DeFi
BiFi, OnX
Balancer
UNISWAP
SERUM
AKROPOLIS

Institutional Trading
coinbase
Maple
matrixport
Blockchain.com
Genesis
SFOX

Asset Management
PANTERA
Badger
GRAYSCALE
dHEDGE
CoinShares

Tokenization
trusttoken
Centrifuge
SECURITIZE
tZERO
HARBOR

Infrastructure
Chainlink
Figment
NYDIG
Alpaca
coinbase
bloq

Crypto Banking
crypto.com, coinbase
BlockFi
nexo
YOUHODLER
CIRCLE

Retail Wallets (Execution)
crypto.com, PayPal
Robinhood
Cash App
METAMASK
nexo, coinbase

Miners
HUT8, Cipher MINING
HIVE
Bitfarms
RIOT
Canaan
CLEANSPARK

NFT Solutions
OpenSea
Dapper
Decentraland
iMMUTABLE
Rarible

Tax Solutions
blockpit
TokenTax

Crypto ATMs
COINFLIP
coinme

Data
Chainalysis
CoinGecko
amberdata
Dune Analytics
CIPHERTRACE

Borrowing/Lending

CeFi
Blockchain.com
Ledn
CoinLoan
unchained capital
nexo

DeFi
Liquity
IMPERMAX
DeFiner
Kava
Compound

Payments
bitpay, coingate, coinbase
ripple, fuse, Coinify
PAXFUL, simplex
Stellar, veem, CIRCLE

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Crypto exchanges such as Binance that enable users to buy, sell, or trade cryptocurrencies are one of the most prominent examples in the sector

Largest cryptocurrency exchanges based on 24-hour volume in US$ billion in 2022

Exchange	Value
BINANCE	24.1
mandala	7.0
UPbit	6.8
OKX	6.6
CoinFLEX	6.0
HitBTC	5.6
coinbase	5.3
Deepcoin	4.8
TOKENCAN	4.0
FMFW.io	3.8
KUCOIN	3.4
crypto.com	3.4
DIGIFINEX	2.9
INDOEX	2.8
changelly	2.8
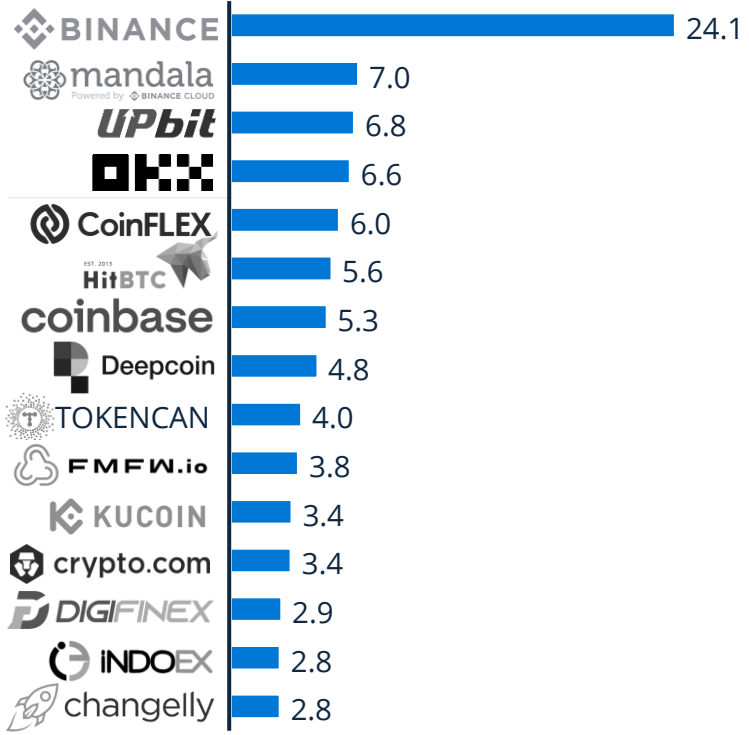
Selected cryptocurrency exchanges and company figures

	BINANCE	coinbase	crypto.com
Founded	2017	2012	2016
Employees	4000+	3700+	3000+
Cryptocurrencies offered	500+	40+	200+
Users	29m	89m	10m
Revenue (2021)	~US$14.6bn	US$7.8bn	~US$1bn

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With a seven-fold increase from 2020, crypto exchanges earned US$24bn from trading fee revenues in 2021 and overtook earnings from traditional exchanges

Global crypto spot exchanges share of annual trading volume[1]

Other
9%
3%
5%
Bitstamp
Liquid
kraken
49%
4%
8%
coinbase
BINANCE
22%
LBANK

**Q3 2020 Total Trading Volume
US$1.6tn**

Other
bitFlyer
Bitstamp
gate.io
LBANK
4% 1%
2% 2%
3%
4%
FTX
4%
kraken
11%
coinbase
69%
BINANCE

**Q3 2021 Total Trading Volume
US$13.3tn**
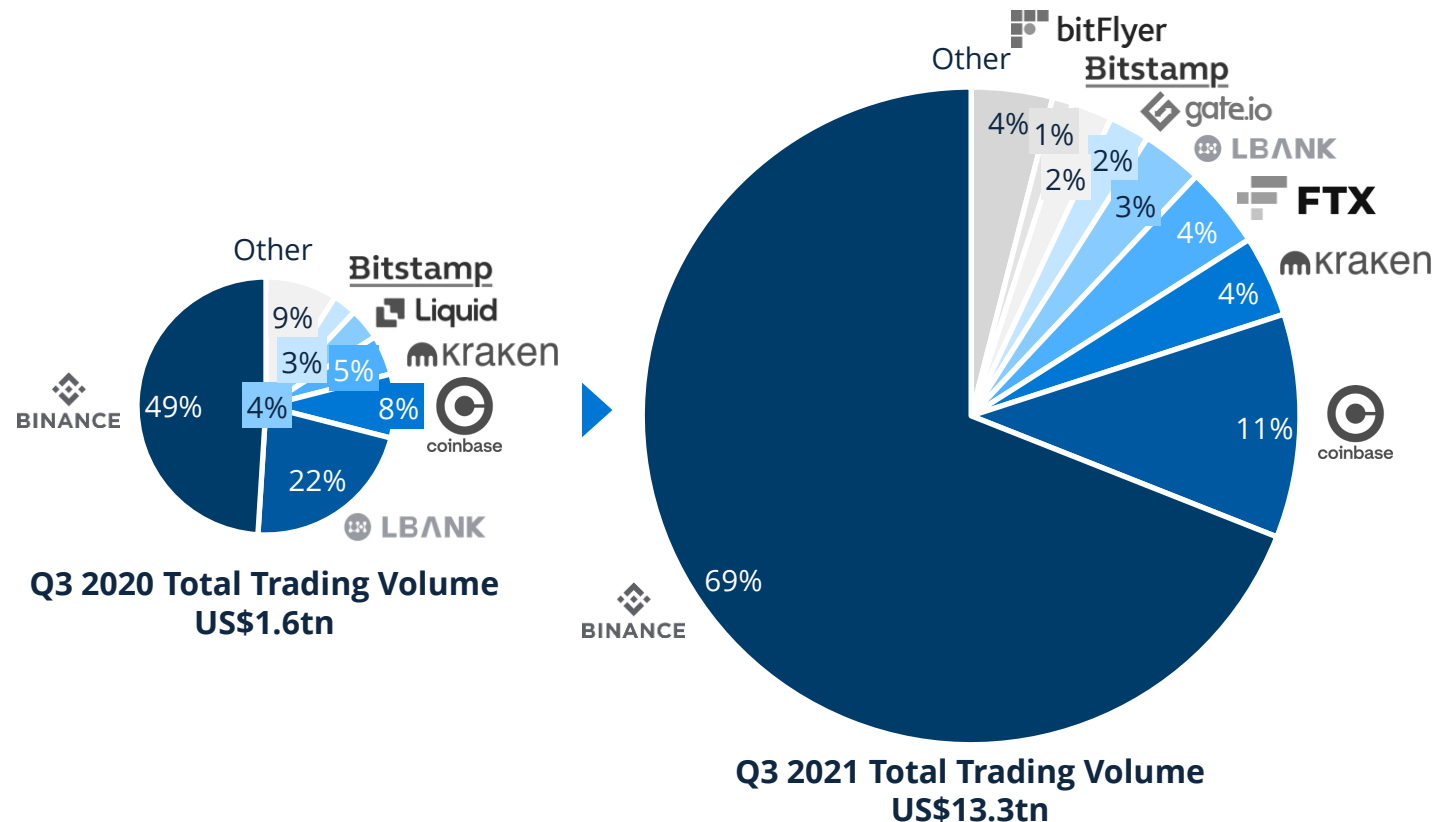
Global revenues from trading fees[2] in US$ billion

7x

24

14

13

3

1

15

2019   2020   2021

■ Crypto Exchanges   ■ Traditional Exchanges

Notes: (1) Bubble size only indicative (2) Also included are clearing fees

Sources: Nomics, Opimas

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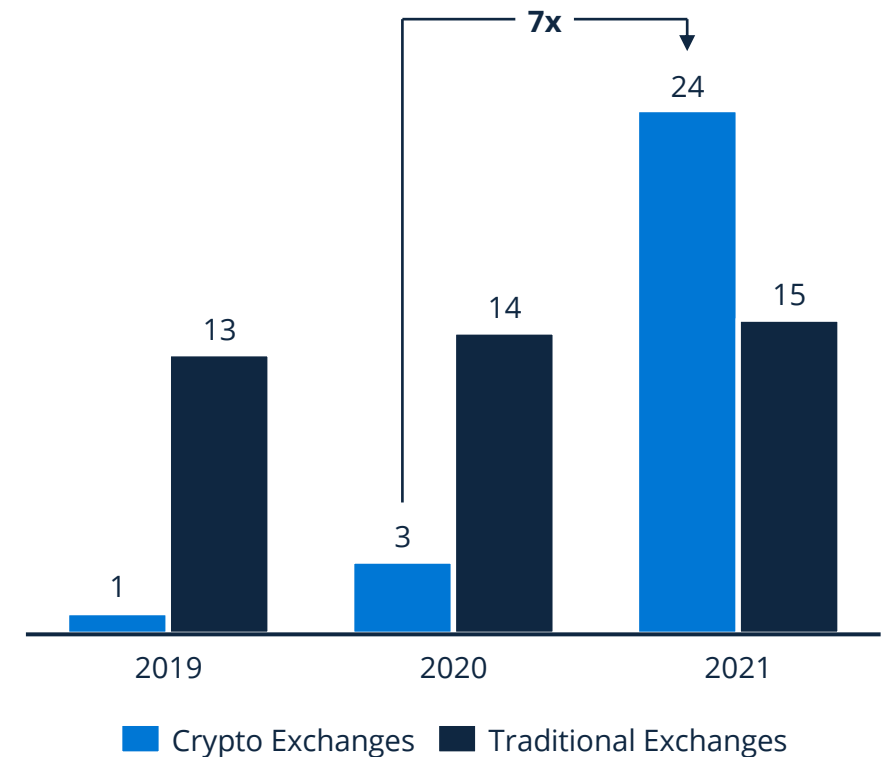
Coinbase, with its hyped IPO in 2021, achieved strong revenue growth over time but plunging share prices in 2022 raise question marks for the future

coinbase

Revenue per segment in US$ million

+283%

	2019	2020	2021
	534	1,277	7,838
Transaction	463	1,096	6,837
Other	51	45	484
Subscription and services	20	136	517

- Transaction
- Other
- Subscription and services
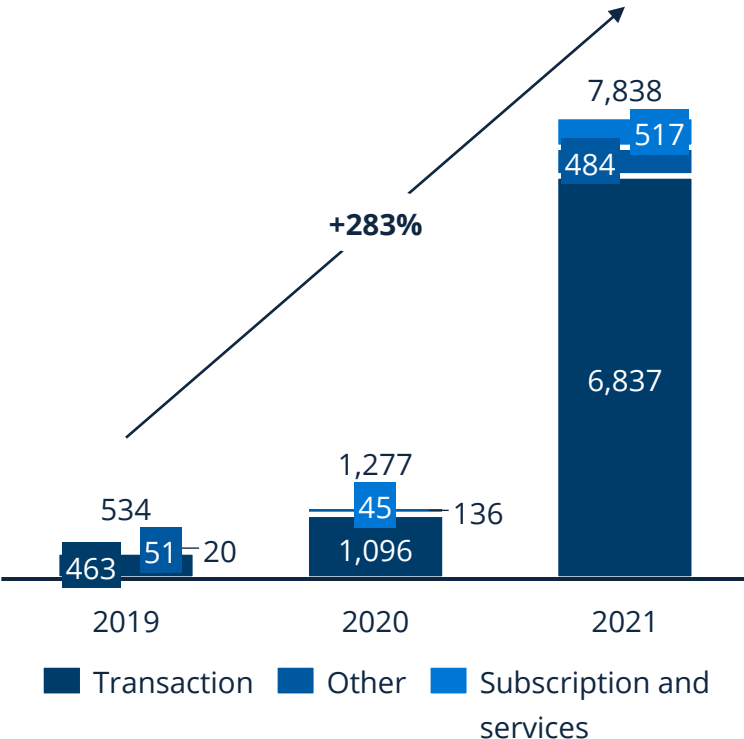
Total verified users vs. monthly transacting users (MTU) in million

	2019	2020	2021
Verified Users	32	43	89
MTU	1	3	11

- Verified Users
- MTU
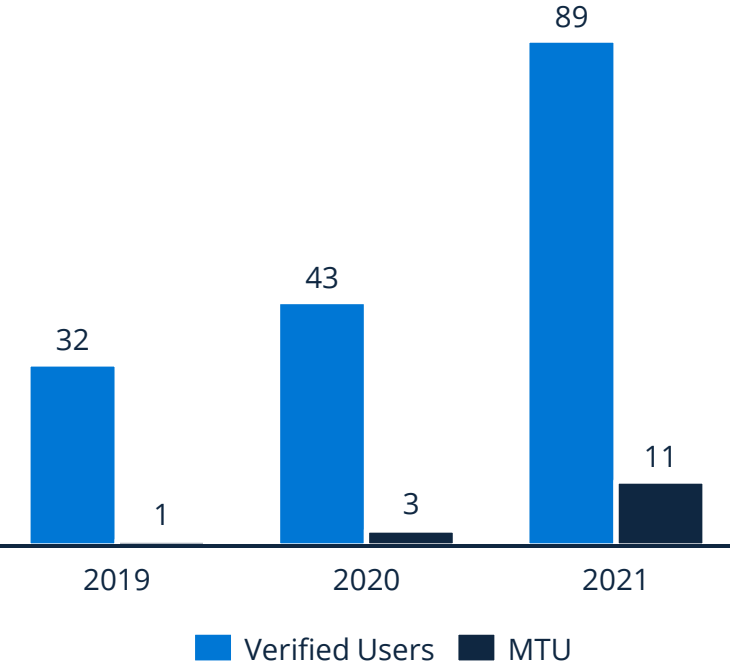
Market Cap development in US$ billion from IPO to April 2022

-57%

89.8 ATH[1]

16. Apr	14. May	30. Jun	13. Aug	10. Sep	16. Oct	13. Nov	18. Dec	15. Jan	12. Feb	14. Mar	16. Apr
63.6	48.1	52.9	68.4	65.0	73.5	89.8	63.7	60.2	51.0	41.9	38.6

2021 · 2022

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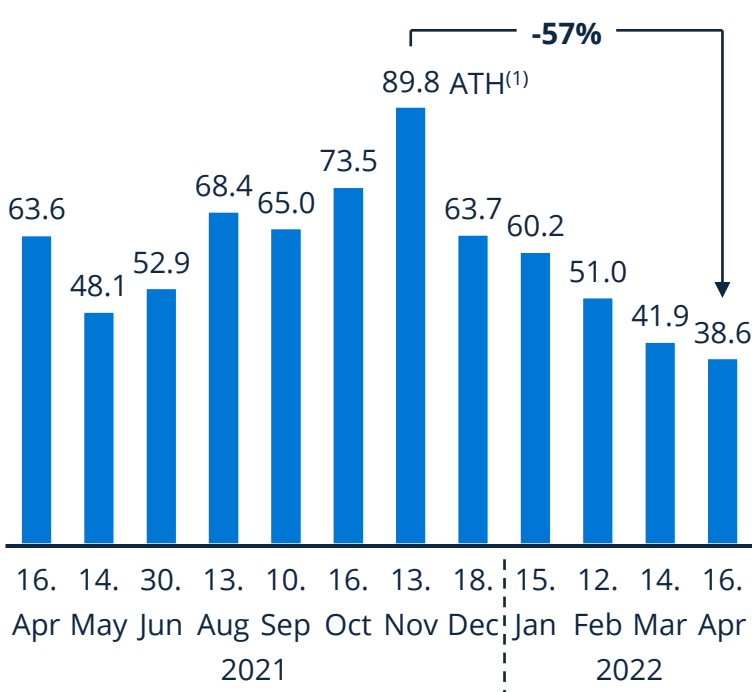
Another revenue stream lies within cryptocurrency mining, which has increased over the years and yielded a US$71 million payout on a single day in 2021

How does crypto mining work?

Cryptocurrency mining is the method of verifying transactions on a digital ledger for a blockchain using machines with extensive computing power. Cryptocurrency mining can be done by any individual or organization with adequate hardware and software resources. Mining is essential to keep the Bitcoin network running. Transactions in the network are verified by miners; as a reward they get newly minted units. Miners compete against each other to solve mathematical tasks.

Someone initiates a **transaction**.

1 ▶ The transaction request is bundled into a **block** with other transactions.

2 ▶ The block is broadcasted to all **mining nodes** in the network.

The network of nodes **validates** the transaction using algorithms.

3 ▶ The first miner to validate a new block for the blockchain receives a part of the Bitcoin as **reward**.

4 ▶ The block is added to the blockchain and is then **permanent** and cannot be modified.

Total value of block rewards and transaction fees paid to miners every day in US$ million

Total mining revenues in US$ billion

	2020	2021
Bitcoin	7.3	15.3
Ethereum	2.4	16.5

Chart values along the line: 50, 26, 71, 68, 20

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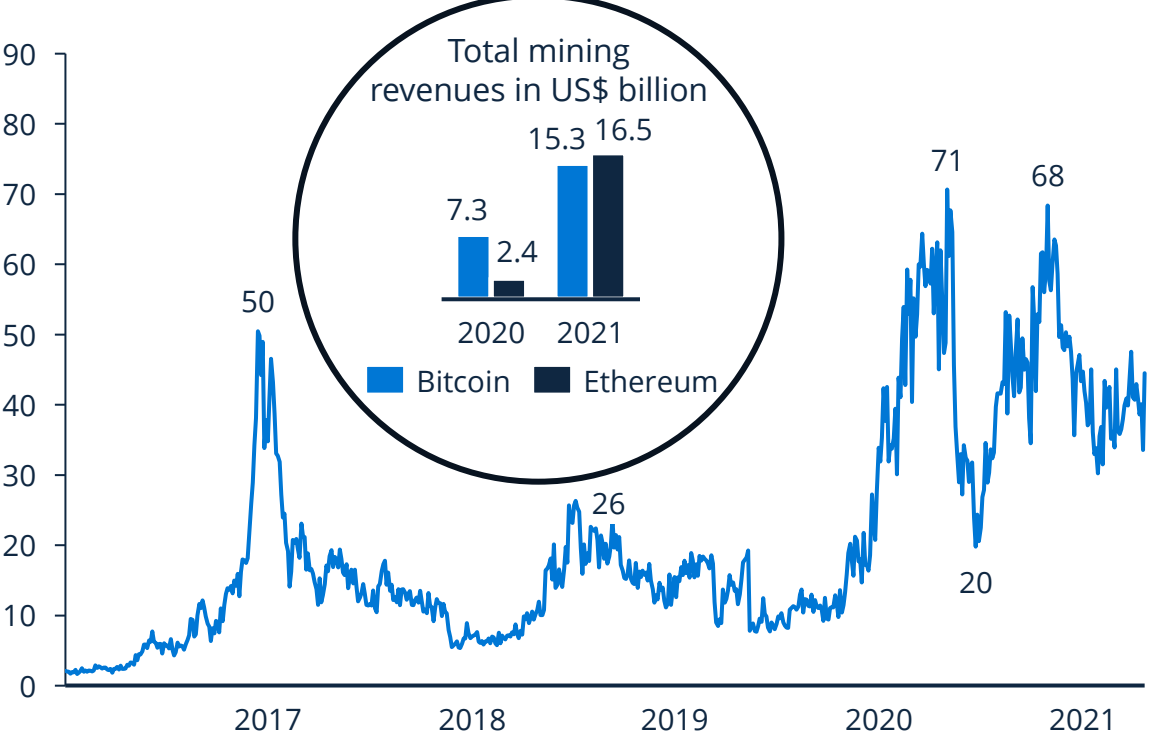
After the crackdown on cryptocurrency was announced in May 2021, China lost its position as the dominating force in Bitcoin mining

Global distribution of bitcoin mining hashrate[1]
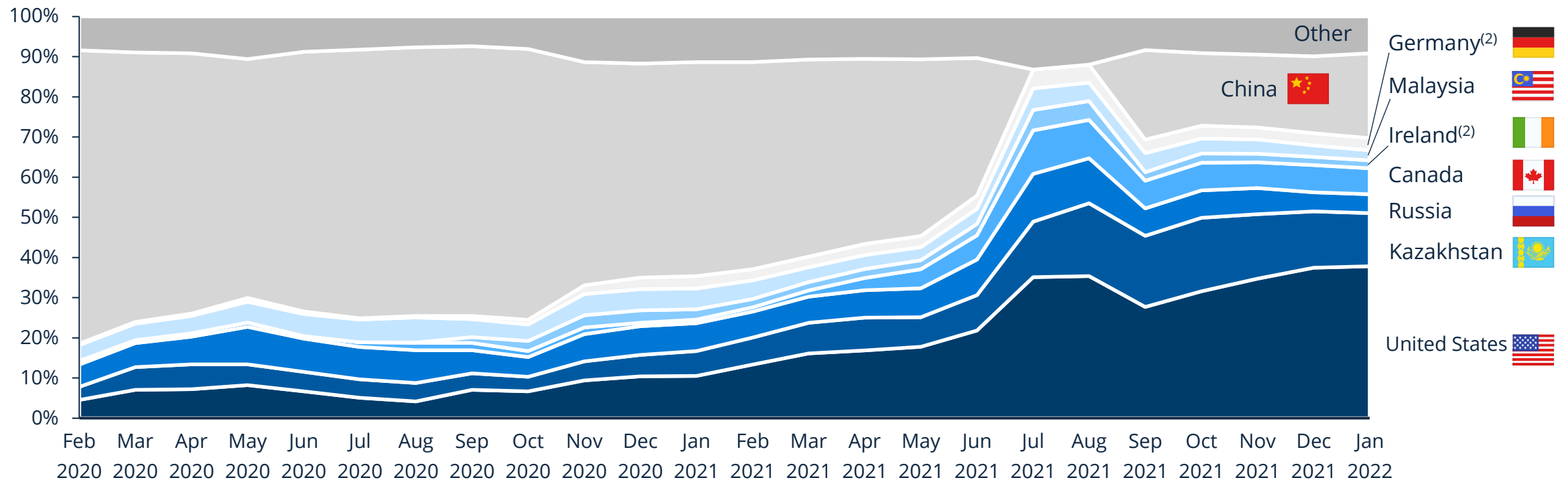
Notes: (1) The hash rate measures the total computing power in PoW networks like Bitcoin (2) Ireland and Germany are unlikely to have any major mining operations, figures may be inflated due to VPN and proxy use

Sources: Cambridge Centre for Alternative Finance, BTC.com, Poolin, ViaBTC

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Because mining with PoW[1] consensus is very energy intensive, the energy consumption of cryptocurrencies is at the level of individual countries

Energy consumption by country including Bitcoin and Ether in TWh per year

Brazil	France	UK	Bitcoin +Ether	Italy	Saudi Arabia	Mexico
530	460	331	312	304	290	259
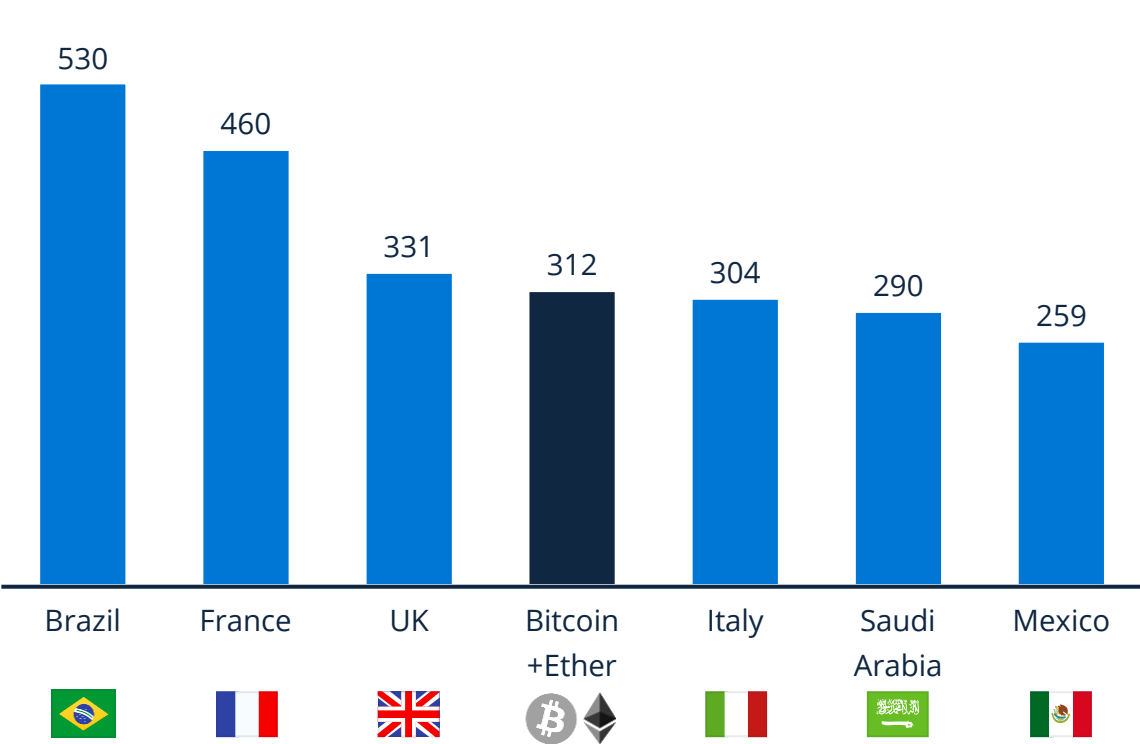
Energy consumption by cryptocurrency including NFT in kWh per transaction
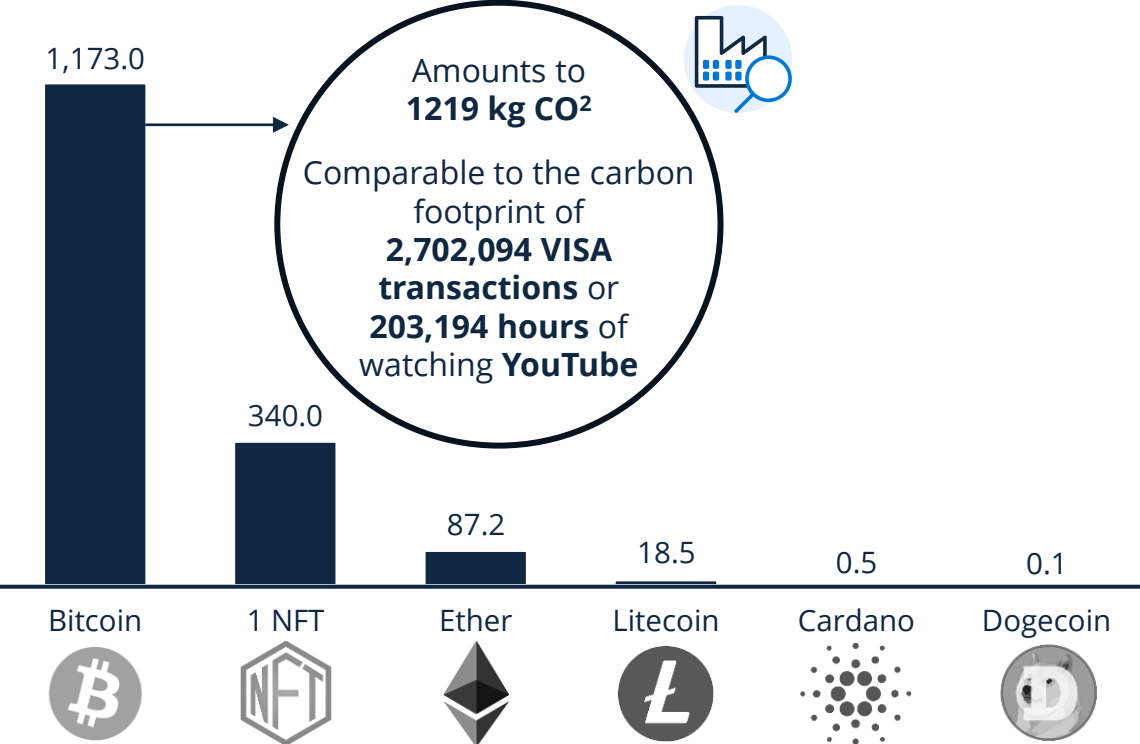
Bitcoin	1 NFT	Ether	Litecoin	Cardano	Dogecoin
1,173.0	340.0	87.2	18.5	0.5	0.1

Amounts to **1219 kg CO_2**

Comparable to the carbon footprint of **2,702,094 VISA transactions** or **203,194 hours** of watching **YouTube**

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The recent PoS[1] consensus addresses key challenges of PoW[2]: energy consumption and cybersecurity concerns

What is the difference between crypto mining and staking?

Crypto Mining (PoW[1])
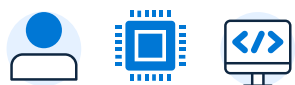
Mining capacity is dependent on computational power.

The first miner receives a block reward for solving the cryptographic puzzle.

In order to override the network, hackers require more than 51% of the network's computational power.

Crypto Staking (PoS[2])

Validation capacity is dependent on the stake in the network.

There is no block reward here; the validator earns transaction fees.

In order to override the network, hackers need to own more than 51% of the native tokens.

How does crypto staking (PoS[2]) work?

Owners **lock** their native tokens in **staking pools**.

Algorithm pseudo-randomly elects a **validator node**.

The **validator node proposes** a block of transaction.

Validator **earns transaction fees** in native tokens.

The block is **added** to the blockchain and becomes **immutable**.

Other **validators verify** and **approve** transactions.

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How blockchain technology is reimagining the world of internet, money, and finance

Since the inception of blockchain technology in 2008, tremendous advancements have led to the implementation of several novel ideas and features such as smart contracts. The introduction of smart contracts has unlocked a plethora of possibilities and given rise to an entire crypto ecosystem. One such use case of this technology is decentralized finance, which is disrupting the financial payment, lending, and investment industry by offering similar services without the need for intermediaries. Non-fungible tokens are reshaping the way retail and art is being sold with NFT marketplaces improving accessibility and reach among consumers. Web 3.0 intends to shift power from big technology corporations into the hands of users by offering novel services built on core concepts of decentralization, openness, and better internet user utility.
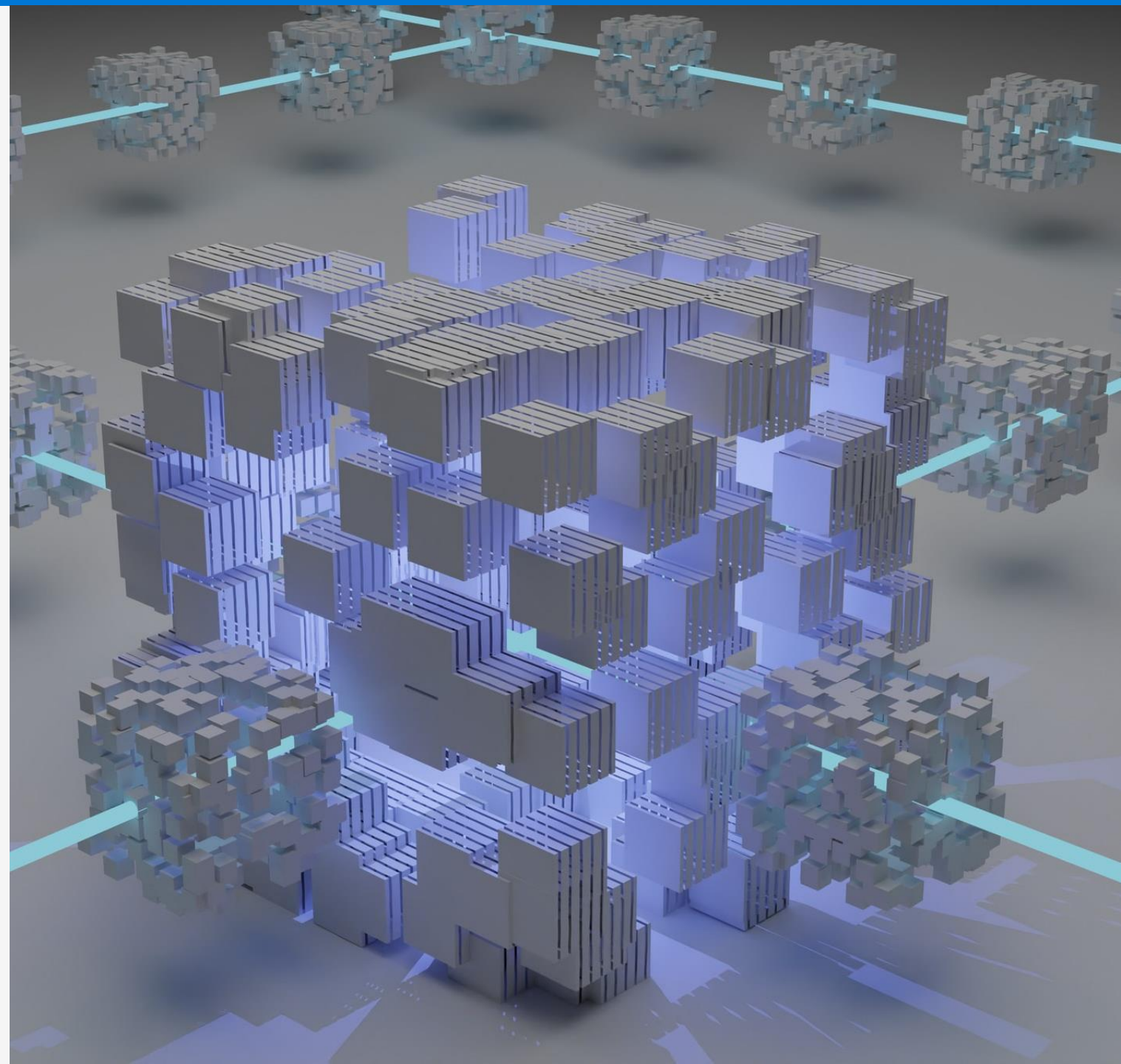
Newer iterations of blockchain technology boast improved functionality and promote a more decentralized financial system

Blockchain 1.0

The first iteration of blockchain was conceived to solve technical issues associated with trustless payment systems, i.e., those without the need for intermediaries. It was first introduced for Bitcoin but has since been adapted for a wide variety of use cases. Still, it remains largely connected to cryptocurrencies. First-generation blockchains only have a rudimentary set of features and rely on distributed ledger technology. Transactions are bundled in blocks, which are then immutably chained together.

Examples: Bitcoin, Litecoin

Blockchain 2.0

The range of features of the first generation of blockchains was rather limited, eventually leading to the development of blockchain technology that could do more than just process payments. One major innovation defining the second generation of blockchains is the smart contract. They are self-managed contracts that are triggered by an event, such as the receipt of a payment or achievement of a price goal and operate independently of external entities and third parties.

Examples: Ethereum, NEO
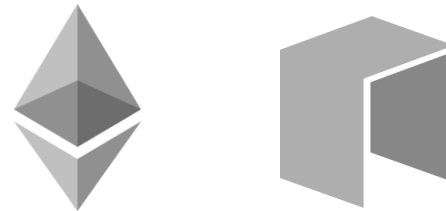
Blockchain 3.0

Blockchain technology suffers from a fundamental drawback: it is not very scalable. If the network handles a lot of transactions, it slows down significantly, and transaction fees can become prohibitively high, therefore reducing the practicability of large-scale networks. Many new blockchain projects are attempting to solve this scalability issue, but with varying success. The third generation of blockchain therefore remains largely theoretical.

Examples: Cardano, Solana

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Various forms of blockchains exist for different use cases, but for all of them, decentralization is a focal point

Different blockchain types and their use cases

Private Blockchain

Private blockchains are permissioned blockchains controlled by a central authority that can decide which ones can function as nodes and which permissions each node has. Not all nodes need to have the same privileges: some are only allowed to validate transactions but are not permitted to initiate them or access the information stored on the blockchain.

Use cases: B2B transactions, internal voting, asset ownership, supply chain management

Examples: Ripple, Hyperledger, Corda

Consortium Blockchain

Consortium blockchains are semi-decentralized, permissioned blockchains controlled by a group of organizations, such as trade groups. Distributing authority among several organizations allows for broader oversight of the information on the blockchain and increases the robustness and security of the network.

Use cases: Banking, supply chain management, digital identity

Example: R3 CargoSmart

Hybrid Blockchain

Hybrid blockchains are controlled by a single organization. In a hybrid system, there are public as well as private features that allow the organization or participating nodes to keep certain information either public or private, depending on the requirements of the transaction or application.

Use cases: Medical records, medical research, real estate, supply chain management

Example: IBM Food Trust

Public Blockchain

Public blockchains are permissionless, thus allowing anyone to join the network and create, access, and validate blocks of data. As a result, this type of blockchain is entirely decentralized.

Use cases: Digital transactions (i.e., cryptocurrencies), smart contracts, document validation

Examples: Bitcoin, Litecoin, Ethereum

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The most far-reaching forms of new coordination are coming from public blockchain infrastructures with revolutionary concepts such as Web 3.0

Overview of public blockchain opportunities

Public Blockchain Infrastructure
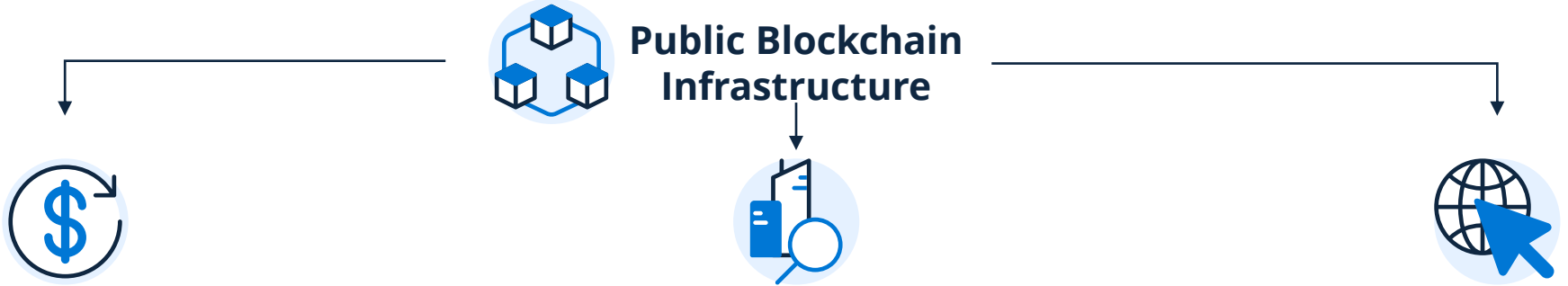
Money Revolution

Ever since the 2008 financial crisis, blockchain has triggered a gradual shift in the monetary landscape where value transfer from centralized authorities (central banks/governments) is slowly moving to a more decentralized and autonomous system.

Cryptocurrency

Fiat Currencies → Decentral Global Currencies

Financial Revolution

Blockchain technology companies powered by smart contracts are disrupting the way traditional financial institutions operate by offering similar services that surpass these centralized institutions and do not require intermediaries.

DeFi[1]

Centralized Services → Decentralized Services

Internet Revolution

Blockchain technology is also rewriting the fundamentals on how major technology companies and media conglomerates have been operating by providing novel services built on core concepts of decentralization, openness, and greater user utility.

Web 3.0

Big tech platforms → Interoperable web

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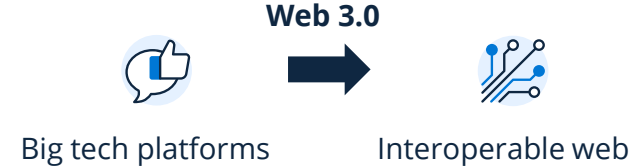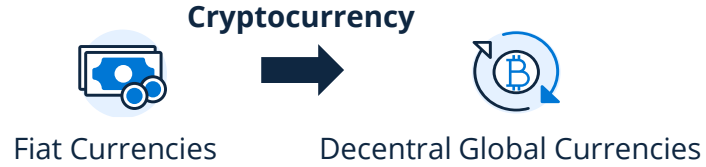
It is anticipated that Web 3.0 will open massive opportunities by shifting its focus from consumer to financial markets

The developmental stages of the Internet

Web 3.0
Blockchain & AI

Web 2.0
Mobile, Social, Cloud

Web 1.0
Desktop

Hardware Economy

1970 1980 1990 2000 2010 2020 2030 2040
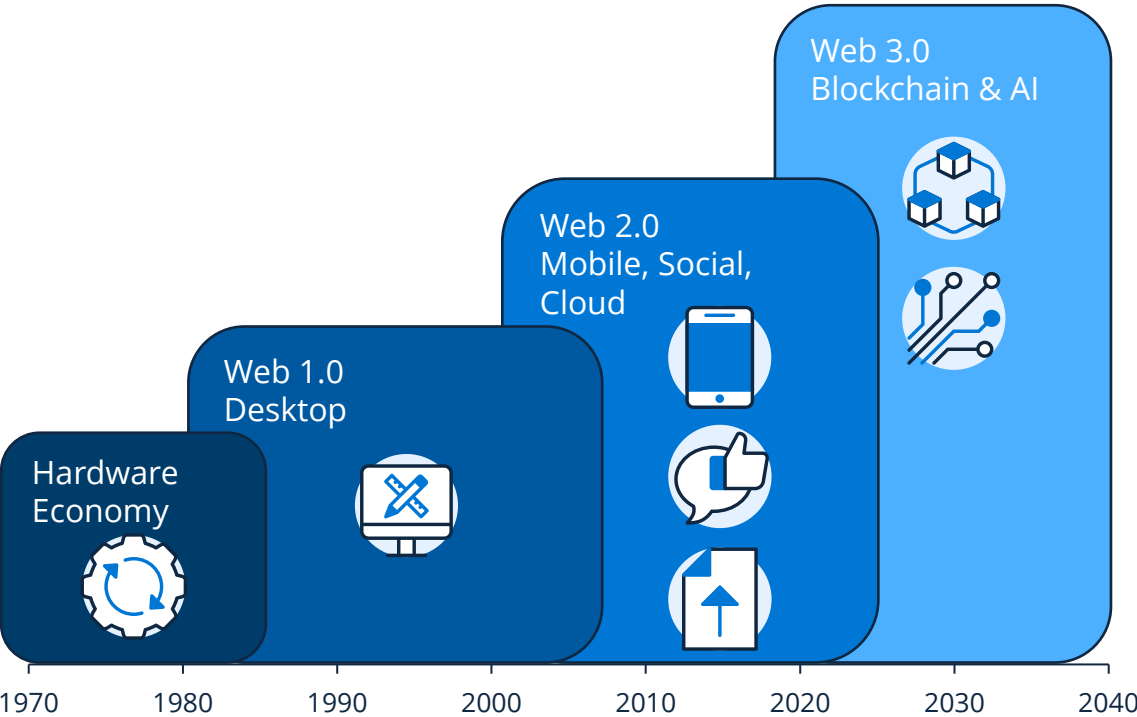
Web 2.0 vs. Web 3.0 revenue opportunities

US$3.8tn
Consumer Sales

US$347bn
Gig Economy

US$22.5tn
Financial Products

US$2.5tn
Banking/Access

US$2.5tn
Contracts/Trade Payment

Web 2.0
1990s-2010s
US$5tn

NETFLIX
US$420bn
Video/Music/Games

Web 3.0
(+Financialization)
2020s-2030s+
US$27T

US$181bn
Social Networks

US$258bn
Asset Management

US$183bn
Search

US$50.5bn
Regtech/Identity

statista
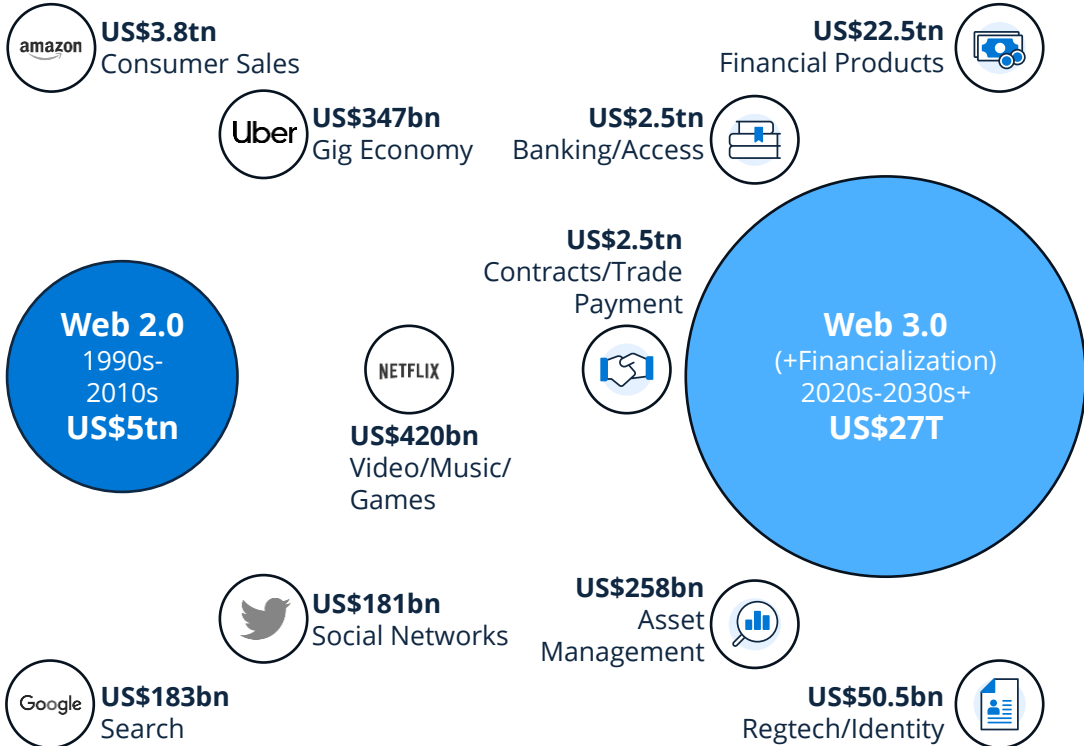
The term DeFi[1] encompasses initial applications for financial services in the Web 3.0 universe that provide permissionless and transparent solutions

Differences between Centralized Finance (CeFi) and Decentralized Finance (DeFi)

CeFi[2]	DeFi[1]
Stock exchanges	Digital Exchanges
Banks	DeFi Lending/ Borrowing
Classic Issuers	DeFi Token Issuers
Portfolio Manager	DeFi Asset Manager
Insurance	DeFi Insurance

	CeFi[2]	DeFi[1]
Organization	Companies	DAO[3]
Custody	Regulated Custodians	Self-Custody
Technology	Proprietary Software	Open Source on PB[4]
Security	Liability umbrella	Ownership & DYOR[5]
Management	Management decision	Community decision
Regulation	Regulated and supervised	Unregulated (so far)
Direct Fiat connection	Yes	No
Human manipulation	Yes	No
Automation	<100%	100%

! Similar surface functions…

…but very different in the background

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Within DeFi[1], DAOs[2] replace centralized corporate structures via smart contracts executed by decentralized, autonomously run communities

DAO[2] comparison to traditional company

Traditional Corporations **DAOs[2]**

Ownership	Permissioned	Permissionless
Governance	Costly	Frictionless
Accounting	Opaque	Transparent
Discourse	Private	Public

UNISWAP

- Decentralized crypto exchange founded in 2019
- 60% of genesis supply allocated to early community members
- US$5.6 billion in UNI token market cap
- >US$ 884 billion in trade volume
- >250,000 unique addresses

Top 20 DAO[2] Tokens[3] by market capitalization in US$ billion in April 2022[4]

Token	Value
ApeCoin	6.2
UNISWAP	5.6
AAVE	2.2
MAKER	1.6
Curve DAO Token	1.1
DASH	1.0
Kyber Network Crystal	0.9
deCRED	0.8
Compound	0.8
BitDAO	0.7
0x	0.7
SYNTHETIX	0.6
SushiSwap	0.4
UMA	0.4
Ethereum Name Service	0.4
illuvium	0.3
Nervos Network	0.3
Rari Governance Token	0.2
inSure DeFi	0.2
ARAGON	0.2

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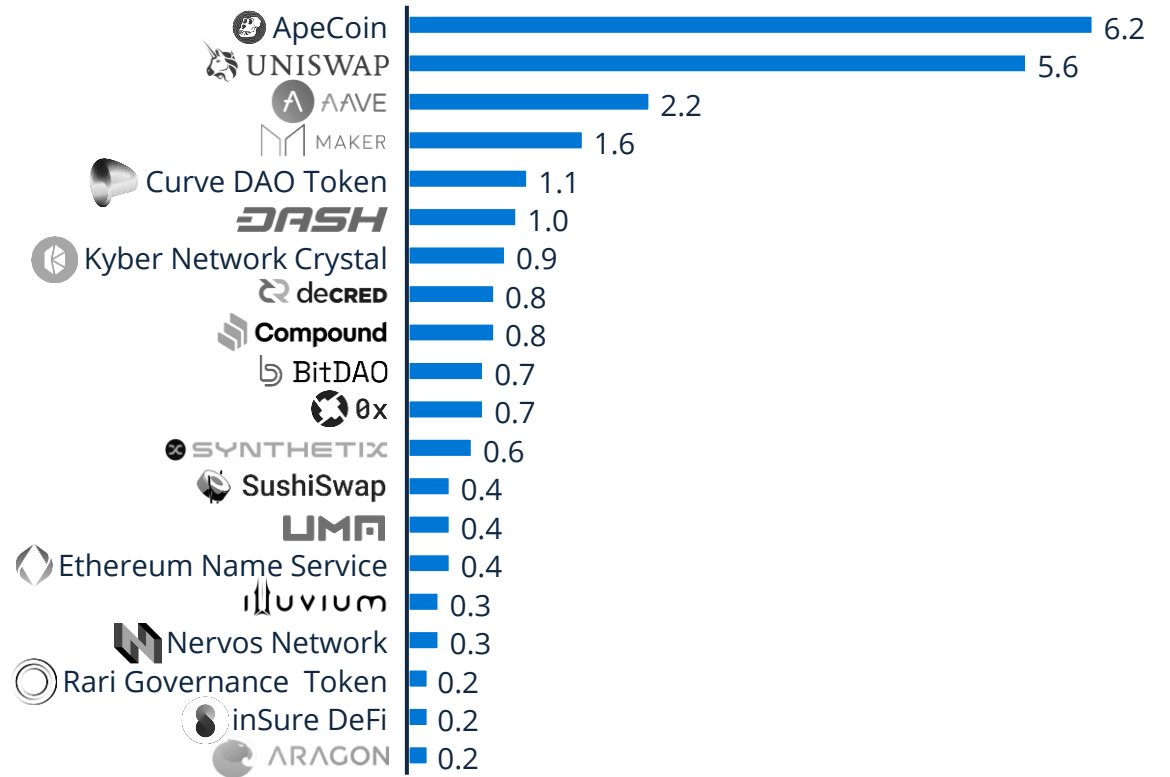
With over US$200 billion in value, a significant amount of money is already being moved within DeFi(1) applications

Global TVL(2) across multiple DeFi(1) blockchains in US$ bn
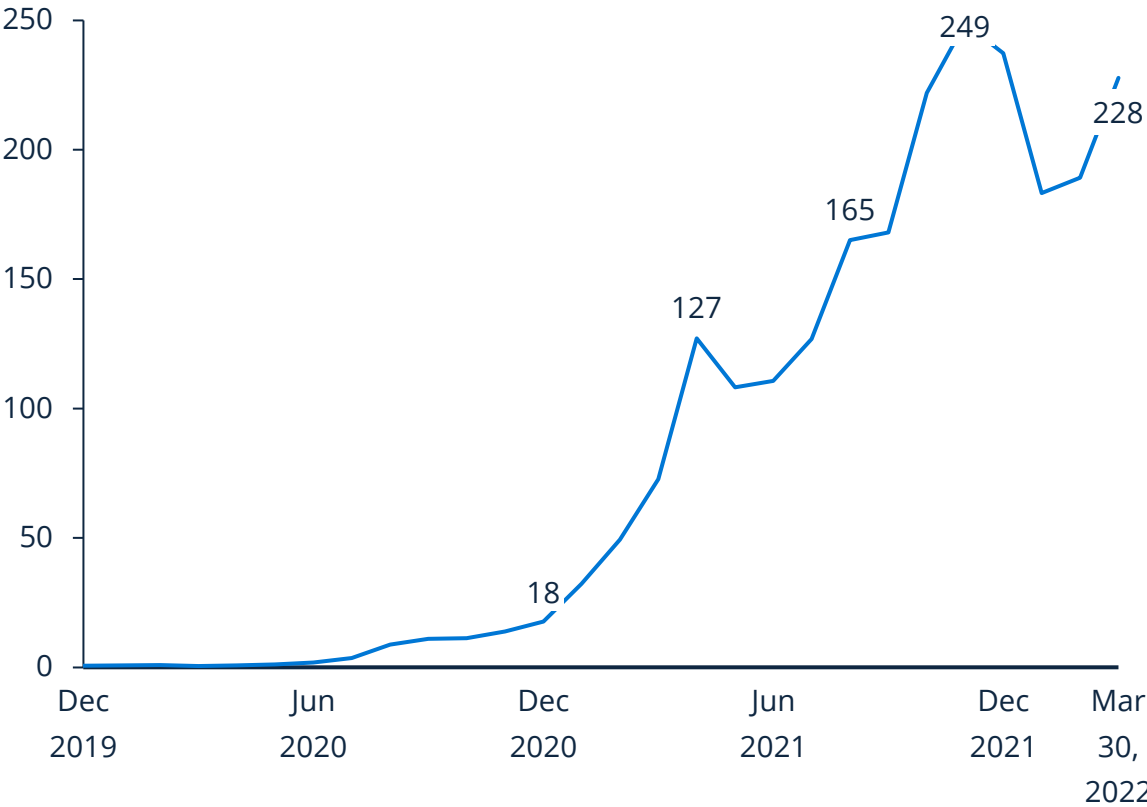
Global TVL(2) per segment across DeFi(1) blockchains in US$ bn in March 2022
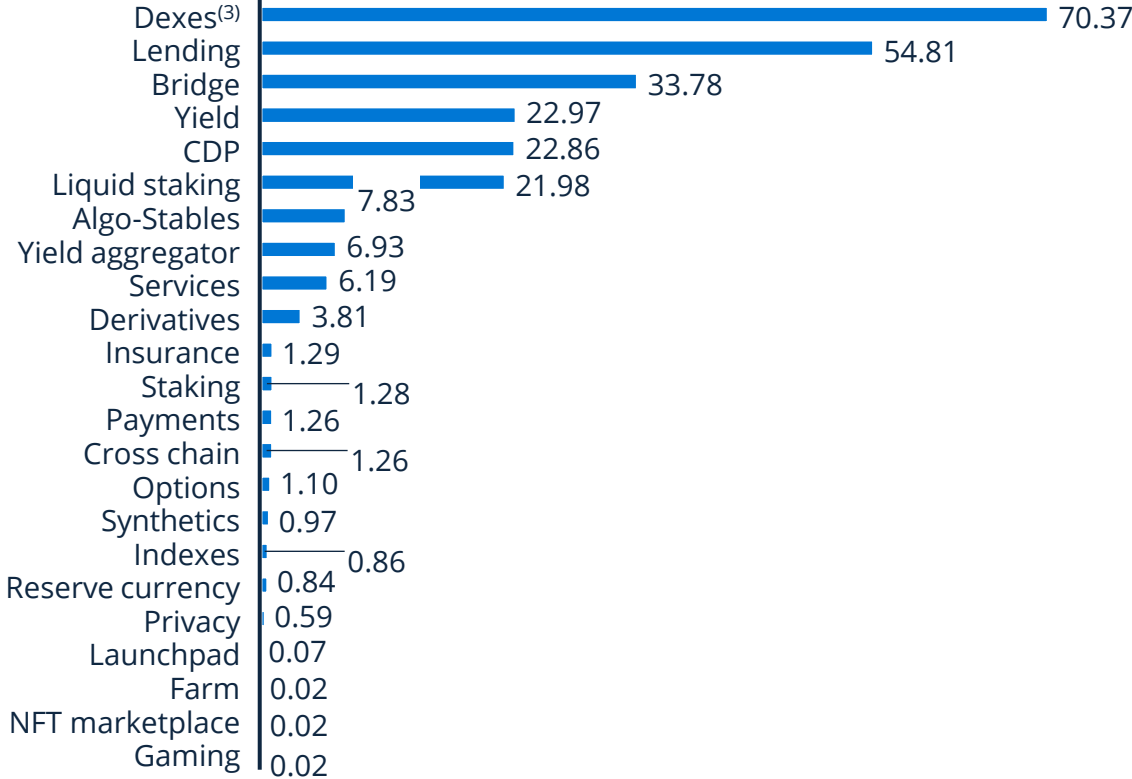
Segment	Value
Dexes(3)	70.37
Lending	54.81
Bridge	33.78
Yield	22.97
CDP	22.86
Liquid staking	21.98
Algo-Stables	7.83
Yield aggregator	6.93
Services	6.19
Derivatives	3.81
Insurance	1.29
Staking	1.28
Payments	1.26
Cross chain	1.26
Options	1.10
Synthetics	0.97
Indexes	0.86
Reserve currency	0.84
Privacy	0.59
Launchpad	0.07
Farm	0.02
NFT marketplace	0.02
Gaming	0.02

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Smart contracting platforms such as Ethereum (ETH) are the foundation for DeFi[1], NFTs[2], Stablecoins, and other connected use cases

Smart contracts as DeFi[1] foundation

- The backbone of all DeFi[1] protocols and applications is smart contracts (asset and settlement layer):

Technical DeFi[1] building blocks

Aggregation layer	Aggregator 1	Aggregator 2	Aggregator 3
Application layer			
Protocol layer	Exchange	Lending	Asset Management	...
Asset layer	Native protocol asset (ETH)	Fungible tokens: ERC-20	Non-fungible tokens: ERC-721	...
Settlement layer		(Ethereum) blockchain	
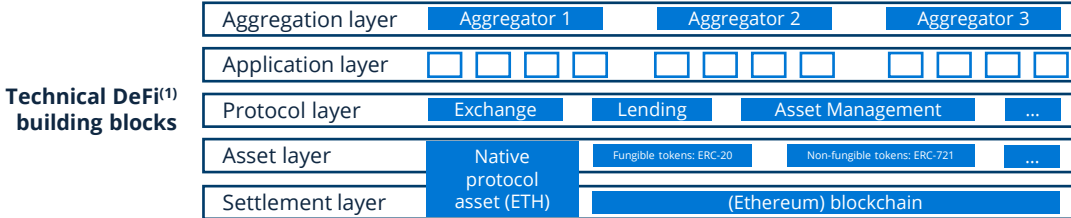
- Smart contracts are a collection of code and data that runs on a blockchain. They enable the automatic execution of agreements between parties, reduce counterparty risk, and ensure the trustless exchange (i.e, one without the need for intermediaries) of value and information.

- The Ethereum blockchain is the most significant enabler of smart contract-based services. Unlike Bitcoin, Ethereum contains a scripting language that enables users to build applications with the Ethereum Virtual Machine (EVM)[3].

- NFTs are minted through smart contracts that assign and manage their ownership and transferability.
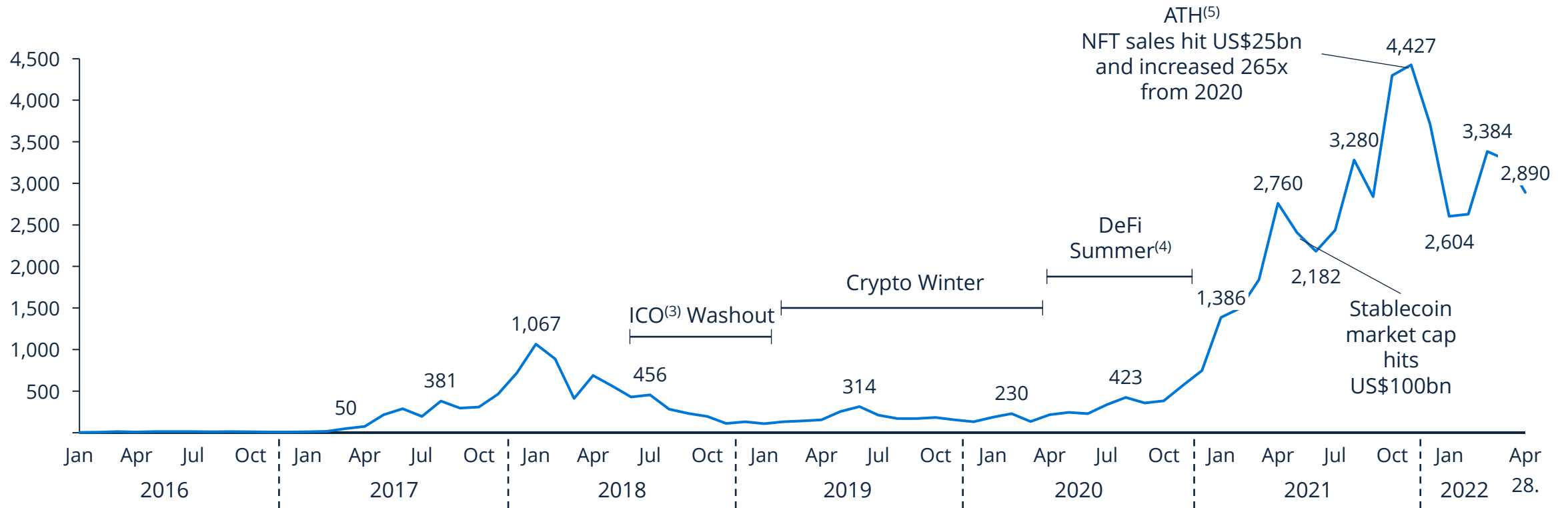
Examples of Ethereum applications

Non-Financial

File Storage
With a decentralized storage system, individuals can rent out their hard drives.

Cloud Computing
Users can proof and ask other users to proof computations.

Online Voting
Digital assets can be sent to the ICO smart contract.

Decentralized Governance
Tokens are automatically sent to the user's wallet.

Semi-Financial

Identity & Reputation Systems
Registration systems are structured similar to domains.

Wills
A person's desire for post-mortem asset distribution can be reliably documented.

Data Feeds
Financial contracts are based on differences with decentralized data feeds.

Prediction Markets
Decentralized prediction markets have more transparent odds.

Financial

Sub-Currencies
Token systems can easily be made to represent assets such as USD.

Financial Derivates
Instead of a single issuer. there is a decentralized market of speculators.

Hedging Contracts
Ethereum is held in escrow and provides security to both contract parties.

Saving Wallets
Funds can be placed in banks and banks can grant or deny the ability to access funds.

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As DeFi[1], NFTs[2], and Stablecoins went mainstream, the value of Ethereum soared to new heights at the end of 2021

Ethereum (ETH) price in US$
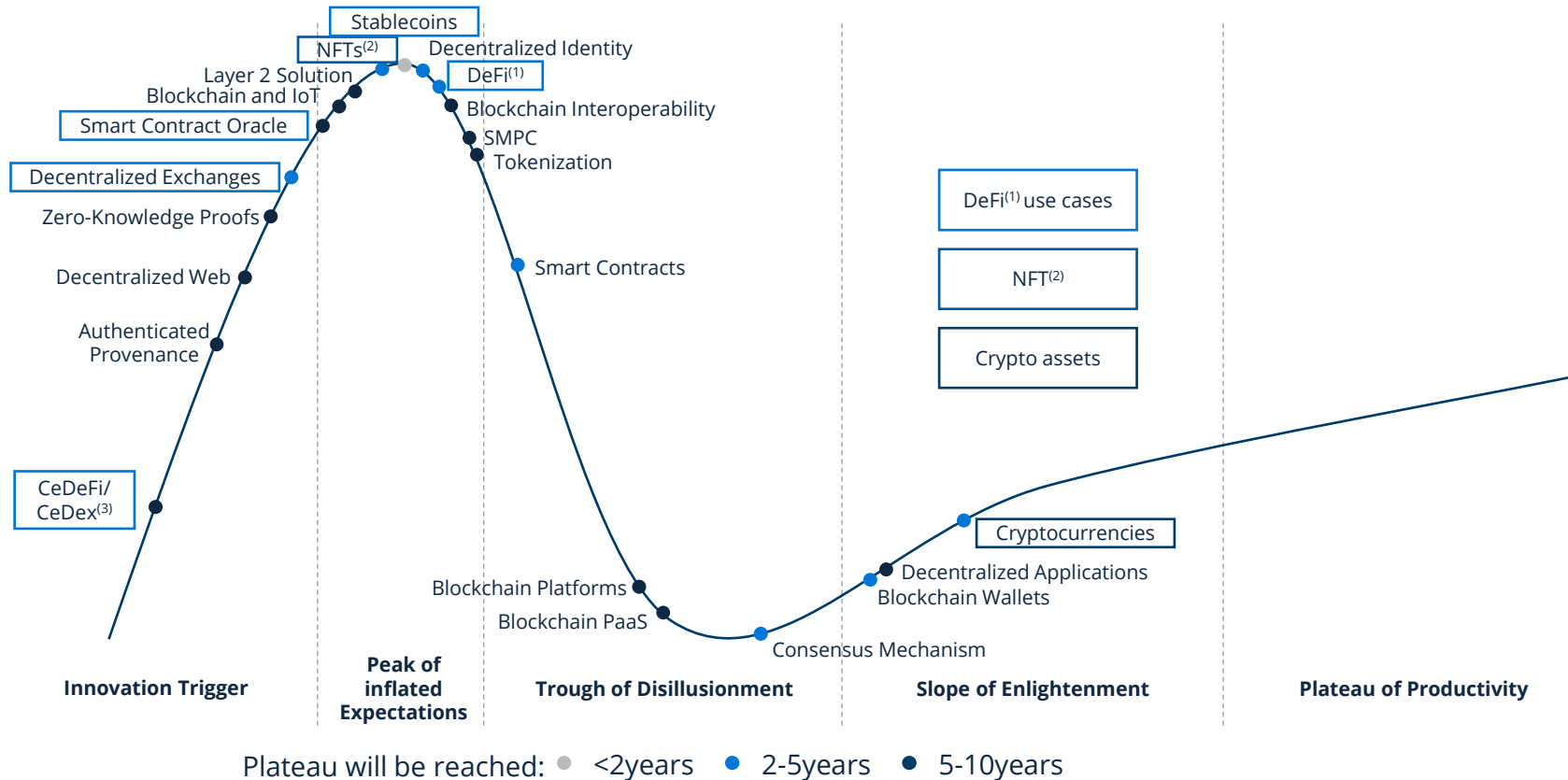
ATH[5]
NFT sales hit US$25bn
and increased 265x
from 2020

DeFi
Summer[4]

Crypto Winter

ICO[3] Washout

Stablecoin
market cap
hits
US$100bn

4,500 — 4,427
4,000 — 3,384
3,500 — 3,280
3,000 — 2,890
2,760
2,500 — 2,604
2,000 — 2,182
1,500 — 1,386
1,067
1,000 —
500 — 381 456 314 423
50 230

Jan Apr Jul Oct | Jan Apr Jul Oct | Jan Apr Jul Oct | Jan Apr Jul Oct | Jan Apr Jul Oct | Jan Apr Jul Oct | Jan Apr 28.
2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022

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The Blockchain Hype Cycle shows crypto assets as most advanced whereas DeFi[1] use cases and NFTs[2] are still in a rather early stage of development
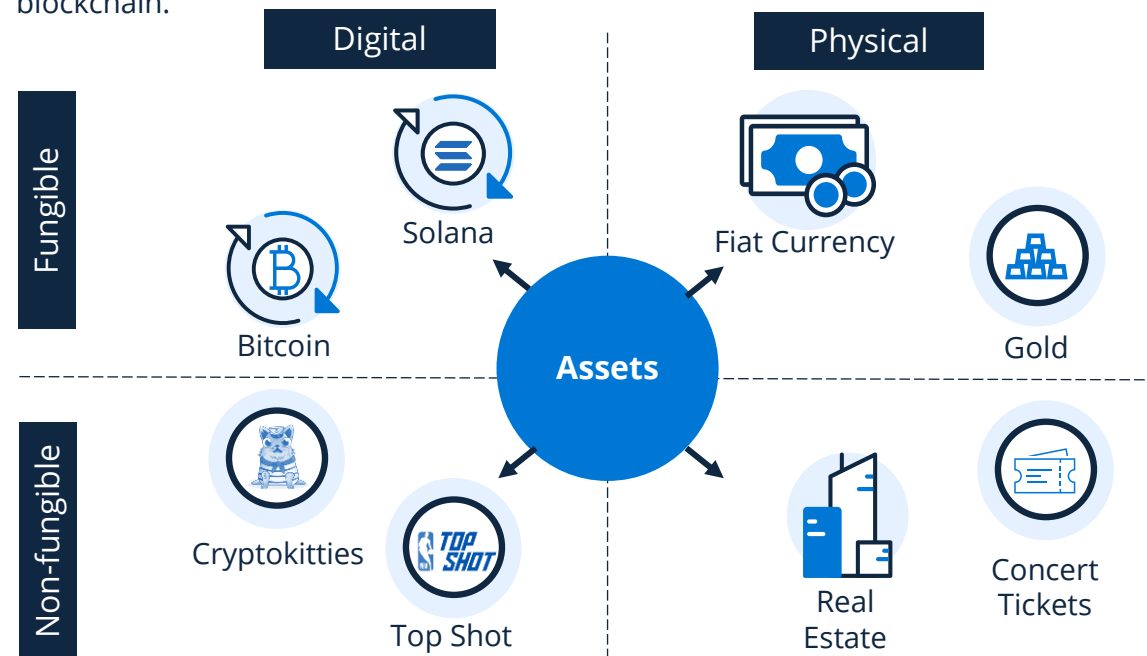
Gartner Hype Cycle for Blockchain 2021

Stablecoins

NFTs[2]

Decentralized Identity

Layer 2 Solution
Blockchain and IoT

DeFi[1]

Smart Contract Oracle

Blockchain Interoperability

SMPC

Tokenization

Decentralized Exchanges

Zero-Knowledge Proofs

Decentralized Web

DeFi[1] use cases

Authenticated
Provenance

Smart Contracts

NFT[2]

Crypto assets

CeDeFi/
CeDex[3]

Cryptocurrencies

Decentralized Applications
Blockchain Wallets

Blockchain Platforms

Blockchain PaaS

Consensus Mechanism

Innovation Trigger | **Peak of inflated Expectations** | **Trough of Disillusionment** | **Slope of Enlightenment** | **Plateau of Productivity**

Plateau will be reached: ● <2years ● 2-5years ● 5-10years

DeFi[1] use cases explained

- **CeDeFi/CeDex[3]**: A combination of traditional centralized financial organizations with mature DeFi[1] applications can create CeDeFi[3] offerings.

- **Decentralized Exchanges:** These offer buying and selling of digital assets without an intermediary organization.

- **Smart Contract Oracle**: Smart contracts are still restricted by their limited capacities. Oracles are data feeds from external systems that feed vital information into blockchains.

- **Stablecoins**: To overcome issues of volatility, their prices are pegged to a crypto-currency, fiat money, or to commodities.
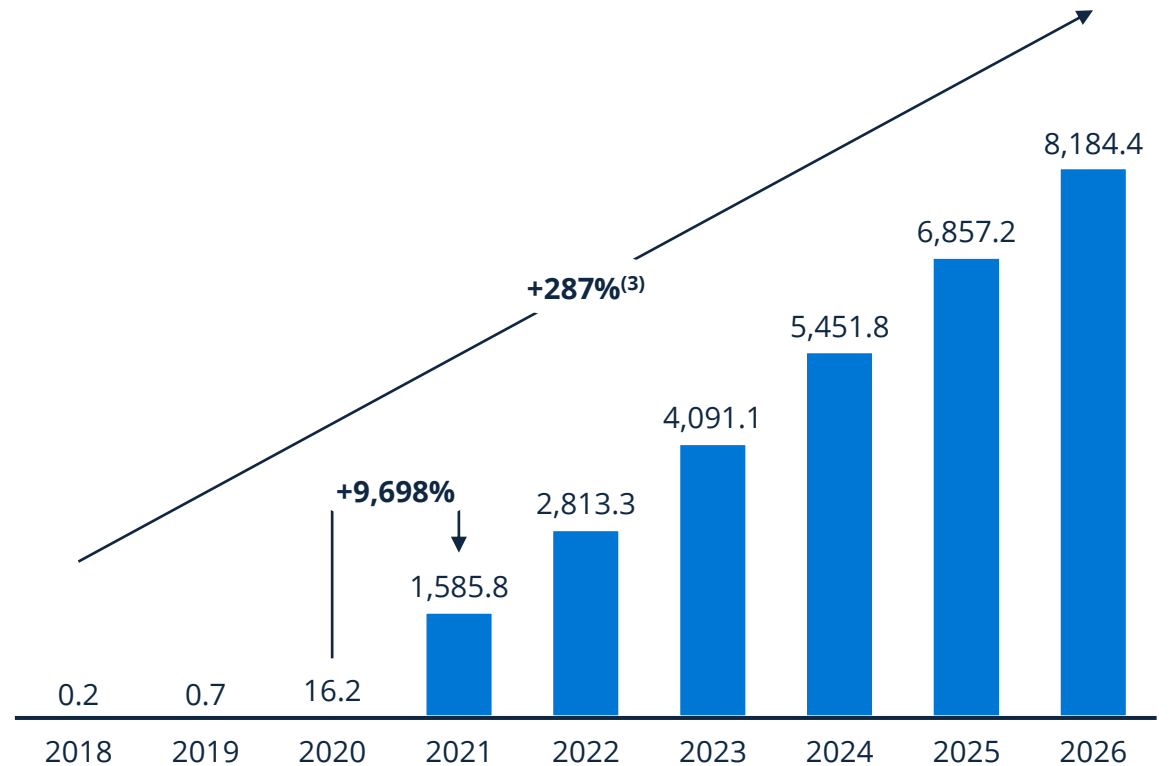
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As DeFi[1] revolutionizes the internet-based financial system, NFTs[2] disrupt the world of art, music, and retail

What is a non-fungible token (NFT)?

A non-fungible token is a unique, cryptographically secured identifier that represents ownership of a digital asset, such as art, music, or a collectible on a blockchain.
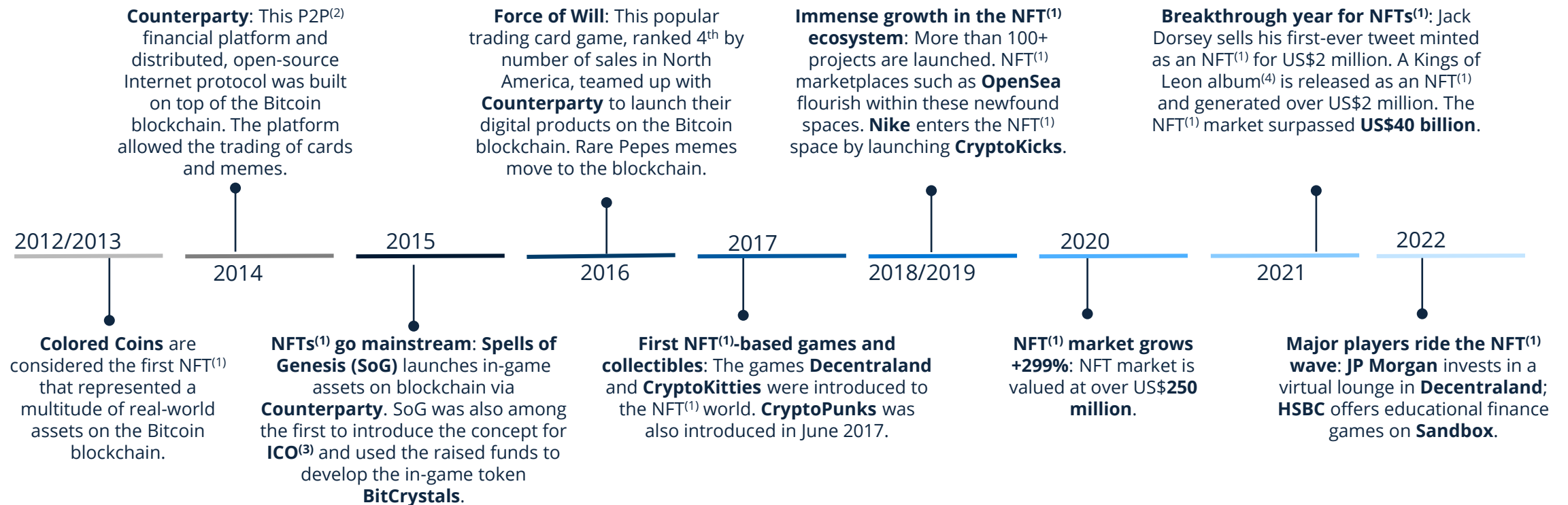
Digital **Physical**

Fungible

Solana

Bitcoin

Fiat Currency

Gold

Assets

Non-fungible

Cryptokitties

Top Shot

Real Estate

Concert Tickets

Global NFTs[2] revenue forecast in US$ million

+287%[3]

+9,698%

2018	2019	2020	2021	2022	2023	2024	2025	2026
0.2	0.7	16.2	1,585.8	2,813.3	4,091.1	5,451.8	6,857.2	8,184.4

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The concept of NFTs[1] emerged in 2012, but its breakthrough year came in 2021 with a market value of US$40 billion

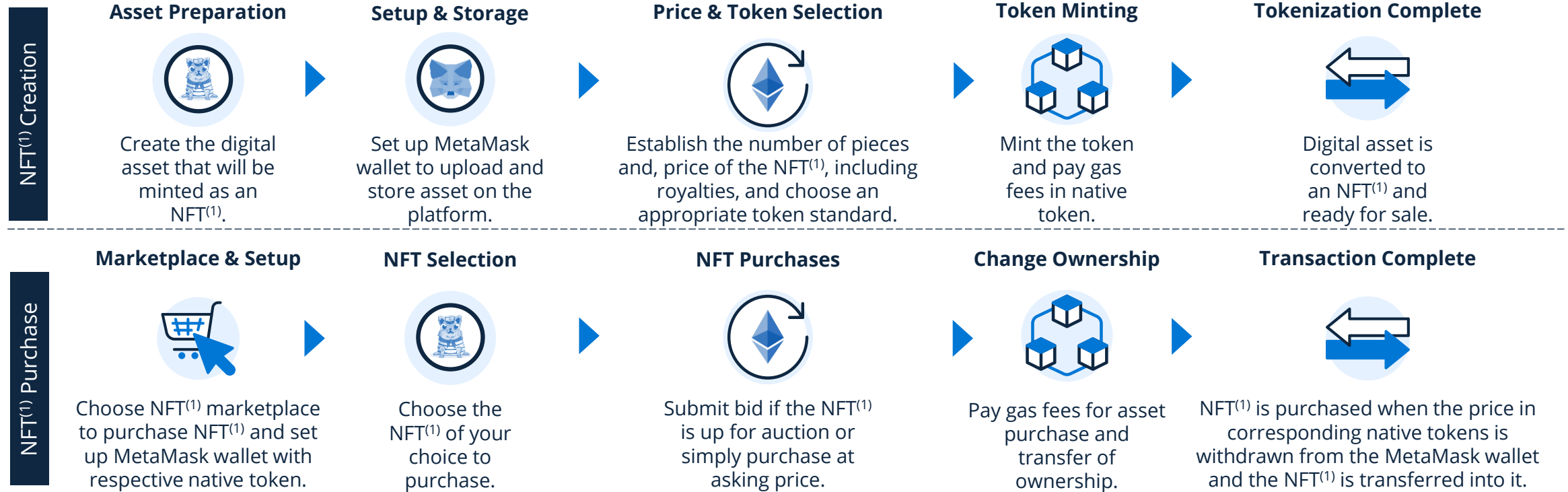**Timeline of events leading to the rise of NFTs[1]**

Counterparty: This P2P[2] financial platform and distributed, open-source Internet protocol was built on top of the Bitcoin blockchain. The platform allowed the trading of cards and memes.

Force of Will: This popular trading card game, ranked 4th by number of sales in North America, teamed up with **Counterparty** to launch their digital products on the Bitcoin blockchain. Rare Pepes memes move to the blockchain.

Immense growth in the NFT[1] ecosystem: More than 100+ projects are launched. NFT[1] marketplaces such as **OpenSea** flourish within these newfound spaces. **Nike** enters the NFT[1] space by launching **CryptoKicks**.

Breakthrough year for NFTs[1]: Jack Dorsey sells his first-ever tweet minted as an NFT[1] for US$2 million. A Kings of Leon album[4] is released as an NFT[1] and generated over US$2 million. The NFT[1] market surpassed **US$40 billion**.

2012/2013   2015   2017   2020   2022

2014   2016   2018/2019   2021

Colored Coins are considered the first NFT[1] that represented a multitude of real-world assets on the Bitcoin blockchain.

NFTs[1] go mainstream: Spells of Genesis (SoG) launches in-game assets on blockchain via **Counterparty**. SoG was also among the first to introduce the concept for **ICO[3]** and used the raised funds to develop the in-game token **BitCrystals**.

First NFT[1]-based games and collectibles: The games **Decentraland** and **CryptoKitties** were introduced to the NFT[1] world. **CryptoPunks** was also introduced in June 2017.

NFT[1] market grows +299%: NFT market is valued at over US$**250 million**.

Major players ride the NFT[1] wave: JP Morgan invests in a virtual lounge in **Decentraland**; **HSBC** offers educational finance games on **Sandbox**.

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NFTs[1] are tradable decentralized digital assets minted on the blockchain network

Creating and purchasing an NFT[1]

NFT[1] Creation

Asset Preparation
Create the digital asset that will be minted as an NFT[1].

Setup & Storage
Set up MetaMask wallet to upload and store asset on the platform.

Price & Token Selection
Establish the number of pieces and, price of the NFT[1], including royalties, and choose an appropriate token standard.

Token Minting
Mint the token and pay gas fees in native token.

Tokenization Complete
Digital asset is converted to an NFT[1] and ready for sale.

NFT[1] Purchase

Marketplace & Setup
Choose NFT[1] marketplace to purchase NFT[1] and set up MetaMask wallet with respective native token.

NFT Selection
Choose the NFT[1] of your choice to purchase.

NFT Purchases
Submit bid if the NFT[1] is up for auction or simply purchase at asking price.

Change Ownership
Pay gas fees for asset purchase and transfer of ownership.

Transaction Complete
NFT[1] is purchased when the price in corresponding native tokens is withdrawn from the MetaMask wallet and the NFT[1] is transferred into it.

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Attractive prices and better customer reach makes NFT[1] marketplaces a new haven for popular artists

Top-5 most expensive NFTs[1] sold in US\$ million[2]

NFT	Value
The Merge	92
The First 5000 Days	69
Clock	53
Human One	29
CryptoPunk #7523	12
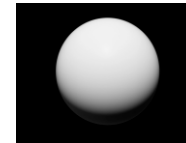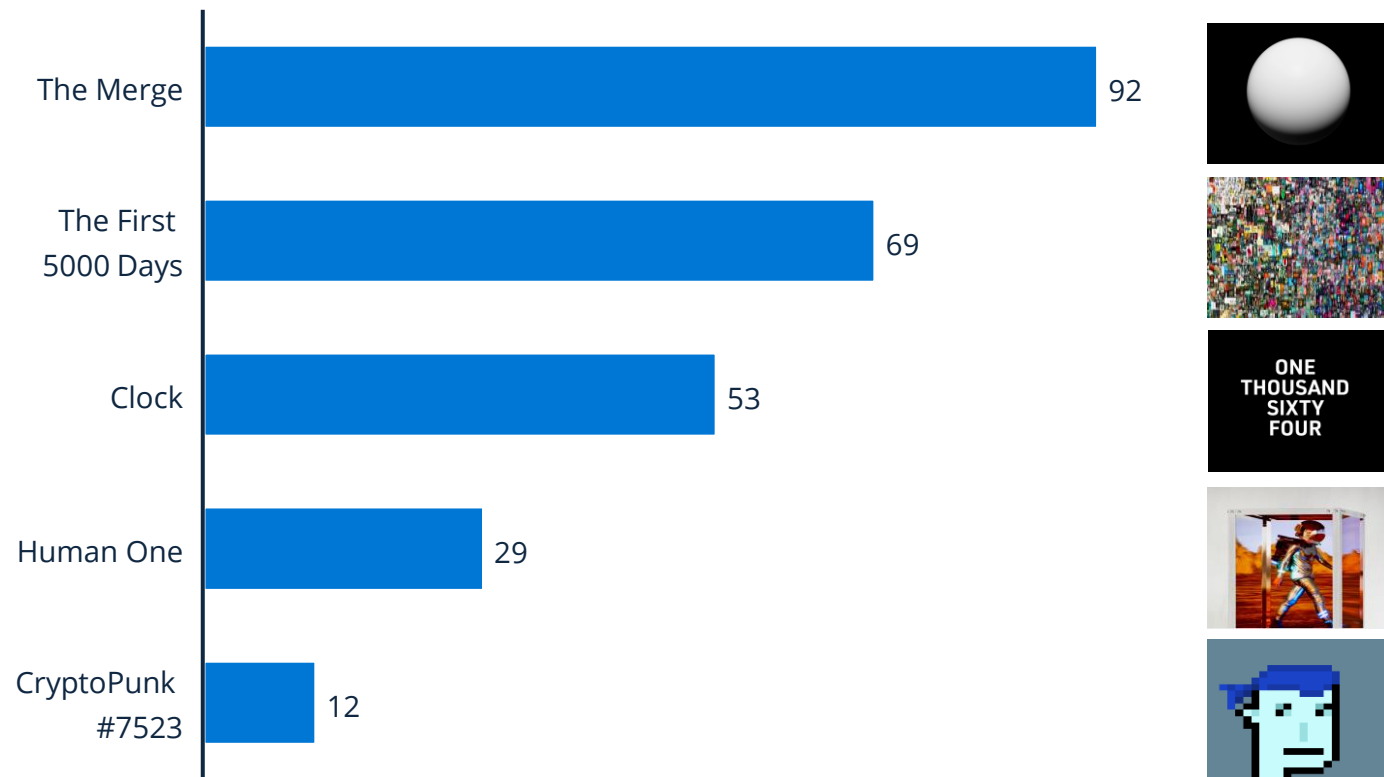
The Merge is a dynamic NFT[1] collectible created by the famous digital artist Pak. The asset represents a collection of 'masses' that grew large based on the value spent by buyers. The final creation was an amalgamation of all these masses that was sold at US\$91.8 million.

This compilation of artworks by Beeple was sold for a record-breaking sum of US\$69 million during the first-ever digital art auction by the auction house Christie's.

Clock was created by Pak and Julian Assange to assist with the controversial WikiLeaks founder's legal fees. Assange has been imprisoned in the UK for several years, and the Clock is a simple counter which displays the number of days he has spent in prison.

This is yet another creation by Beeple. Compared to most NFTs[1] that are exclusively digital, Human One is a hybrid that combines both physical (polished aluminum, mahogany wood) and digital elements (four video screens).

CryptoPunks were introduced in June 2017 when 10,000 randomly generated punks, which accounted to 127,000 ETH[3], were given away.

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OpenSea is by far the largest peer-to-peer marketplace for NFTs[1] by volume

Top-10 NFT[1] marketplaces by sales volume in US$ million 2021

Marketplace	Volume
OpenSea	13,057
BakerySwap	4,464
Larva Labs CryptoPunks	4,265
Axie Infinity Marketplace	2,374
Magic Eden	860
Top Shot	826
Solanart	647
Binance NFT	548
Foundation	406
Nifty Gateway	349
Atomic Hub	307
Mobox	263
SuperRare	122
Digital Eyes Market	118
Decentraland	112
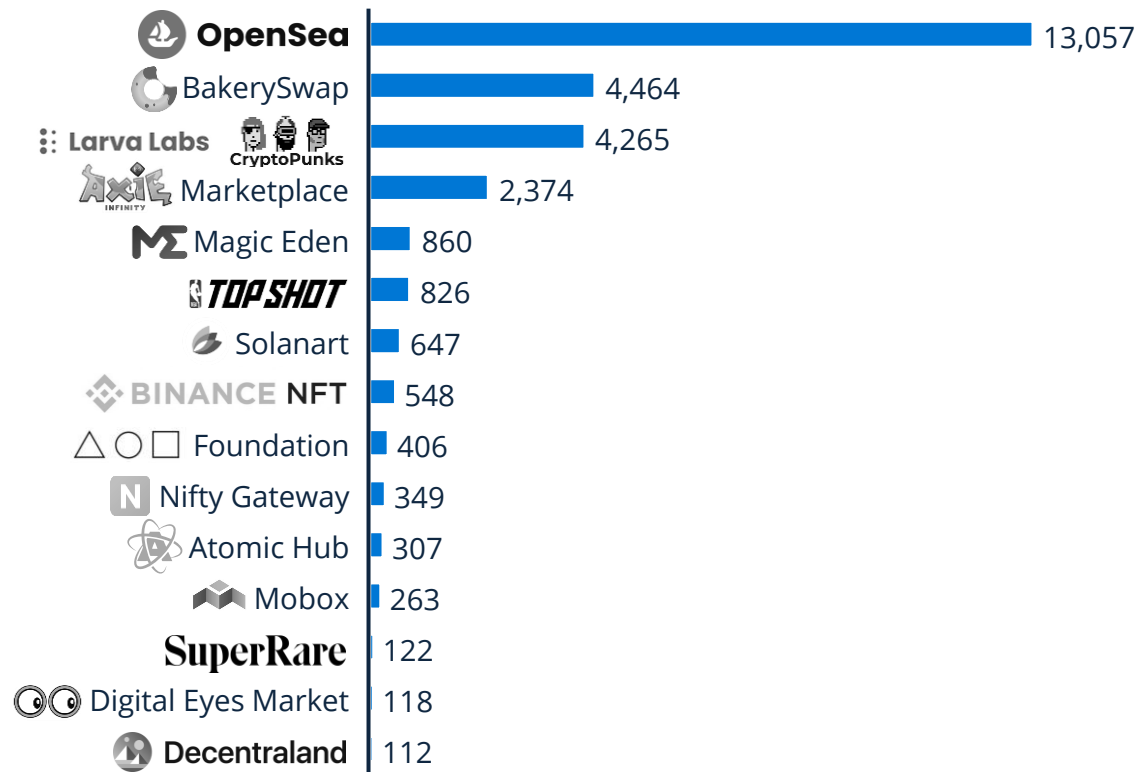
OpenSea as NFT[1] marketplace example

- Founded in 2017 as a peer-to-peer marketplace for NFTs[1], rare digital items, and crypto collectibles
- Offers platform for users to create their own marketplace for NFTs[1]
- Its API enables developers to search for assets, collections, users, and more
- In addition to the Ethereum-based exchange, OpenSea offers a gas-free exchange based on the polygon protocol with multi-chain support

Key metrics 2021:

Revenue:	US$326 million
Users:	900,206
ARPU:	US$363

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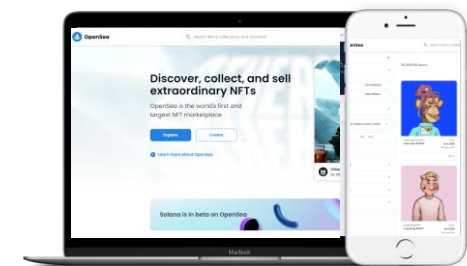
Ethereum facilitates the majority of all NFT[1] sales; however, its average gas prices[2] have also been rising over the years

Share of all-time NFT[1] sales volume by blockchains

- 75%
- 12%
- 6%
- 3%
- 2%
- 3%

Legend:
- ethereum
- SOLANA
- Polygon
- Ronin
- flow
- Other
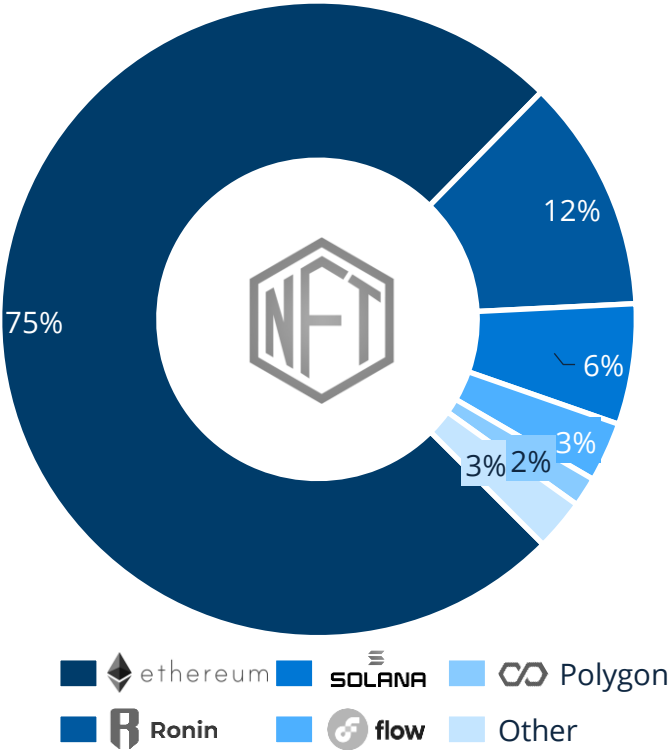
Average gas price[2] of Ethereum (Gwei[3])
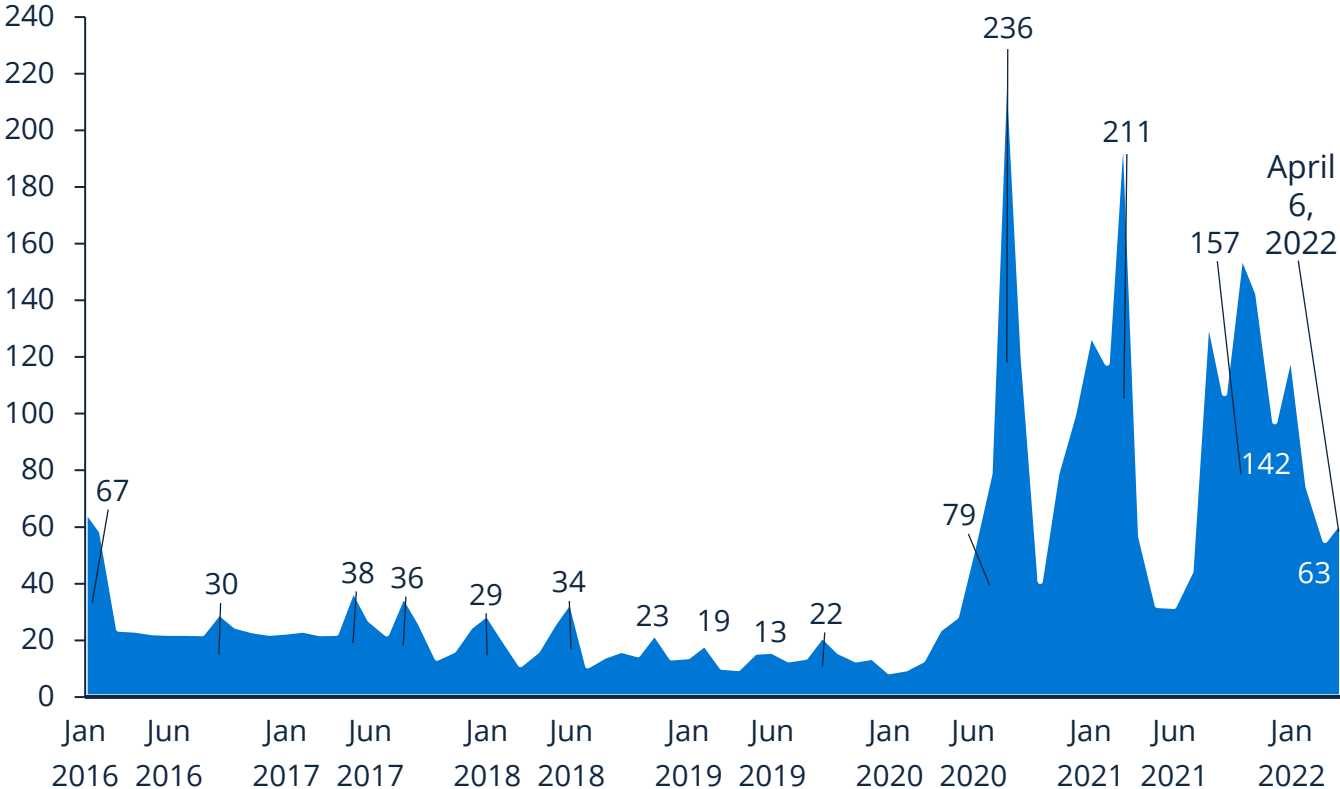
Data labels on chart: 67, 30, 38, 36, 29, 34, 23, 19, 13, 22, 79, 236, 211, 157, April 6, 2022, 142, 63

X-axis labels: Jan 2016, Jun 2016, Jan 2017, Jun 2017, Jan 2018, Jun 2018, Jan 2019, Jun 2019, Jan 2020, Jun 2020, Jan 2021, Jun 2021, Jan 2022

Y-axis: 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240

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NFTs[1] are gaining significant traction among certain Asian countries such as Thailand, China, and Vietnam

Top-10 countries by NFT[1] users in 2021

Country		Users (millions)
Thailand		5.65
Brazil		4.99
United States		3.81
China		2.68
Vietnam		2.19
India		1.50
Canada		1.40
Indonesia		1.25
Germany		1.23
South Africa		1.23

NFTs[1] user penetration rate[2] in 2021

Canada
3.67%

Brazil
2.33%

Thailand
8.08%

Vietnam
2.24%

Australia
2.41%

0.03% ▬▬▬▬▬▬ 8%   not data available

statista
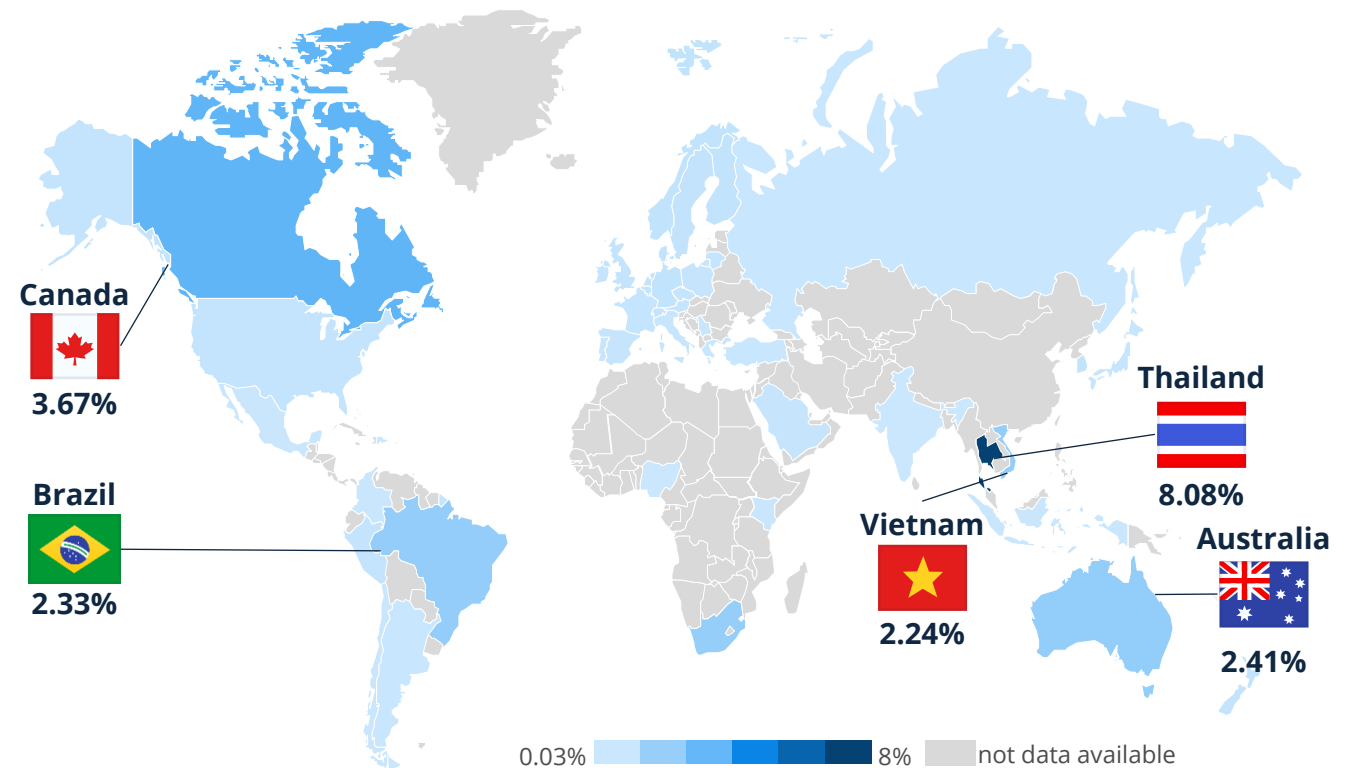
NFT[1] financialization was brought about by advancements in DeFi[2] services and the convergence of its concepts in the NFT[1] market

The NFT[1] financialization landscape

NFT[1] Lending

P2P[3] Lending: Borrowers and sellers can negotiate loan terms.

Liquidity Pool-based Lending: This lending model enables NFT[1] holders to put their NFTs[1] as collateral in the liquidity pool and take out permissionless loans. Lenders earn fees for providing liquidity.

DAO-to-DAO[3] Lending: Gaming guilds can lend or lease their assets to emerging guilds.

FLOOR_DAO   NFTIFY   PAWNFI   JPEG'd   DROPS

NFT[1] Rental

Collateral-backed Rental: Renters deposit assets as collateral managed by protocol.

Wrapped NFT[1] + Custody by Marketplace: Renters pay rent to receive a wrapped NFT[1] whereas lenders lock their NFT[1] into the protocol and receive rent.

Expirable Dual-Role NFT[1]: Renters assume the role of a user and the NFT[1] automatically expires when the rental period ends.

VERA   LANDWORKS   reNFT

NFT[1] Pricing

Machine Learning-based Pricing: Data analysis and machine learning technologies are used to derive a value range for any NFT[1] based on its historical trading data.

Time-weighted Average Price (TWAP) : JPEG'd has built their customized floor TWAP for NFTs[1] on Chainlink.

Peer-to-Peer Pricing: Reward incentives and curated committees are used to directly appraise NFT[1] values or make market-based valuation predictions.

TAKER   UPSHOT

NFT[1] Fractionalization

Indexing: A floor price index is established by fractionalizing similarly priced NFTs[1] from the same collection into fungible tokens.

Collection: The creation of this product resembles an index fund and buckets different NFTs[1] into the fund.

NFT20   NFTX

Aggregators

Aggregation: Its end goals are lower gas fees and better prices across marketplaces: Genie.xyz and Gem.xyz are frontrunners in the space.

HYPERSPACE

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Currently, collectibles and art account for nearly 80% of the NFT[1] market value, but demand for gaming and virtual worlds could rise in the near future

NFT[1] segment share from total sales volume of segments[2]
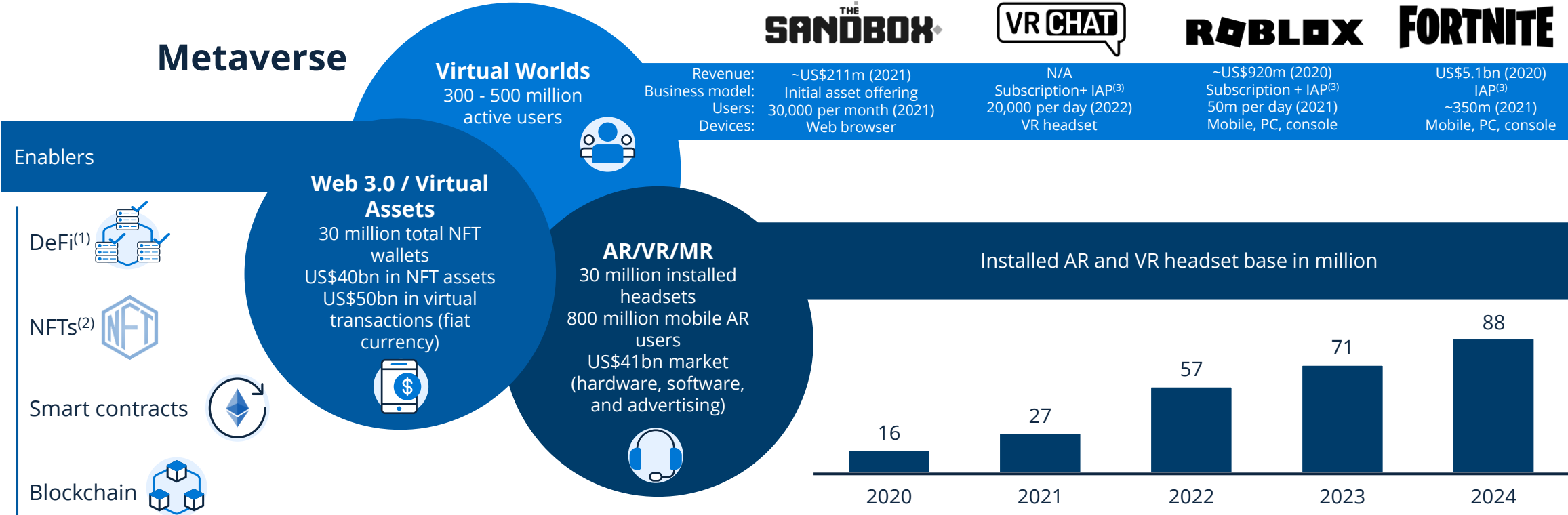

Legend: Collectible, Game, Meta, Art
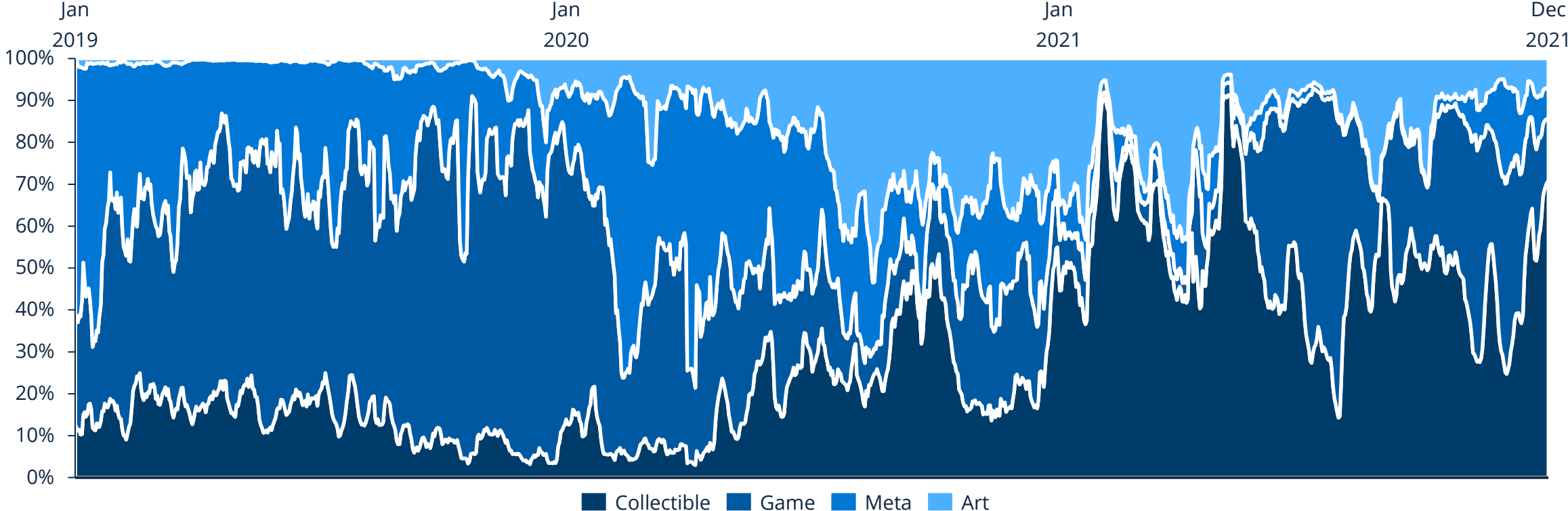
Notes: (1) Non-fungible Token (2) Only covering NFTs based on the Ethereum network. DeFi and Utilities were excluded from the original sourced data.

Sources: Nonfungible

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Web 3.0, DeFi[1], and NFTs[2] come altogether at the intersectional concept of the Metaverse: virtual worlds focused on social connection

Intersection of the Metaverse

Metaverse

Virtual Worlds
300 - 500 million active users

Web 3.0 / Virtual Assets
30 million total NFT wallets
US$40bn in NFT assets
US$50bn in virtual transactions (fiat currency)

AR/VR/MR
30 million installed headsets
800 million mobile AR users
US$41bn market (hardware, software, and advertising)

Enablers

- DeFi[1]
- NFTs[2]
- Smart contracts
- Blockchain

	THE SANDBOX	VR CHAT	ROBLOX	FORTNITE
Revenue:	~US$211m (2021)	N/A	~US$920m (2020)	US$5.1bn (2020)
Business model:	Initial asset offering	Subscription+ IAP[3]	Subscription + IAP[3]	IAP[3]
Users:	30,000 per month (2021)	20,000 per day (2022)	50m per day (2021)	~350m (2021)
Devices:	Web browser	VR headset	Mobile, PC, console	Mobile, PC, console

Installed AR and VR headset base in million

2020	2021	2022	2023	2024
16	27	57	71	88

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All blockchain-related activities are growing quickly but are still small and years away from mass adoption

User numbers of selected metaverse and blockchain connected areas in million

Video Gaming: 3,218.1 (2021), 3,937.6 (2026)
Meta (Facebook)[1]: 2,465.7 (2021), 2,981.0 (2026)
Digital Assets[2]: 250.8 (2021), 422.3 (2026)
DeFi[3]: 4.5 (2021), 17.5 (2026)
Blockchain Gaming (GameFi)[4]: 8.1 (2021), 34.1 (2026)
Metaverse: 0.1 (2021), 1,023.4 (2026)

■ 2021 ■ 2026
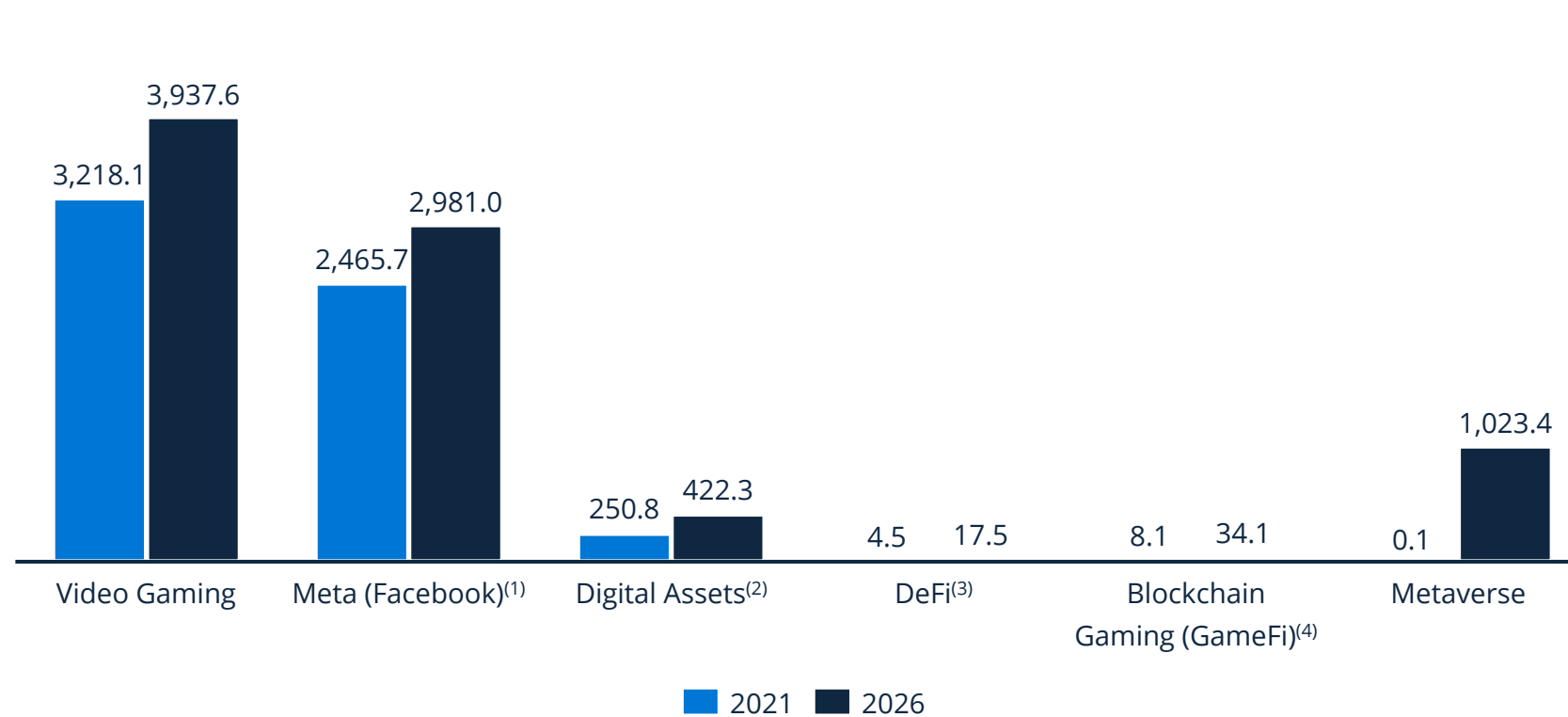
Metaverse revenue in US$ billion

+34%

2021: 121 total (Virtual-asset economy 90, AR/VR/MR 16, Cloud 9, Network 6)
2025: 394 total (Virtual-asset economy ~150-300, AR/VR/MR 47, Cloud 28, Network 19)

■ Virtual-asset economy   ■ Cloud
■ AR/VR/MR[1]   ■ Network
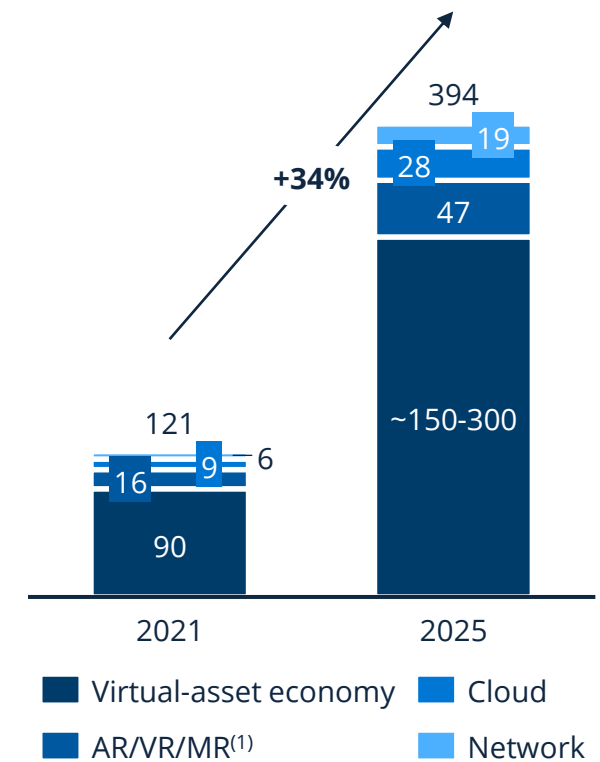
Notes: (1) Only includes Facebook users – own estimation, not to compare with Meta Platforms Inc. self-reported MAUs (2) Including cryptocurrencies and NFTs (3) Decentralized Finance (4) MAUs

Sources: Statista Advertising & Media Outlook 2022, BCG, Artillery IntelligenceWeAreSocial, Greyscale, Nonfungible, PwC, Dune Analytics, Bloomberg Intelligence, Crypto.com, IDC, Two Circles, Gartner, DappRadar

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Gaming and the Metaverse: Will the evolution of gaming give rise to a new digital economy?

Originally released December 2022 (as Chapter 5)

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Table of contents

Gaming isn't only for nerds anymore – with full speed towards a mainstream audience

Thanks to gaming's significant role in culture, entertainment, and technological growth, the gaming industry is one of the most interesting media sectors. In the next few years, it will become the highest-grossing media segment, overtaking TV and digital video. Even today, gamers outnumber the number of inhabitants in Europe and Africa combined. It is no longer a niche. Gaming progressed from the arcade boom to home consoles and PCs to online and mobile and is now becoming a new kind of immersive social gaming experience. This has been made possible above all by the smartphone and the easy accessibility of mobile gaming for everyone. As market potential and consumer demand increase, big tech is increasingly going full-stack next to incumbents in the sector. New technologies such as AR&VR are driving the future vision of total immersive gaming.

Gaming is taking the lead over TV and Digital Video and will become the highest-grossing media segment by 2027

Global media segment revenue development in billion US$
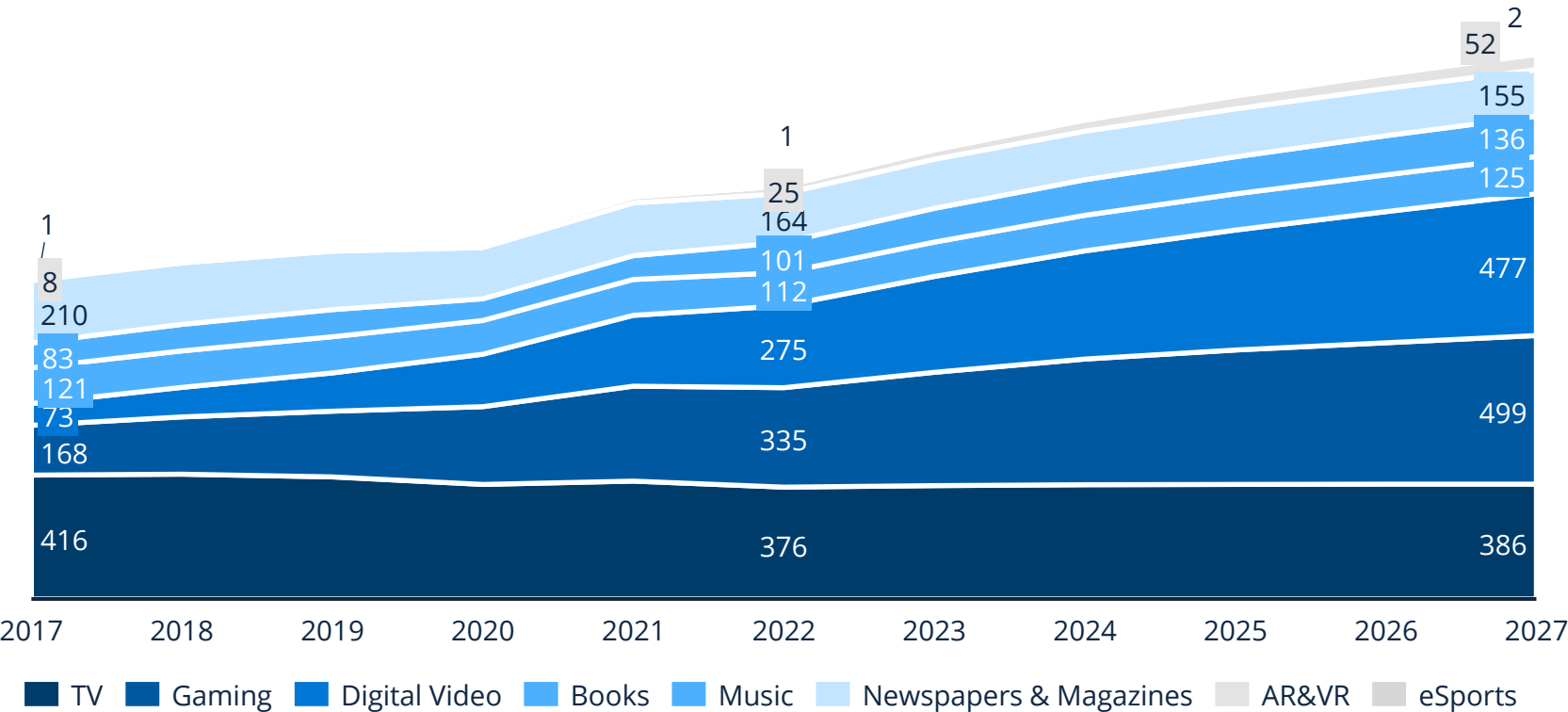
Media category CAGR 2017-2027

	Digital Video	+20.7%
	AR&VR	+20.0%
	eSports	+13.7%
	Gaming	**+11.5%**
	Music	+5.1%
	Books	+0.3%
	TV	-0.7%
	Newspapers & Magazines	-3.0%

Legend: TV · Gaming · Digital Video · Books · Music · Newspapers & Magazines · AR&VR · eSports

statista

Gamers outnumber the inhabitants of Europe and Africa combined

Number of users of selected media segments and population numbers of selected regions in millions in 2022

eSports
0.53

0.75

Europe

1.23

Africa

Digital Music
1.25

Physical Books & eBooks
2.53

Games
3.04

OTT Video
3.26

4.56

Asia

Traditional TV
5.41

statista
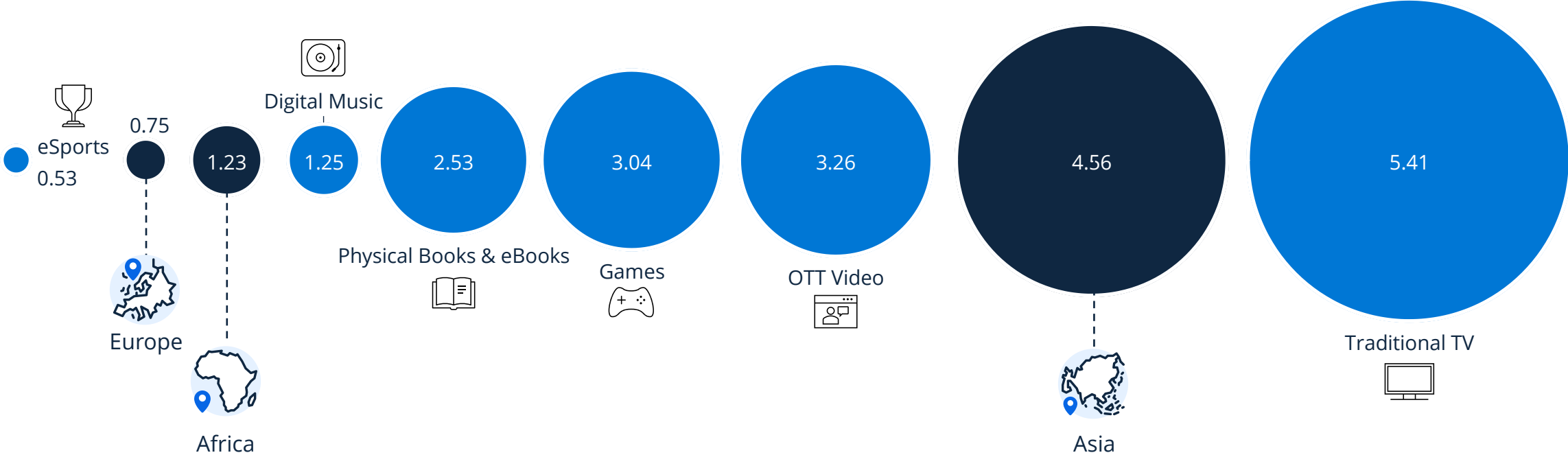
Gaming started in the early 80s with the arcade boom and has shifted to social gaming as mobile gaming continues to increase its reach

Timeline for most prominent gaming developments[1]
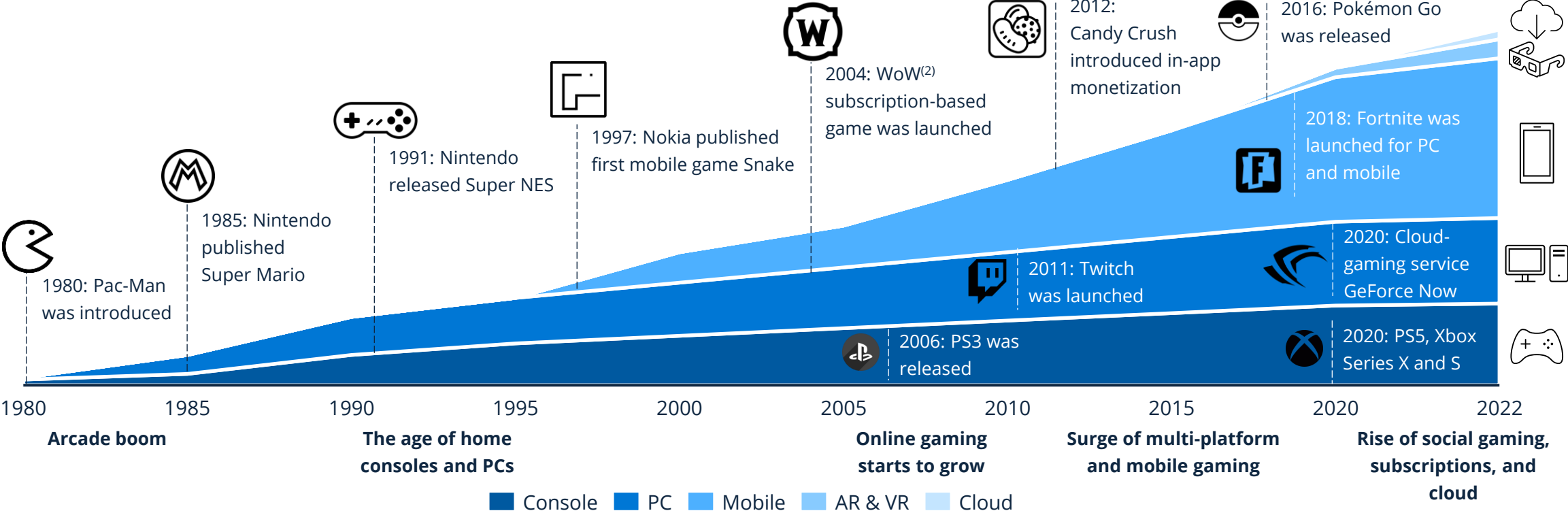
2012: Candy Crush introduced in-app monetization

2016: Pokémon Go was released

2004: WoW[2] subscription-based game was launched

2018: Fortnite was launched for PC and mobile

1997: Nokia published first mobile game Snake

1991: Nintendo released Super NES

2011: Twitch was launched

2020: Cloud-gaming service GeForce Now

1985: Nintendo published Super Mario

1980: Pac-Man was introduced

2006: PS3 was released

2020: PS5, Xbox Series X and S

| 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2022 |

Arcade boom

The age of home consoles and PCs

Online gaming starts to grow

Surge of multi-platform and mobile gaming

Rise of social gaming, subscriptions, and cloud

Console PC Mobile AR & VR Cloud

statista

Owing to its easy access and high reach, the Mobile Gaming segment represents nearly 50% of today's entire Gaming market

Global Gaming revenue by segment in billion US$ and segment share of total market in 2022

Mobile Games	**In-Game Advertising**	**Online Games** 23.56
		Download Games 17.72
152.50	126.11	**Physically Sold Video Games** 11.22 / Gaming Networks & eSports 4.56

US$ 335.7

Pie chart:
- Mobile Games 46.2%
- Gaming Advertising 36.5%
- Online Games 7.1%
- Download Games 5.4%
- Physically Sold Video Games 3.4%
- Gaming Networks eSports 1.0%
- 0.4%

statista
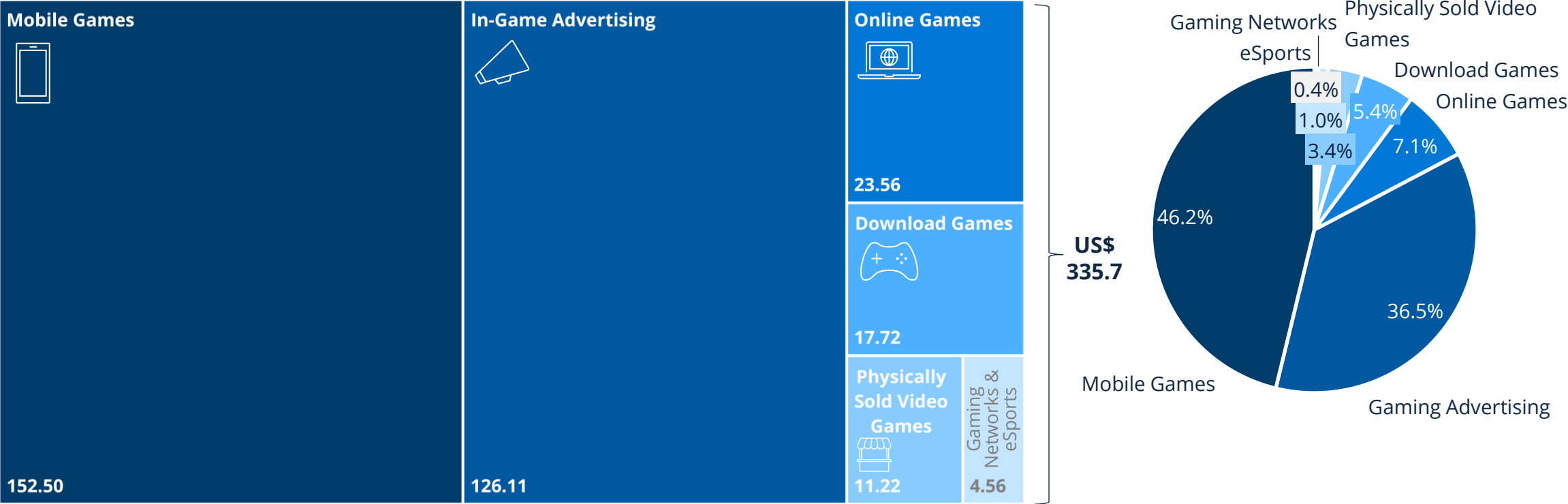
COVID-19 boosted revenues in the video games market, whereas the Russia-Ukraine war only had a minor negative impact

Original and after COVID-19 global Gaming revenue in billion US$ in 2020

US$156bn

21.3
17.0
2.8
1.5
0.9
18.4
0.2
115.9
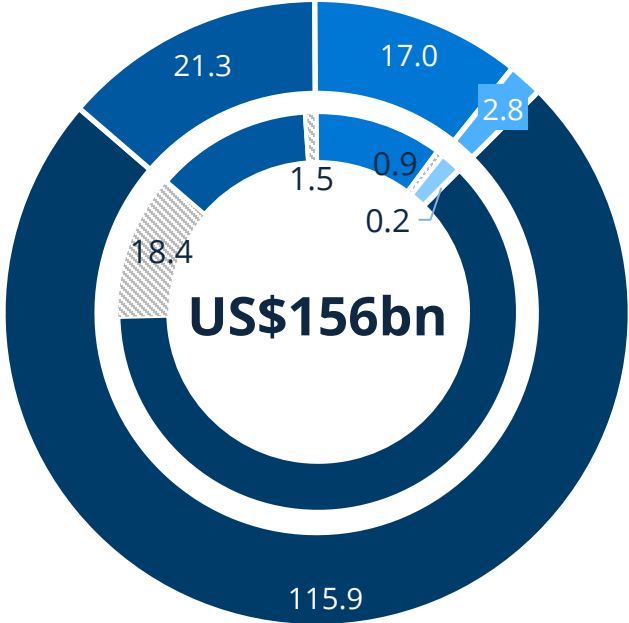
- ■ Mobile Games
- ■ Online Games
- ■ Download Games
- ■ Gaming Networks
- ▨ Covid impact

Growth rates and markets size before and after Russia-Ukraine war

Market size in 2027: US$285bn

17.4%
17.3%
10.7%
8.2%
11.7%
11.2%
8.8%
8.5%
5.8%
5.7%
4.9%
4.8%
4.6%
4.6%

War shock -2.5%-points

2021   2022   2023   2024   2025   2026   2027

— Before war   — After war
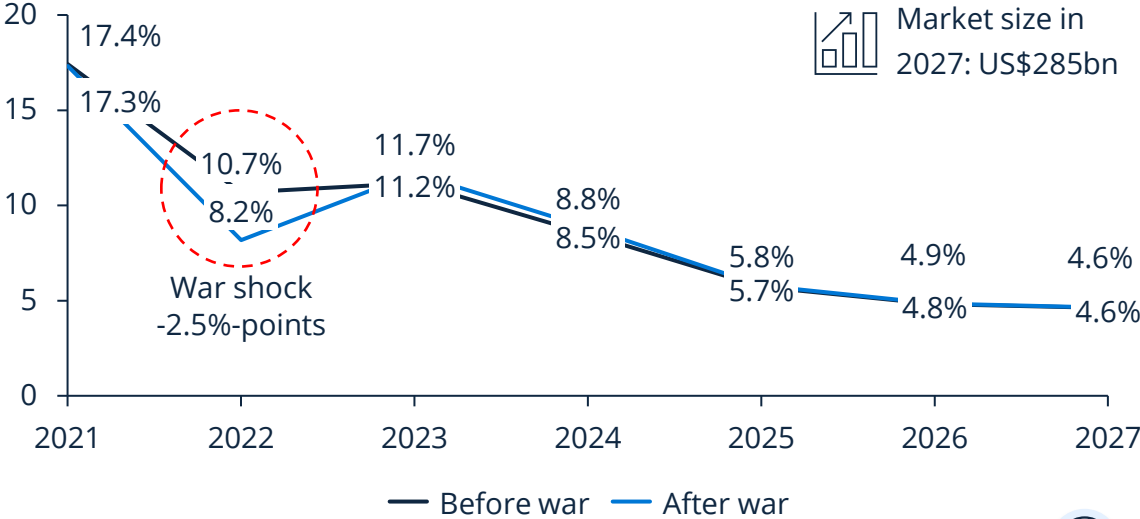
Even though the market is suffering a decline in growth rates in 2022, the market is expected to recover quickly and even show higher growth in 2023. In the long run, the market will bounce back to its normal level, ending up with a market size of US$285 billion in 2027.

statista

The U.S. will have the largest gaming market in 2027, but China will witness the strongest growth at 59%

Gaming market revenue comparison for top 5 countries in billion US$

U.S.
- 54.9
- 75.4 **+37%**

China
- 44.0
- 70.0 **+59%**

South Korea
- 39.9
- 54.1 **+36%**

Japan
- 12.0
- 17.3 **+44%**

U.K.
- 6.1
- 8.8 **+43%**

■ 2022 ■ 2027

statista
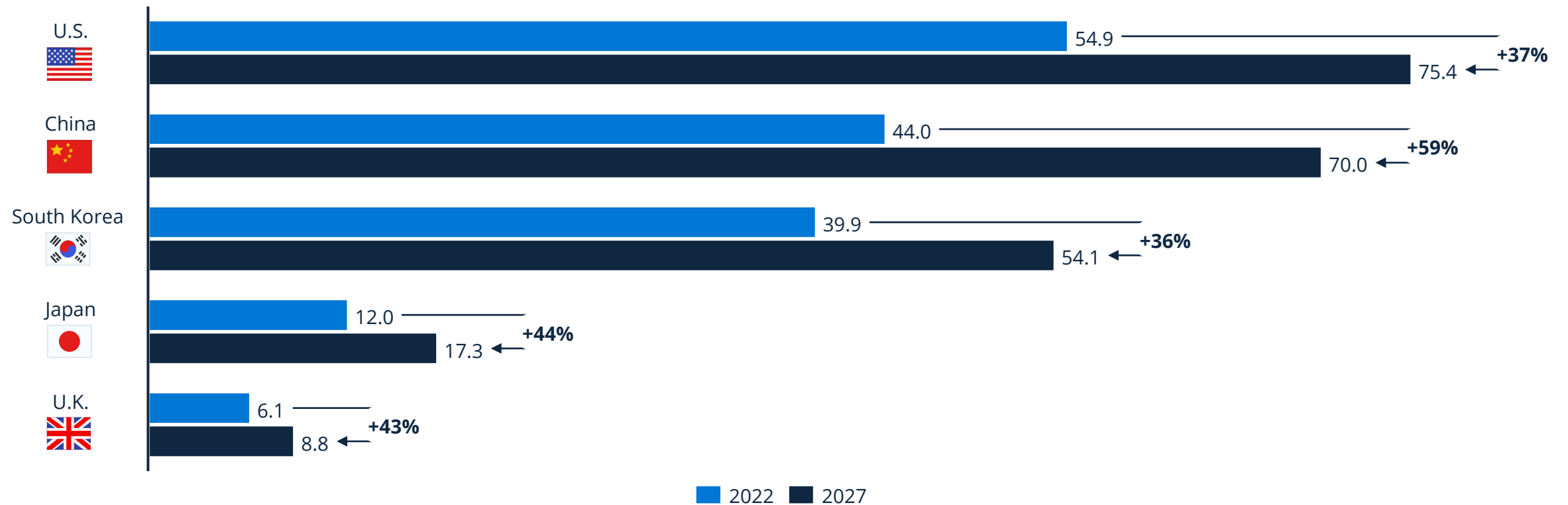
By 2027, 30% of gaming users will come from China, as roughly 34% come from Mobile Gaming alone

Gaming market user development in as percent share of total market

ROW(1) — 63% → 61% → 61%

China 🇨🇳 — 25% → 30% → 30%

U.S. 🇺🇸 — 8% → 6% → 5%

Japan 🇯🇵 — 4% → 3% → 3%

South Korea 🇰🇷 — 1% → 1% → 1%

2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
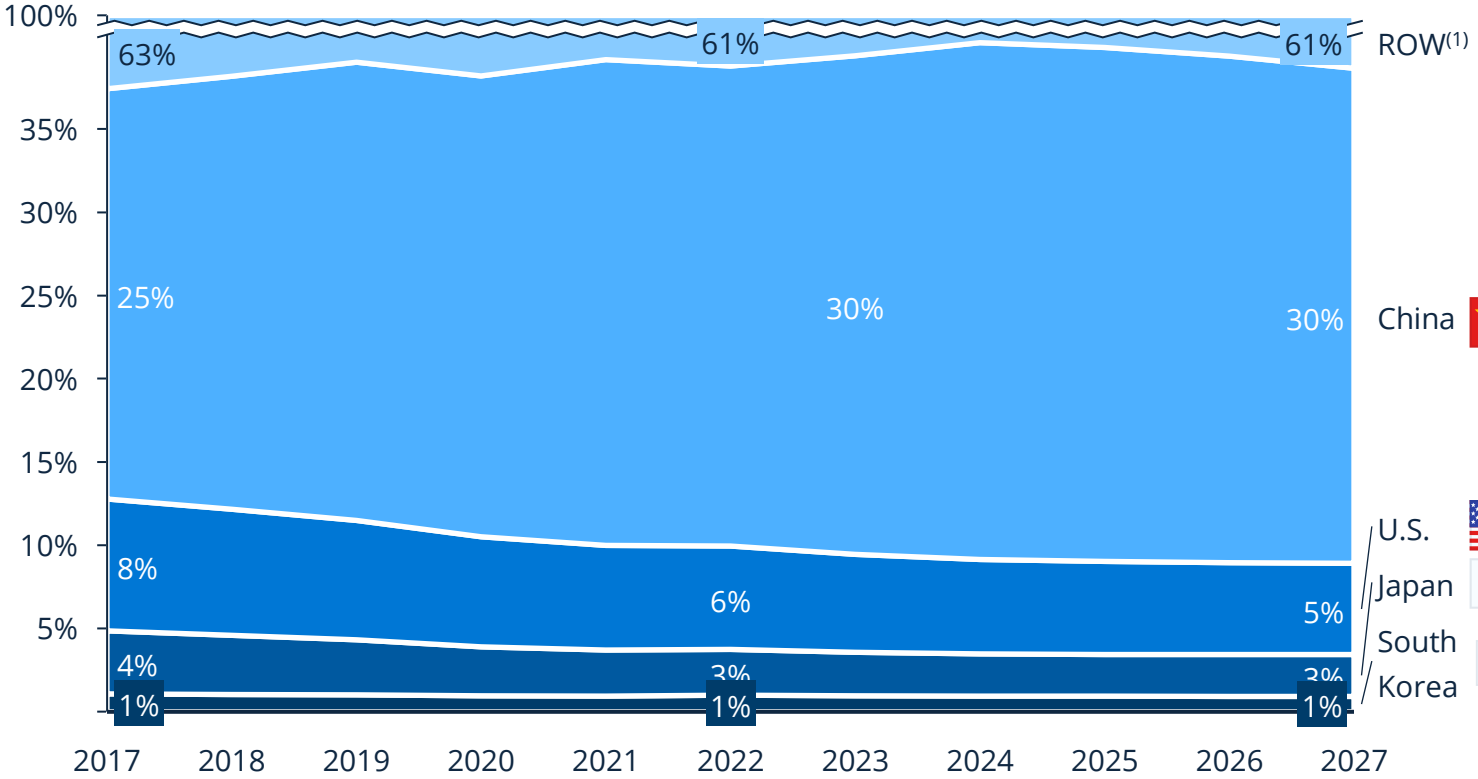
China and U.S. users by gaming segments in 2022

China 🇨🇳
- Online Games 26%
- Gaming Networks 1%
- Mobile Games 34%
- Download Games 18%
- Physical Video Games 21%

U.S. 🇺🇸
- Online Games 17%
- Gaming Networks 5%
- Mobile Games 35%
- Download Games 30%
- Physical Video Games 14%

statista
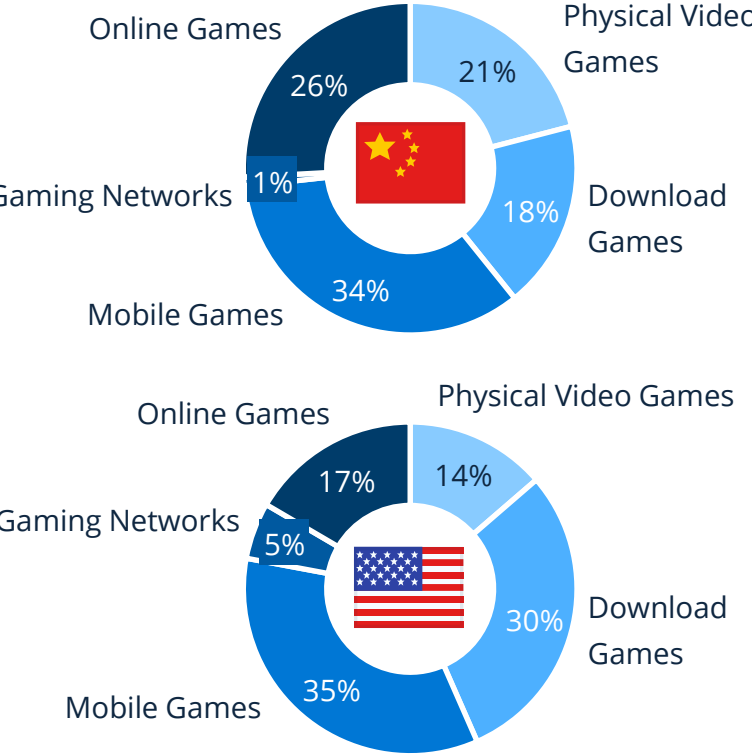
Overall gaming time in China is higher compared to other countries, as only 8% of the population plays less than an hour per week

Share from internet users of video gamers in %(1)

China
U.S.
South Korea
U.K.
Japan
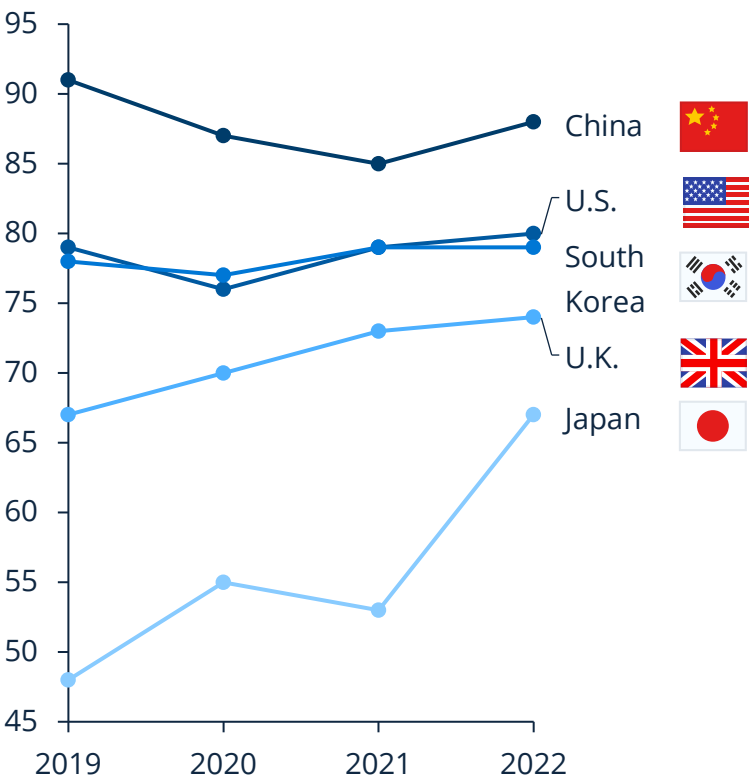
Average hours spent on gaming per week(2)

Country	Less than 1 hour	1 to 5 hours	6 to 10 hours	11 to 15 hours	16 to 20 hours	More than 20 hours
China	8%	31%	30%	18%	7%	7%
Japan	26%	36%	16%	8%	5%	9%
South Korea	28%	36%	18%	9%	4%	5%
U.K.	13%	34%	24%	13%	7%	7%
U.S.	12%	34%	24%	13%	8%	9%

Legend:
- Less than 1 hour
- 1 to 5 hours
- 6 to 10 hours
- 11 to 15 hours
- 16 to 20 hours
- More than 20 hours
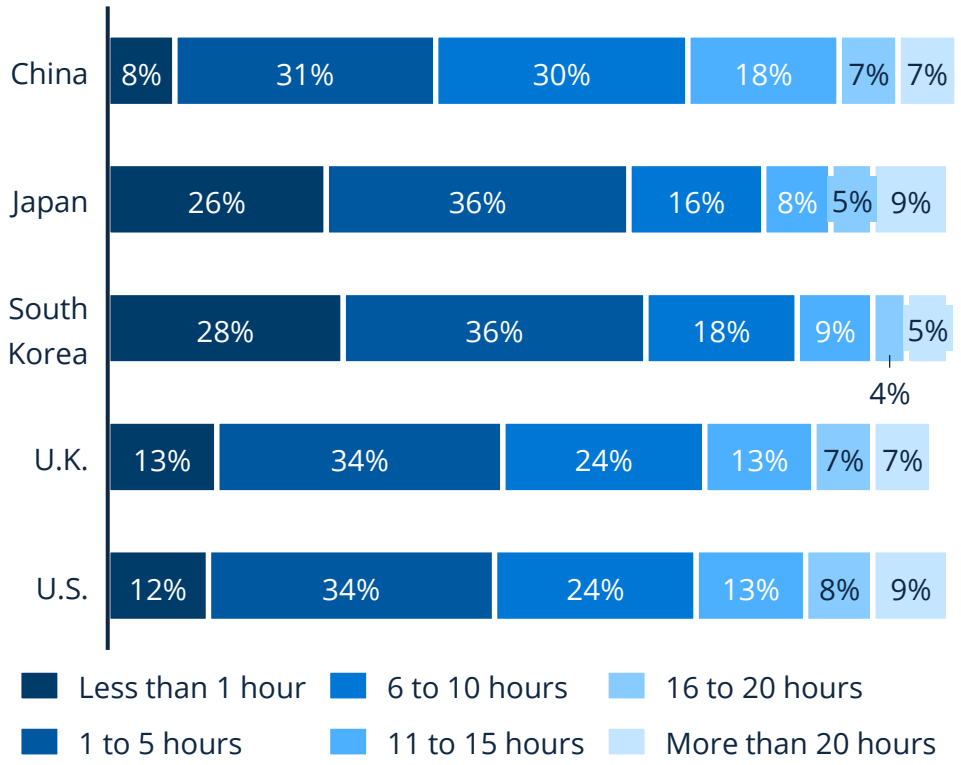
Distribution of video gamers in the United States in 2022, by age group
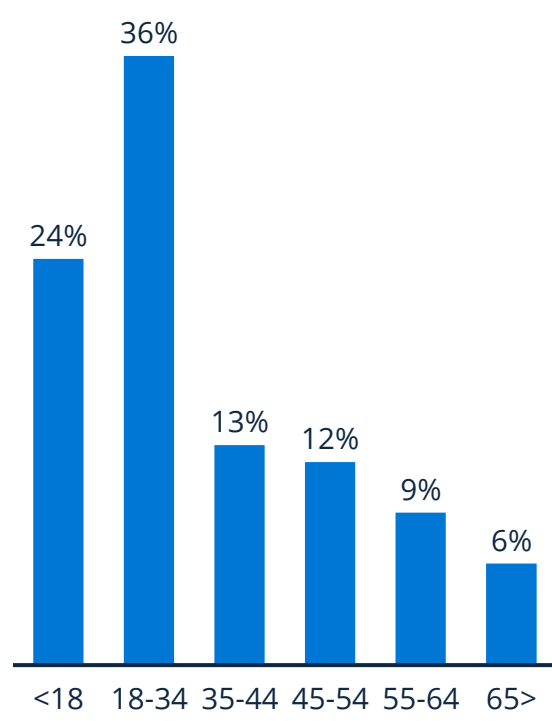
<18	18-34	35-44	45-54	55-64	65>
24%	36%	13%	12%	9%	6%

statista

The more you play, the more you pay: Frequent gamers are more likely to spend money on video games than occasional gamers

Demographics and purchase behavior in the US by gaming intensity[1]

Frequent gamer
- Male: 61%
- Female: 39%

Occasional gamer
- Male: 49%
- Female: 51%

Legend: ■ Male ■ Female

Frequent gamer
50%	45%	28%	27%	26%	20%

Occasional gamer
33%	24%	14%	16%	13%	40%

Legend:
- ■ Downloads
- ■ Subscriptions
- ■ Online games
- ■ In-game purchases
- ■ Games on a data medium (e.g. disc)
- ■ No Purchase
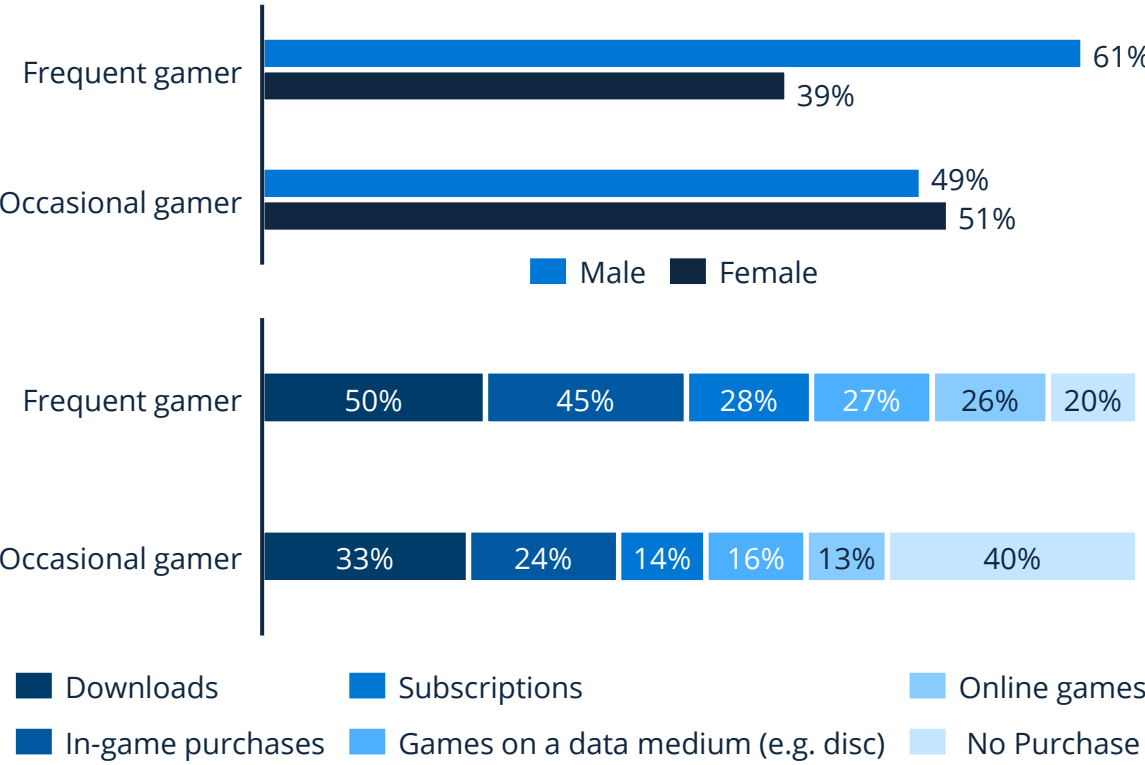
US In-app purchases in billion US$ and in-game purchases[2] by device 2022
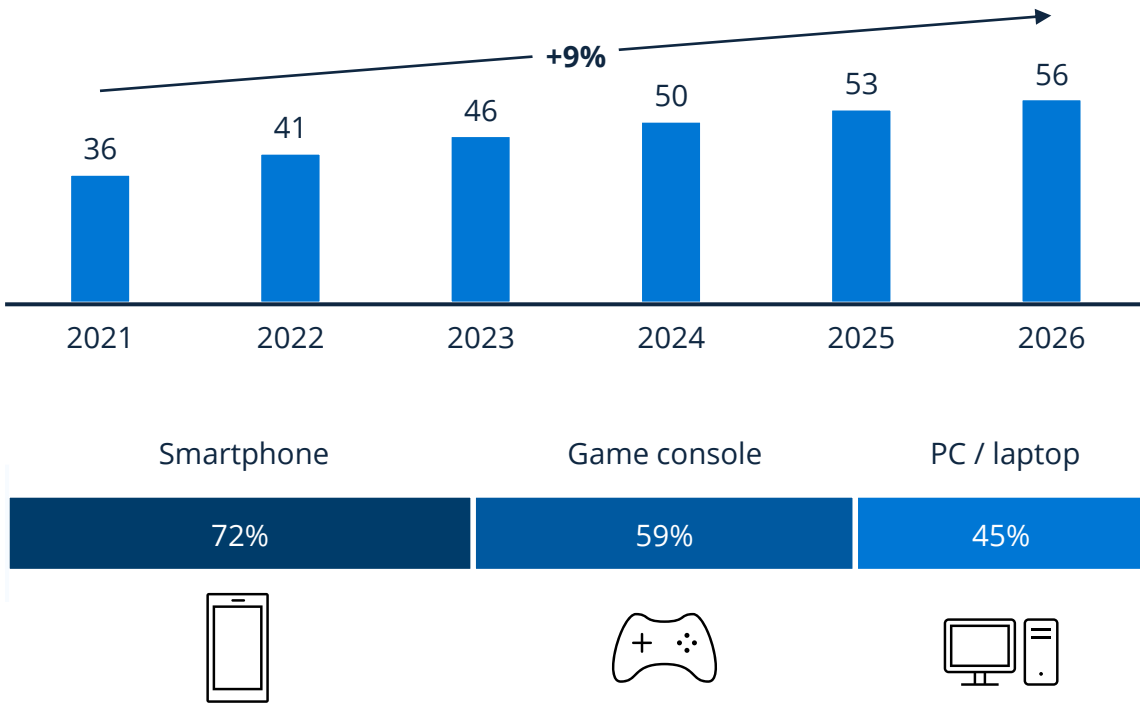
+9%

2021	2022	2023	2024	2025	2026
36	41	46	50	53	56

Smartphone	Game console	PC / laptop
72%	59%	45%

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The gaming industry is mainly divided into game developers and community-centric services, which cater to the needs and wants of consumers

Key players in the gaming industry

Game Engines	Developers & Publishers	Distribution Platforms	Game Consoles	Hardware & Tech

Broadcasting & Streaming	Communication & News	Events	Esports Leagues	Esports Organizations

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With Call of Duty and PUBG Mobile, first-person shooter games exhibit the highest revenues across platforms

Highest-earning PC and console[1] games in 2020, worldwide

1   **Call of Duty Modern Warfare: US$1.91bn** | First person shooter with around 8 million monthly users
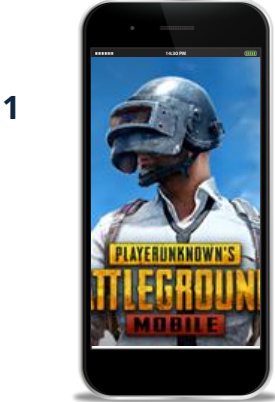
2   **FIFA 20: US$1.08bn** | Football simulation game with almost 25% of player base from the U.S.
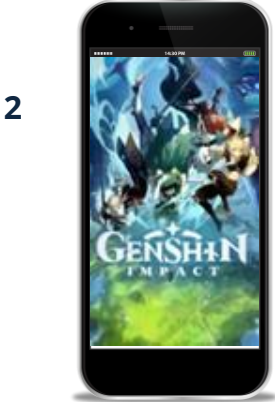
3   **Grand Theft Auto 5: US$0.89bn** | Open world game which is on the market since 2013
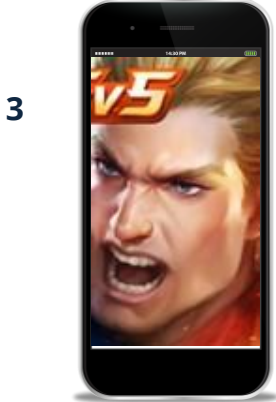
Highest-earning mobile games in 2021, worldwide

1   **PUBG Mobile: US$2.01bn**

First-person shooter with a total of 961 million downloads

2   **Genshin Impact: US$1.33bn**

Role-play game where 36% of in-app revenues come from China
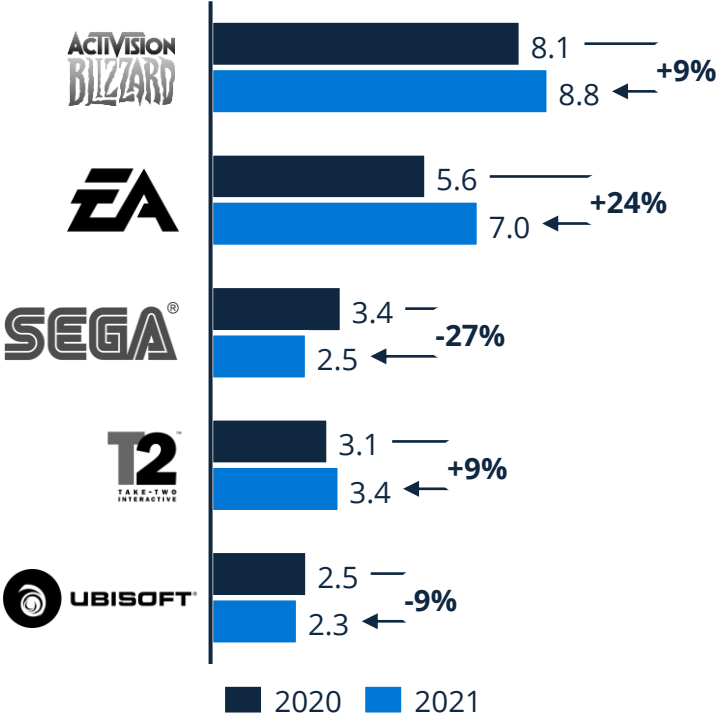
3   **Honor of Kings: US$1.64bn**

Role-play game with 99% of users and revenue from China

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Game studio juggernauts adapt to the freemium business model to capture a wider user base and increase their potential margins

Popular game developers by revenue in billion US$

ACTIVISION BLIZZARD
- 8.1 (2020)
- 8.8 (2021) **+9%**

EA
- 5.6 (2020)
- 7.0 (2021) **+24%**

SEGA
- 3.4 (2020)
- 2.5 (2021) **-27%**

T2 TAKE-TWO INTERACTIVE
- 3.1 (2020)
- 3.4 (2021) **+9%**

UBISOFT
- 2.5 (2020)
- 2.3 (2021) **-9%**

■ 2020 ■ 2021

Activision Blizzard diversifies its business model

With the release of Call of Duty Warzone (the first free-to-play add-on) in March 2020, Activision Blizzard changed its strategic direction to drive high profitability and top-line growth. In general, video game companies observe a seasonal revenue stream generated after game/add-on releases. Two key advantages emerge with the freemium model:
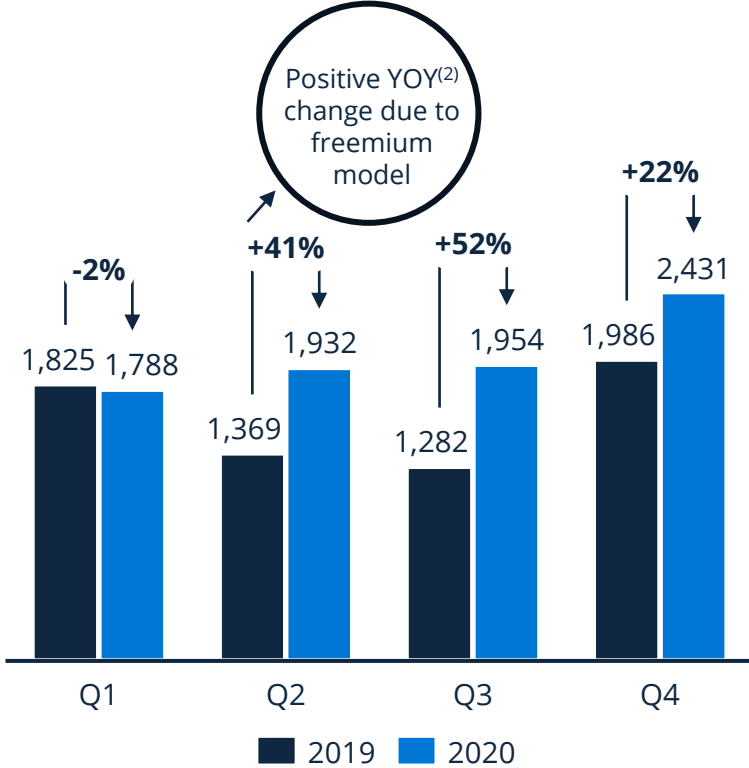
- It introduces scalability to the revenue stream of Activision Blizzard and is assisted by the in-game marketplace offering sales of customized weapons and characters.

- This model greatly increases the potential margins for the business while also increasing its user reach to the TAM[1].

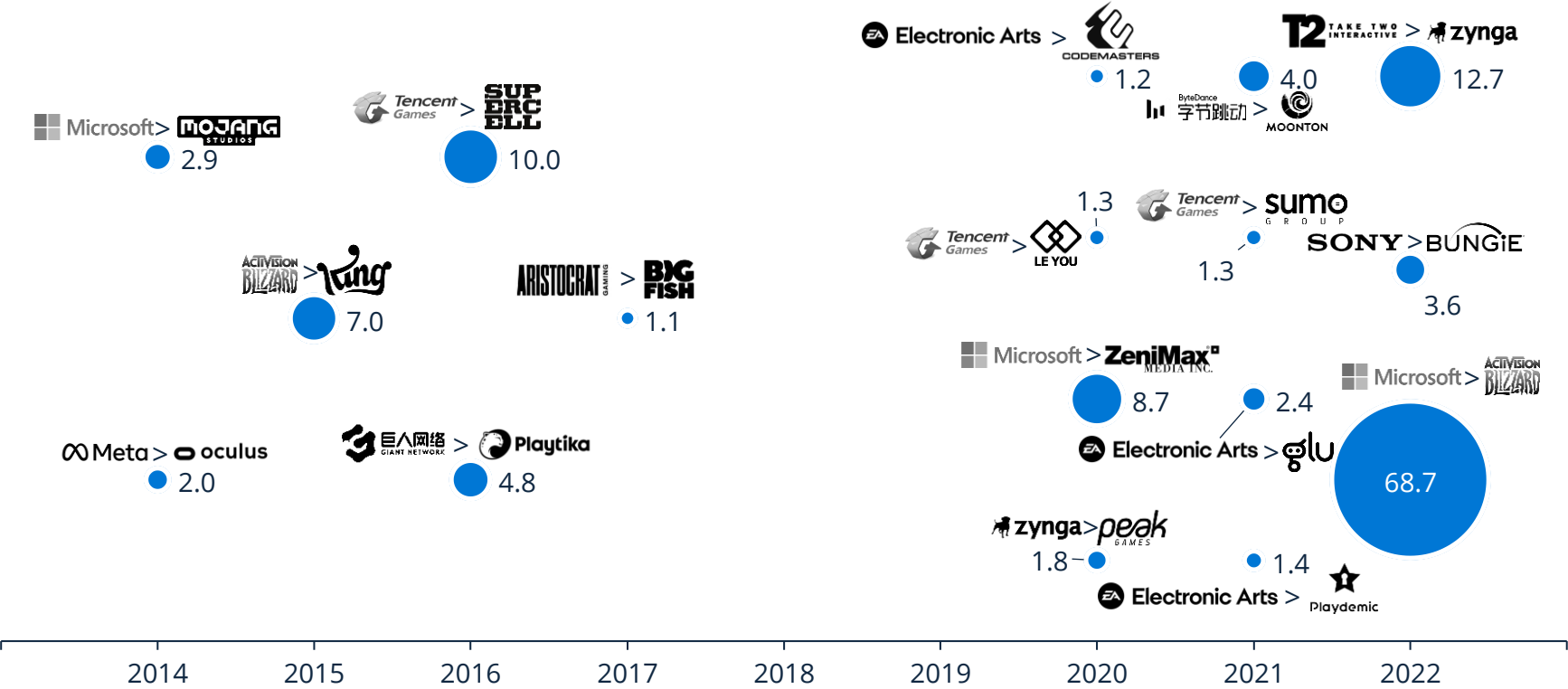## Activision Blizzard quarterly revenue in billion US$

Positive YOY[2] change due to freemium model

Q1
- 1,825 (2019)
- 1,788 (2020) **-2%**

Q2
- 1,369 (2019)
- 1,932 (2020) **+41%**

Q3
- 1,282 (2019)
- 1,954 (2020) **+52%**

Q4
- 1,986 (2019)
- 2,431 (2020) **+22%**

■ 2019 ■ 2020

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Microsoft's deal to buy gaming giant Activision Blizzard has been the most expensive one in the history of gaming development

Biggest acquisitions in the gaming industry in billion US$

Electronic Arts > CODEMASTERS — 1.2

字节跳动 ByteDance > MOONTON

T2 TAKE TWO INTERACTIVE > zynga — 12.7

4.0

Other notable deals < US$1bn

- Pearl Abyss acquired CCP in 2018 for US$448m

- Zynga acquired Small Giant in 2018 for US$738m

- Macarthur Fortune acquired Jagex in 2020 for US$542m

- Embracer Group acquired Saber Interactive in 2020 for US$537m Easybrain in 2021 for US$640m and in 2022 Eidos, Crystal Dynamics and Square Enix for US$300m

Microsoft > MOJANG STUDIOS — 2.9

Tencent Games > SUPERCELL — 10.0

ACTIVISION BLIZZARD > King — 7.0

ARISTOCRAT GAMING > BIG FISH — 1.1

Tencent Games > LE YOU — 1.3

Tencent Games > SUMO GROUP — 1.3

SONY > BUNGIE — 3.6

Microsoft > ZeniMax MEDIA INC. — 8.7

Electronic Arts > glu — 2.4

Microsoft > ACTIVISION BLIZZARD — 68.7

Meta > oculus — 2.0

巨人网络 GIANT NETWORK > Playtika — 4.8

zynga > peak GAMES — 1.8

Electronic Arts > Playdemic — 1.4

2014   2015   2016   2017   2018   2019   2020   2021   2022

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Alongside established players in the gaming industry, big tech is increasingly taking the full-stack road as market potential and consumer demand grow

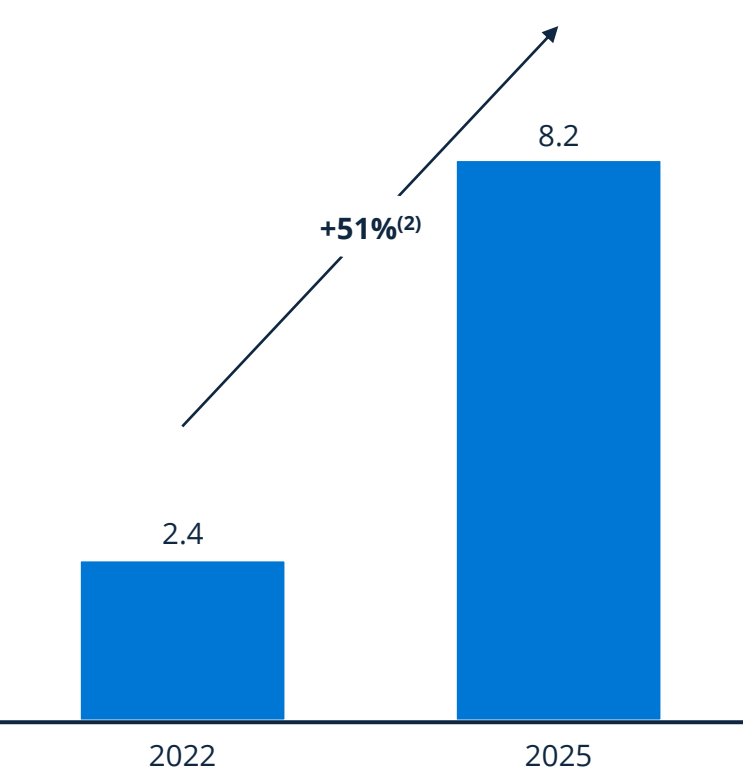**Selected gaming incumbents and big tech player's presence in gaming ecosystem**

Key player	Game publisher	Console	App Store	Subscription Service	Game Video	Cloud Gaming	AR & VR Device	Virtual Worlds
amazon	amazon game studios		amazon appstore	prime gaming / luna	twitch	luna		
Apple			App Store	Arcade			Glasses	
Google			Google Play	Google Play Pass	YouTube		GLASS	
Meta	READYATDAWN studios		Meta Quest Store		FACEBOOK GAMING	FACEBOOK GAMING	Meta Quest / oculus	horizon Worlds
Microsoft	XBOX GAME STUDIOS	XBOX	Microsoft Store	XBOX GAME PASS / XBOX LIVE GOLD / CLOUD GAMING		CLOUD GAMING	Microsoft HoloLens	MINECRAFT / AltspaceVR
NETFLIX	NETFLIX GAMES			NETFLIX				
Nintendo	Nintendo	NINTENDO SWITCH	Nintendo eShop	ONLINE Nintendo Switch Online		ONLINE Nintendo Switch Online	NINTENDO LABO	
SONY	SONY Interactive Entertainment	PlayStation	PlayStation Store	PlayStation Plus		PlayStation Now	PlayStation VR	
Tencent 腾讯	Tencent Games	logitech G Cloud handheld	应用宝 myapp.com	START	斗鱼 DOUYU.COM / HUYA	START	ultraleap	
VALVE	VALVE	STEAM DECK	STEAM		STEAM TV	STEAM Cloud Play	STEAM VR / VIVE	garry's mod

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Although cloud gaming presents a massive market opportunity for the gaming industry, big tech companies are struggling to ride this wave
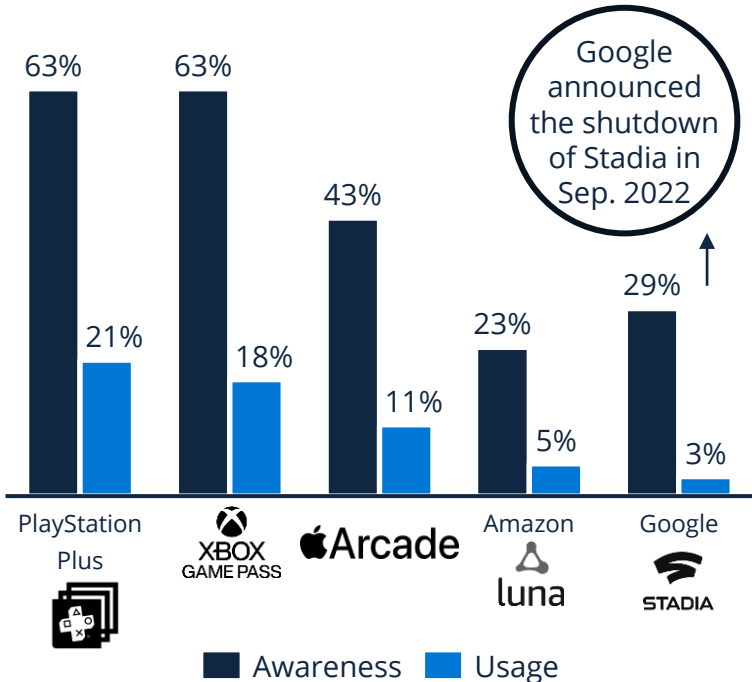
Global SOM[1] in terms of users in millions

SOM [1]
- 220.2
- 464.9 **+111%**

Paying users
- 31.7
- 86.9 **+174%**

■ 2022 ■ 2025
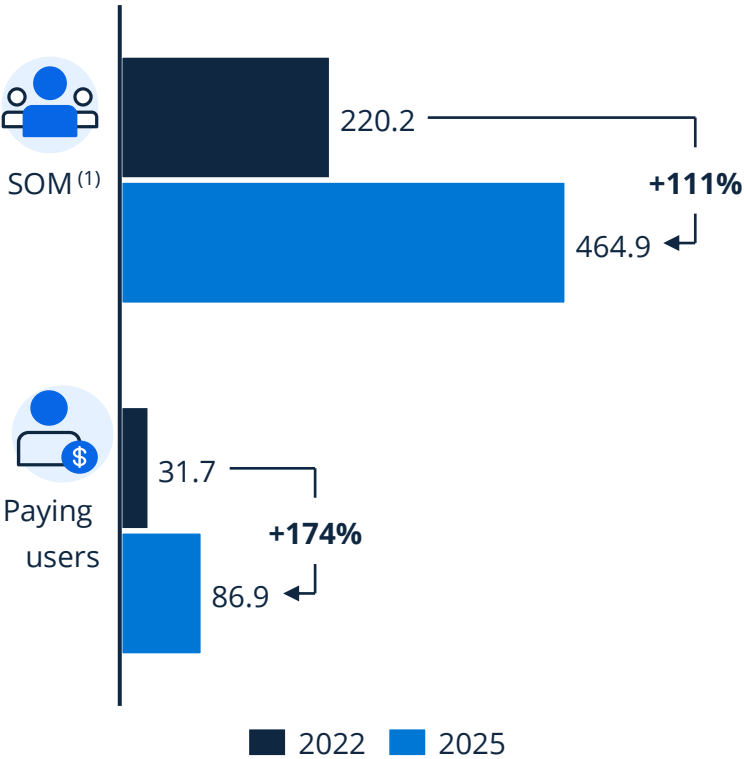
Cloud gaming revenue forecast in billion US$

+51%[2]

2022: 2.4
2025: 8.2

Consumer adoption and awareness of cloud gaming in the U.S.[3]

Google announced the shutdown of Stadia in Sep. 2022

- PlayStation Plus: 63% / 21%
- XBOX GAME PASS: 63% / 18%
- Arcade: 43% / 11%
- Amazon luna: 23% / 5%
- Google STADIA: 29% / 3%

■ Awareness ■ Usage

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Major tech companies have developed their own cloud gaming and subscription services to compete for multiplayer and cross-platform gamers

Timeline for most prominent subscription services initiatives in gaming
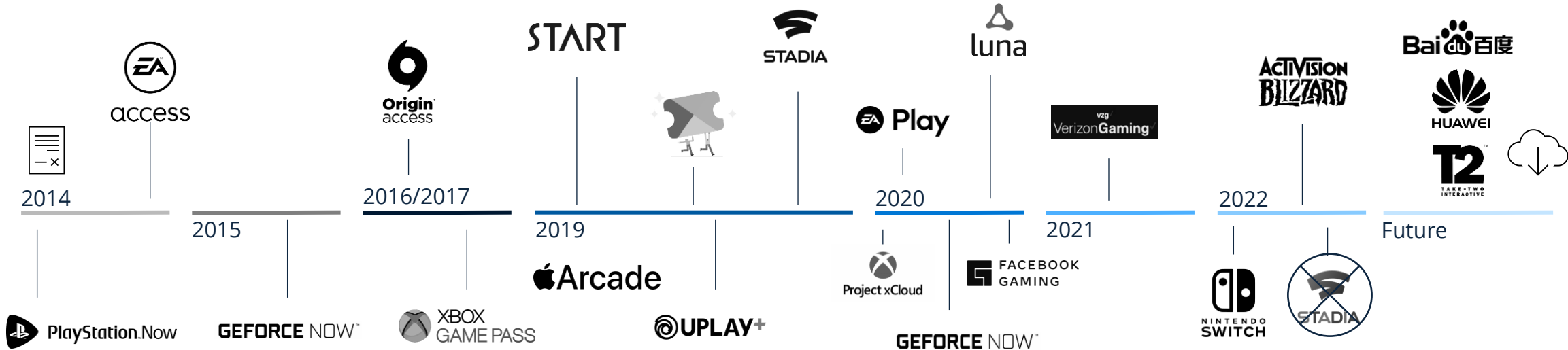
ⓘ From 2014 to 2017, gaming subscription services provided downloaded content for a monthly fee. With the advent of console gaming, companies took advantage of having users already on the platform.

ⓘ In 2019, as technology progressed, business models shifted to cloud gaming. mobile gaming companies joined the race for demand, accelerating the growth of multiplayer and cross-platform gaming.

ⓘ Towards the end of 2022, user momentum slowed. Google announced they would be ceasing operations of Stadia. New entrants are struggling to fight against established players.

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The integration of in-game social activities is paving a new path for the future of the gaming industry

Video games are creating virtual shared spaces to facilitate social interactions

Banking · Music · Social · Dating · Shopping · Messaging · Learning · eSports

In-game digital engagement
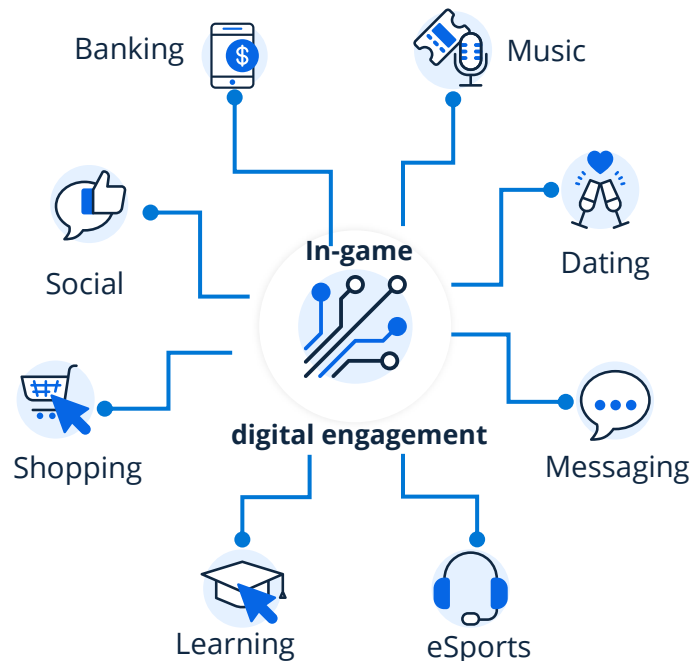
Examples of human interactions in virtual worlds

Music

The Gathering tech conference hosted its first live concert in Minecraft in **2016**

TV & Video

Black Mirror: Bandersnatch introduced an interactive fiction game episode in **2018**

eSports

The annual eSports world competition, the International Dota 2 Championships, started in **2011**

Lifestyle

Age of Wushu introduced in-game marriages in **2021**

Motivation among gamers to start a new game

Good reviews	39%
Friends play	31%
Latest release of a series	22%
Favorite streamer plays	20%
Favorite studio	14%
Kids play	12%
Parents/siblings plays	8%

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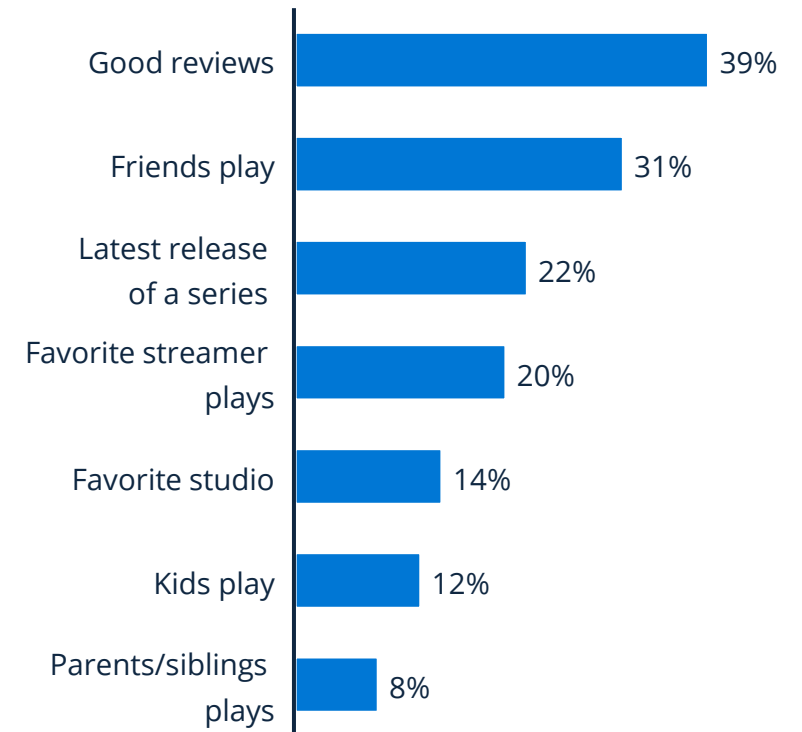
Communication platforms built to support the gaming community are now turning into social hubs for young people
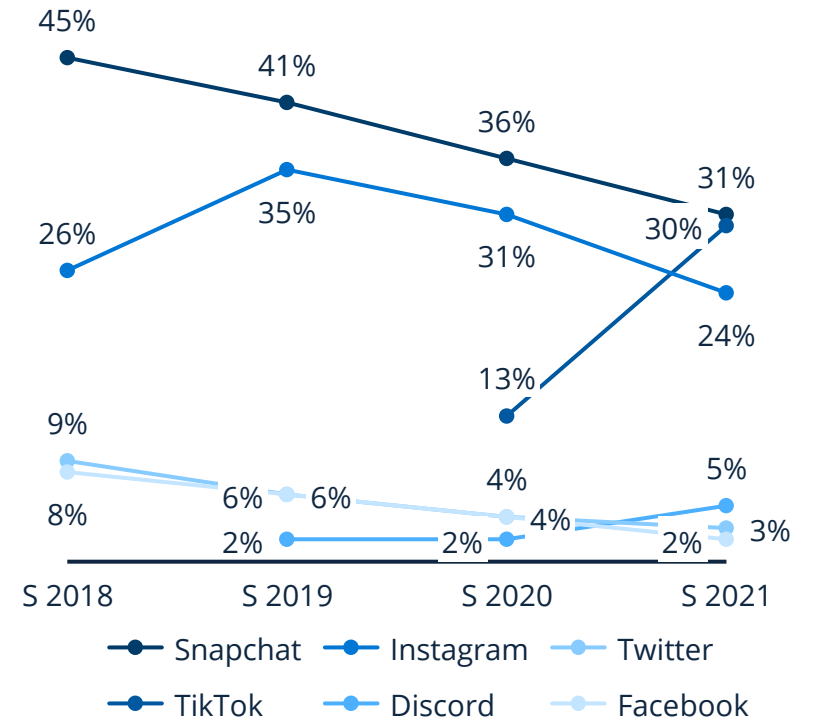
Discord market size development

- 2016: 5
- 2017: 10 / 10
- 2018: 45 / 30
- 2019: 56 / 45
- 2020: 100 / 130
- 2021: 300 / 140

— ● — Annual monthly active users (in millions)

■ Revenue (in million US$)
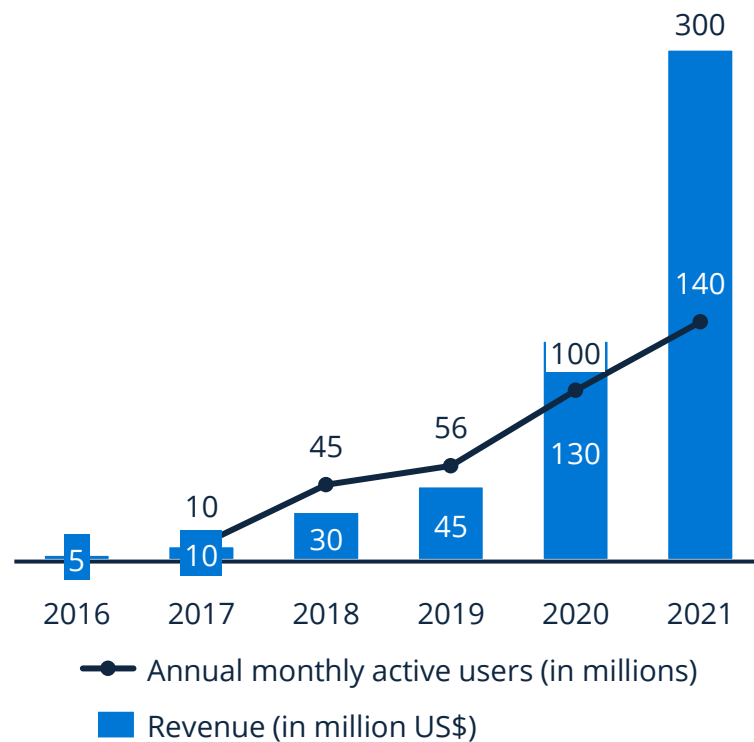
Discord's business model

Discord declared revenues of US$131 million in 2020, which was three times more than the previous year. However, this revenue wasn't from ads; instead, the platform generated revenue from other sources such as:

- Subscription packages & server boosting: Priced at US$9.99/month to US$99.99/year, Nitro users enjoy custom emojis & tags, an animated avatar, two server boosts, and go-live streaming.

- Distribution feeds from game stores: Discord receives a 10% commission from titles that game developers sell through verified servers on Discord.

- Ticket sales for virtual events: In 2021, Discord piloted a new feature that allowed users to sell tickets for virtual audio events, where other users could purchase tickets to join in as listeners.
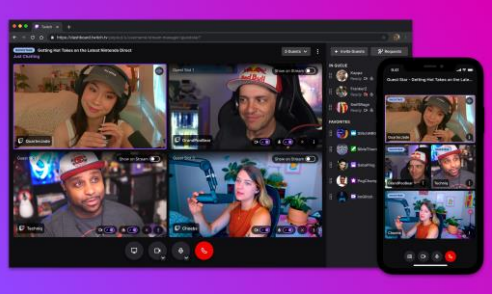
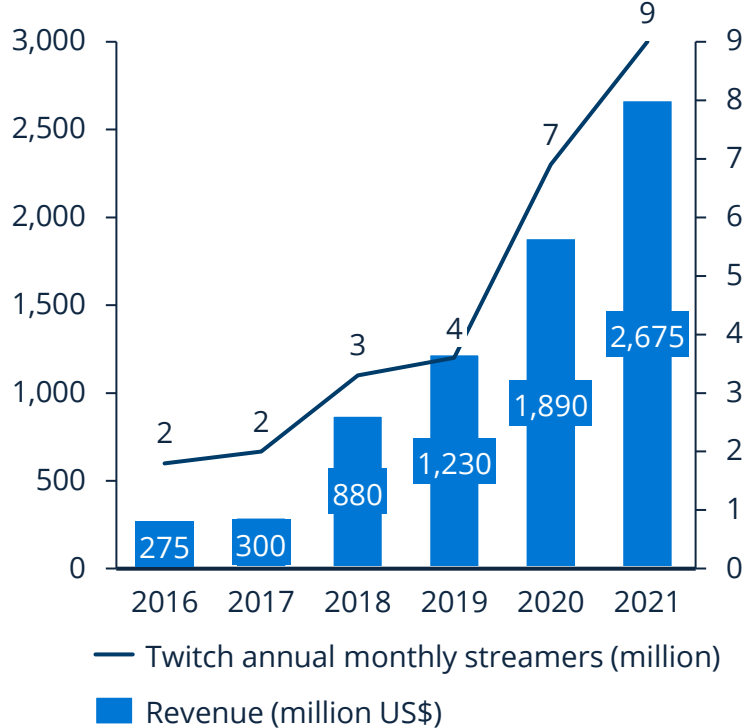## Preference of social media platforms among U.S. teens

- Snapchat: 45%, 41%, 36%, 31%
- Instagram: 26%, 35%, 31%, 24%
- Twitter: 9%, 6%, 6%, 30%
- TikTok: 13%, 5%
- Discord: 8%, 2%, 2%, 4%, 2%
- Facebook: 4%, 3%

S 2018　S 2019　S 2020　S 2021

— ● — Snapchat   — ● — Instagram   — ● — Twitter
— ● — TikTok   — ● — Discord   — ● — Facebook

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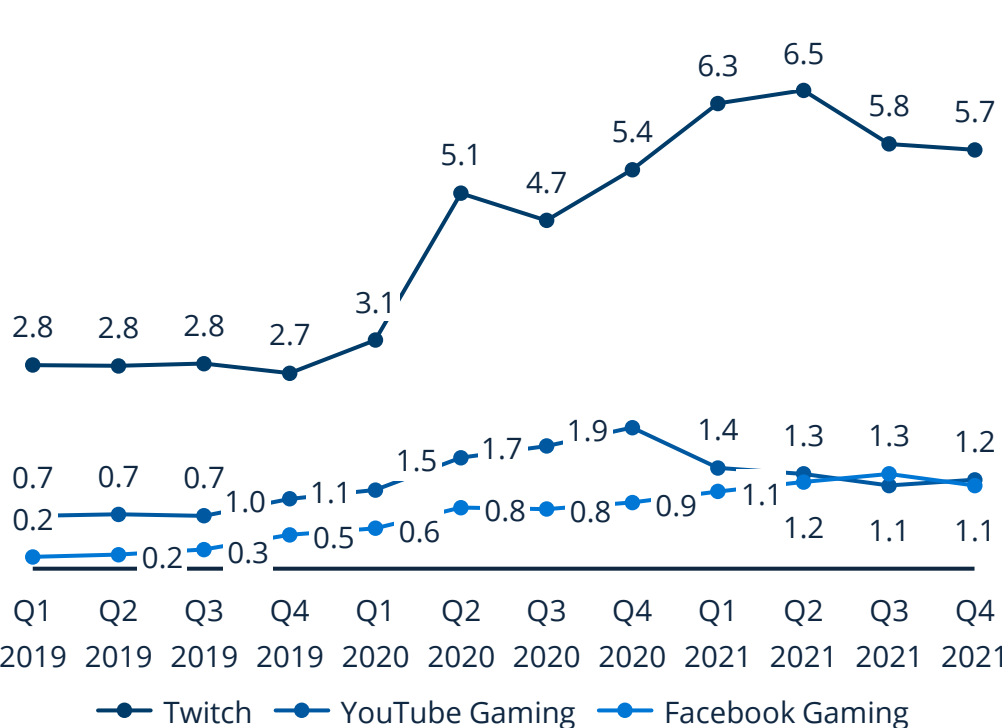## Twitch: video streaming platform built for gaming and viewing eSports competitions

Twitch, an American video live-streaming service with an emphasis on video game live streaming, also includes broadcasts of eSports competitions. Additionally, it offers music broadcasts, creative content, and livestreams. It is a subsidiary of Amazon.

Twitch market size development

Revenue (million US$): 275 (2016), 300 (2017), 880 (2018), 1,230 (2019), 1,890 (2020), 2,675 (2021)

Twitch annual monthly streamers (million): 2 (2016), 2 (2017), 3 (2018), 4 (2019), 7 (2020), 9 (2021)

— Twitch annual monthly streamers (million)

■ Revenue (million US$)

Video streaming quarterly hours watched in billions

Twitch: 2.8, 2.8, 2.8, 2.7, 3.1, 5.1, 4.7, 5.4, 6.3, 6.5, 5.8, 5.7

YouTube Gaming: 0.7, 0.7, 0.7, 1.0, 1.1, 1.5, 1.7, 1.9, 1.4, 1.3, 1.3, 1.2

Facebook Gaming: 0.2, 0.2, 0.3, 0.5, 0.6, 0.8, 0.8, 0.9, 1.1, 1.2, 1.1, 1.1

Quarters: Q1 2019, Q2 2019, Q3 2019, Q4 2019, Q1 2020, Q2 2020, Q3 2020, Q4 2020, Q1 2021, Q2 2021, Q3 2021, Q4 2021

● Twitch ● YouTube Gaming ● Facebook Gaming

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The world of eSports can mainly be divided in 5 components, whereas YouTube and Twitch are the most prominent platforms to view eSports

Overview of the eSports world

Events such as championships and other tournaments pay out massive prize money for teams, e.g., ESL One and World Championship

Publishers merge and enter the professional gaming market with their games, e.g., Activision Blizzard (Call of Duty) and Riot Games (League of Legends)
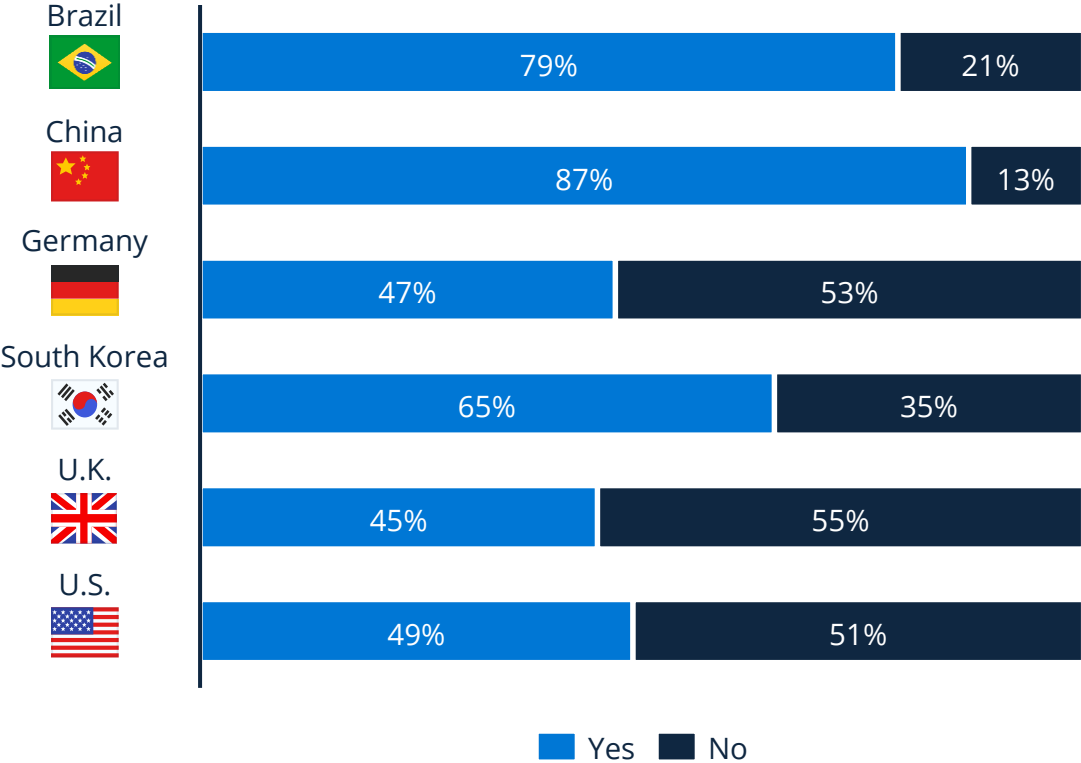
No longer just about gaming, eSports teams have become stock-listed companies with over US$50 million in revenue, e.g., Cloud9 and FaZe Clan

Regular leagues have been established to compete against each other and win prizes, e.g., ESL and Rocket League Championship Series

Channels

Events

Publishers

Teams

Leagues

Sources: Newzoo

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China has the highest interest in eSports at 87% followed by Brazil with 79%, and the market is expected to reach a revenue of US$2.2 billion by 2027

Interest in eSports in 2022[1]

Country	Yes	No
Brazil	79%	21%
China	87%	13%
Germany	47%	53%
South Korea	65%	35%
U.K.	45%	55%
U.S.	49%	51%

■ Yes ■ No

Global eSports users and revenue in million US$
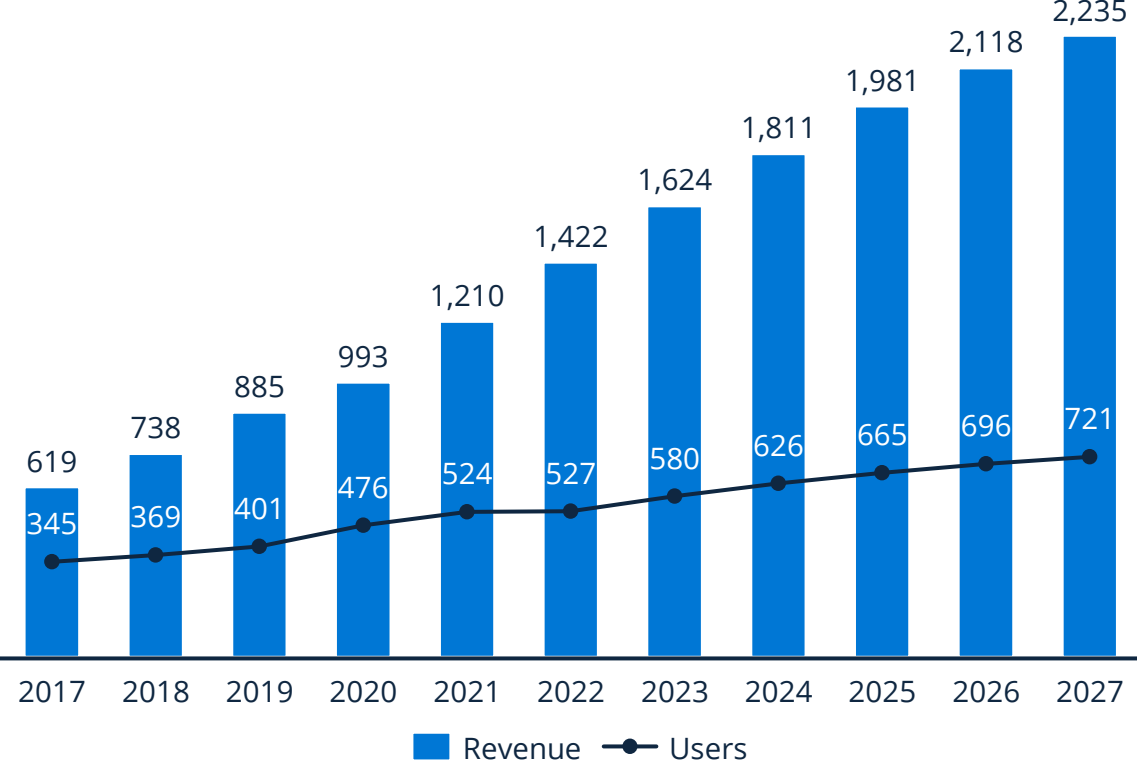
Year	Revenue	Users
2017	619	345
2018	738	369
2019	885	401
2020	993	476
2021	1,210	524
2022	1,422	527
2023	1,624	580
2024	1,811	626
2025	1,981	665
2026	2,118	696
2027	2,235	721

■ Revenue ━●━ Users

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Rapid advancements in the gaming sector are driving the future of the total immersive gaming experience

Changing landscape of the gaming industry

Drivers influencing the future of gaming

Cloud Gaming

eSports

Mobile Gaming

Social Interactions

Immersive Gaming Experience

Video games transport the player into an alternate virtual world where techniques are used to make them feel like the character they're playing.

Technology enablers for next level gaming

Virtual Reality (VR[1])

Augmented Reality (AR[2])

● Drivers ● Enablers

Notes: (1) VR: Virtual Reality; (2) AR: Augmented Reality

Sources: Statista Advertising & Media Outlook 2022

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AR & VR spawned a game revolution and forged a path to the Metaverse

In the past few years, several new technologies have emerged to enhance the consumer experience. Without a doubt, augmented and virtual reality set a foundation for future developments and are a key part of today's technologies. In 2015, many VR possibilities started becoming widely available to the general public, and the market has been growing ever since. More and more developers are working on AR & VR solutions and headsets are now a significant part of today's society. The market is far from reaching its full potential and will continue its growth path as penetration rates increase. One key use case is gaming: starting in 2020 with the launch of the first major VR game, many consumers experienced AR & VR gaming. A more realistic and interactive gaming experience has been attracting gamers around the globe. In the future, technology will develop further and become more accessible to consumers.

New technologies will enhance the gaming experience and will lay down the foundation for new gaming concepts and other applications

Extended reality use case overview

Virtual Reality (VR)

Completely digital environment

- Works with a headset device connected to a PC
- Virtual reality places the user in a completely digital environment
- This results in a fully enclosed environment and a synthetic experience with no sense of the real world

Augmented Reality (AR)

Real world with digital information overlay

- Smartphones and glasses are predominantly used to combine real-world surroundings with digital information
- The real world remains at the center of AR, but digital components enhance the experience

Mixed Reality (MR)

Real and the virtual are intertwined

- Virtual objects are integrated into the natural world and viewed through special glasses
- Objects can be responsive and interactive
- Mixed reality interacts with the environment and alters it at the same time

Gaming

VR enables a greater gaming experience by having games more realistic and interactive

By enhancing games with AR technology, they become more complex and immersive

Similar features as AR in gaming, overall, it will path new ways of gaming and beyond

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While the primary focus of AR is currently mobile games, the application of VR centers upon PCs and other consoles such as PlayStations and Xboxes

Augmented Reality (AR) gaming use cases

Augmented Reality technology is used to connect the real world with the digital world, mainly using smartphone cameras. However, AR glasses can be used to improve that experience. Popular games are Pokémon Go, Jurassic World Alive, and Walking Dead Our World.

Virtual Reality (VR) gaming use cases

Virtual Reality technology enables consumers to dive into the virtual world, not only visually but also interactively and with sound. For that, headsets or even fully installed stations with controllers are needed. Popular games on VR are Half Life Alyx, Skyrim VR, and Beat Saber.

Pokémon Go

is a location-based game where players can catch Pokémons throughout the world

Jurassic World Alive

is a similar gaming concept as Pokémon Go, but with dinosaurs

Walking Dead Our World

is a location-based survival game

Half Life Alyx

is an ego-shooter game that needs an installed unit to physically interact

Skyrim VR

is an open-world game that also needs a fully installed unit

Beat Saber

is a musical game by Reality Labs (part of Meta) for PC, PlayStation, and Oculus Quest

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The AR & VR market is still emerging and expected to grow further, and Apple will boost consumers' demands with new AR glasses in 2023

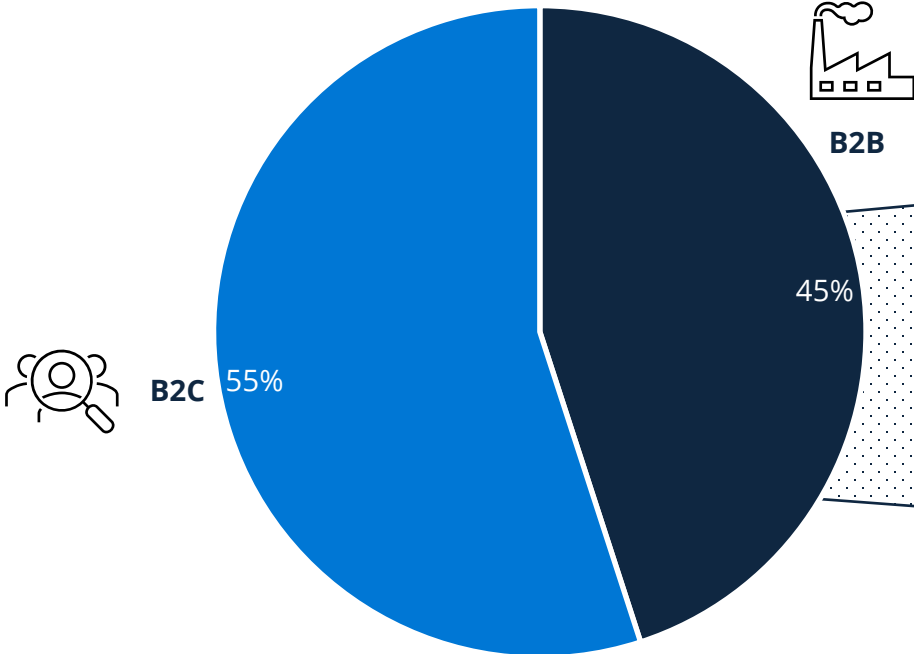**Global AR & VR revenue development in billion US$[1]**
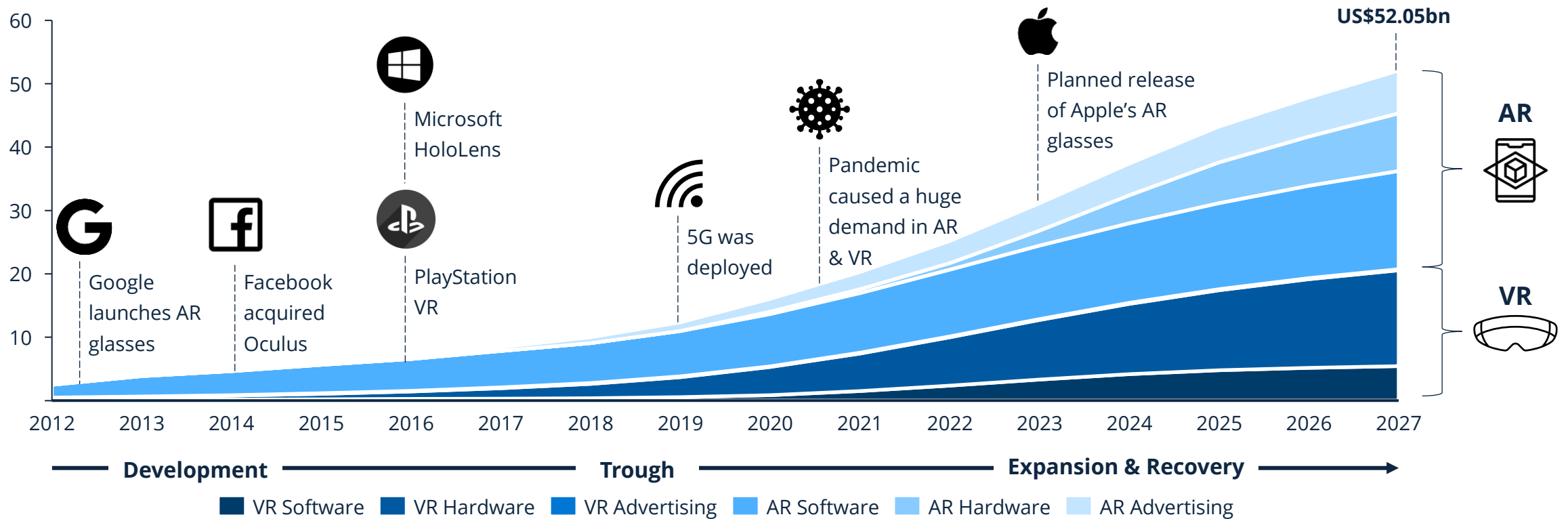
Google launches AR glasses

Facebook acquired Oculus

Microsoft HoloLens

PlayStation VR

5G was deployed

Pandemic caused a huge demand in AR & VR

Planned release of Apple's AR glasses

US$52.05bn

AR

VR

Development **Trough** **Expansion & Recovery**

■ VR Software ■ VR Hardware ■ VR Advertising ■ AR Software ■ AR Hardware ■ AR Advertising

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The AR & VR market is split nearly equally between B2B and B2C, whereas the electronics industry covers almost one third of the market

AR & VR market shares by B2B and B2C in 2022
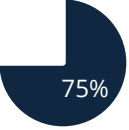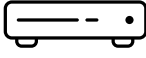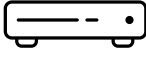
AR & VR market shares by industry in 2022

B2C 55%

45%

B2B

- Electronics 32%
- Service Industry 13%
- Other 11%
- Manufactoring 10%
- E-Commerce 5%
- Government 5%
- Social Media 5%
- Advertising 5%
- Telecommunications 5%
- Robotics 2%
- Gaming 2%
- Health Care 2%
- Training 2%
- E-Learning 2%

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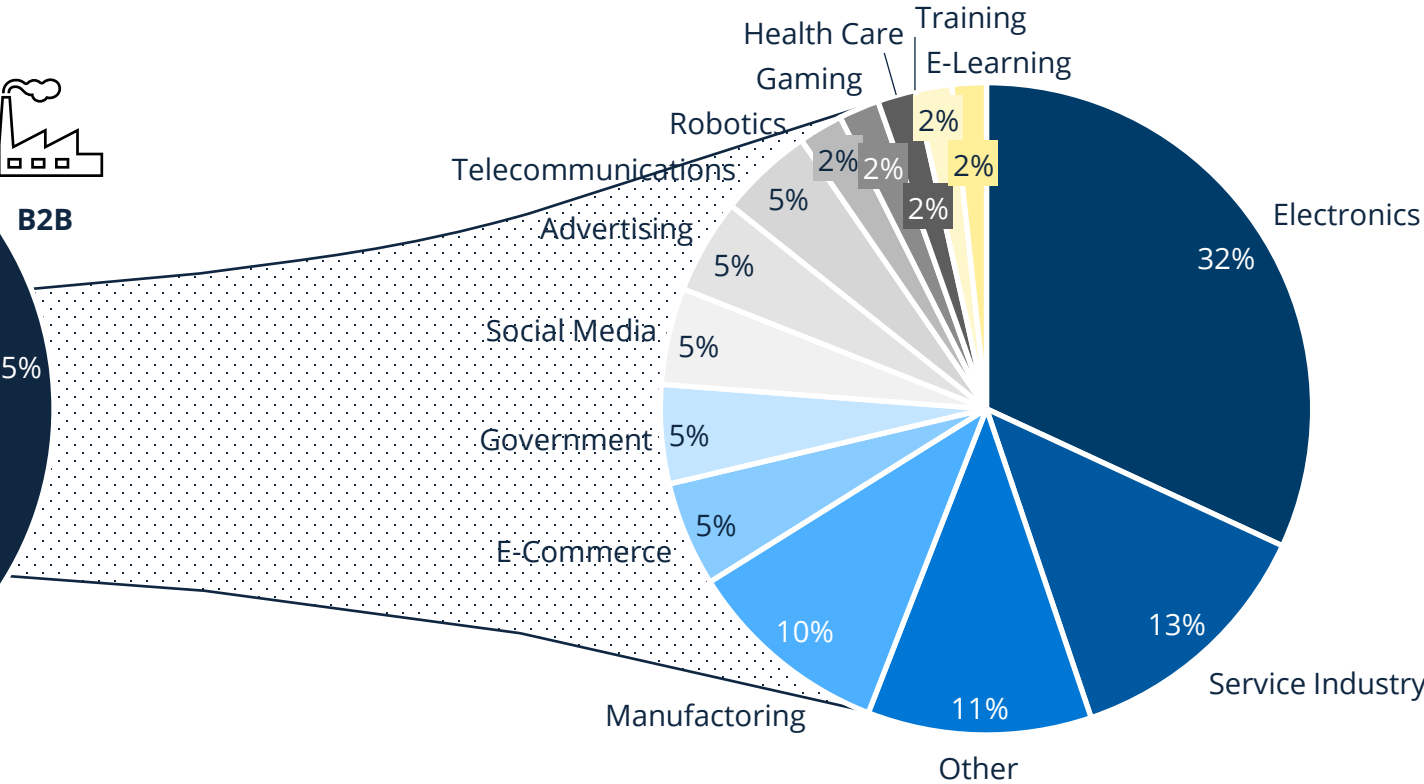
With over 10 million units sold so far, Meta's Oculus Quest 2 is dominating the market and is expected to increase its lead

Top four global companies selling VR headsets

VR product	Company	Revenue 2021 in US$	Hardware revenue in US$	Units sold[1]	Platform	Price in US$	Market share[2]
Oculus Quest 2	Meta Platform	117.9bn	5.2bn	10.4m	PC	499.99	75%
HTC Vive Pro 2	HTC Corporation	199.5m	2.6bn	3.3m	PC	799.99	3%
PlayStation VR	Sony	90.4bn	2bn	6.6m	PlayStation	299.99	5%
Valve Index	Valve Corporation	255m	0.6bn	0.6m	PC	999.00	3%

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Big tech companies are within the AR & VR ecosystem in various stages of the value chain, such as Meta, Microsoft, and Apple

The AR & VR ecosystem overview

Sources: Vancouvereconomic; Company information

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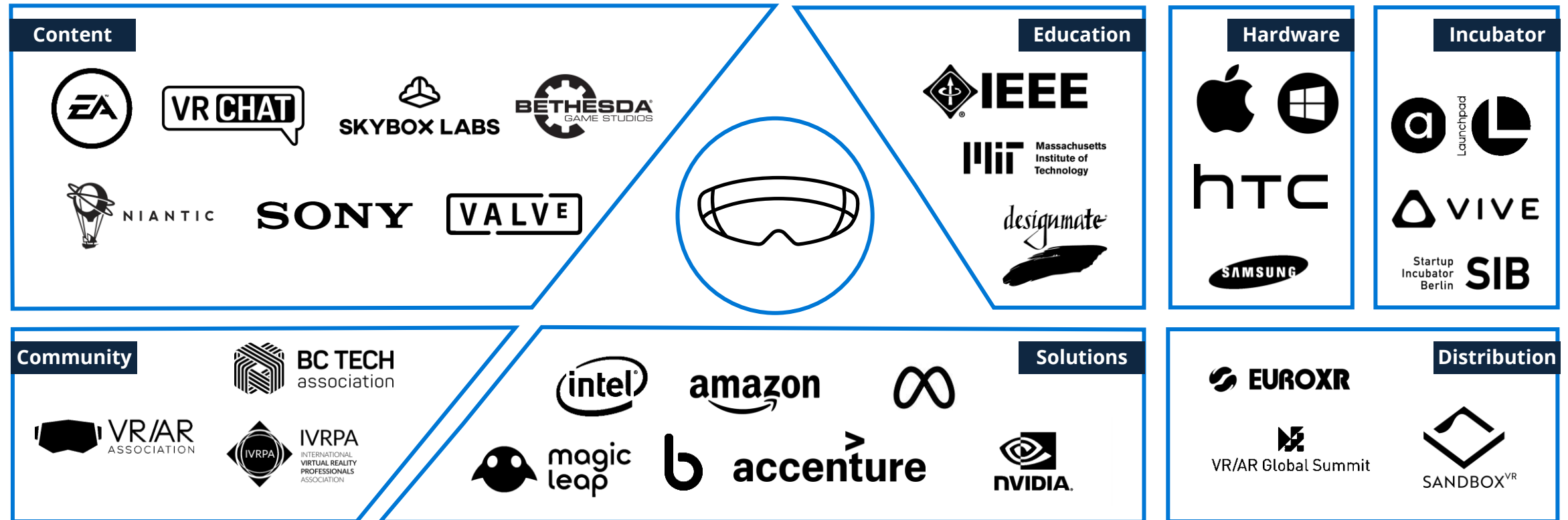
AR & VR is a fundamental pillar for the future of gaming, especially in the Metaverse

The essentials of gaming in the Metaverse

AR & VR

technology allows for motion-controlled gameplay

Collectible items

are items with real-world value, such as Bitcoin

Use of real-time data

helps to create a realistic gaming environment

3D worlds

provide gamers with interactive and immersive gameplay

Immersive media

AR & VR technology

The **Metaverse** is a persistent and immersive simulated world in which consumers can immerse themselves using AR or VR, and it is experienced in the first person by large groups of simultaneous users who share a strong sense of a shared community

The Metaverse paves ways not only for **gaming** but also for **eCommerce**, **virtual assets**, **education**, etc.

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Will the Metaverse change the way humans interact in both physical & digital worlds?

The Metaverse is already part of society's digital economy, whether in the form of online games where people can come together and play or as a social platform to interact with other users. Its potential across various industries is massive, as many industries and companies have already invested vast amounts of money. Nevertheless, it also brings challenges as there is still uncertainty about the Metaverse and connected concepts. Solely investing money won't be enough to generate a concept that attracts consumers; the Metaverse must also be accessible and bring new possibilities. Existing trends such as the normalization/adaptation/establishment of virtual worlds and spatial software, the democratization of eCommerce, the rise of authentic social media, and the adoption of blockchain & remote productivity technologies are accelerating the realization of the Metaverse. Whether the hype can live up to expectations remains uncertain but is likely to become clearer in the next few years.

Following the era of mobile and cloud technology, the Metaverse could mark a new phase

The 4 major eras of computing

IBM launched its first mainframe in 1952, a computer system that revolutionized the IT industry, allowing customers to consolidate all of their data and applications into a single system

Introduced in 1975, the personal computer has inspired new industries, new companies, and turned their founders into millionaires and billionaires

Wireless communication enabled new and easier ways of data transfer, and cloud technologies paved ways to more decentralized storage and computing

The Metaverse could be the fourth era of computing by transforming physical interactions into virtual worlds while increasing learning methods and improving technologies

Mainframes	Personal Computing	Mobile and Cloud	Metaverse
1950s – 1970s	**1970s – present**	**mid 2000s - present**	**2020s – ?**

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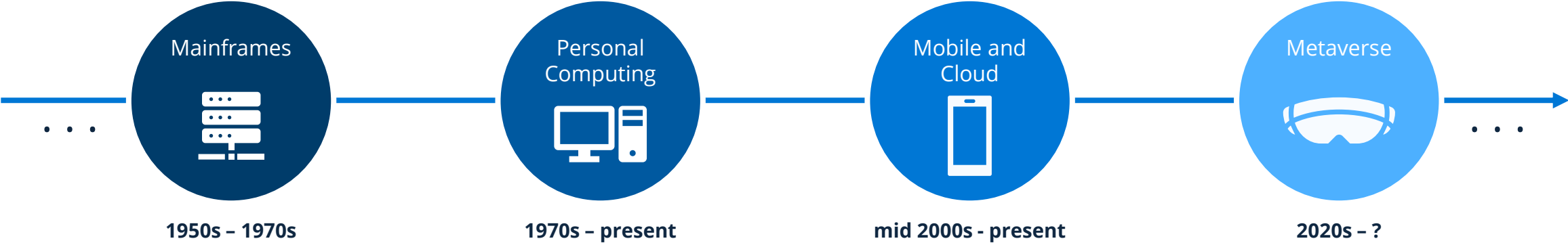
The minimum viable Metaverse is the result brought about by the convergence of emerging digital trends across different sectors

What is the Metaverse?

The Metaverse is a term used to describe a combination of the VR[1] and MR[2] worlds, accessed through a browser, mobile device, or headset, and allows people to have real-time interactions and experiences.

The minimum viable Metaverse is a result of the combination of four converging spheres of work:

- virtual worlds and spatial software going mainstream
- the democratization of eCommerce[3]
- authentic social media
- adoption of blockchain & remote productivity technologies

Trends shaping the minimum viable Metaverse
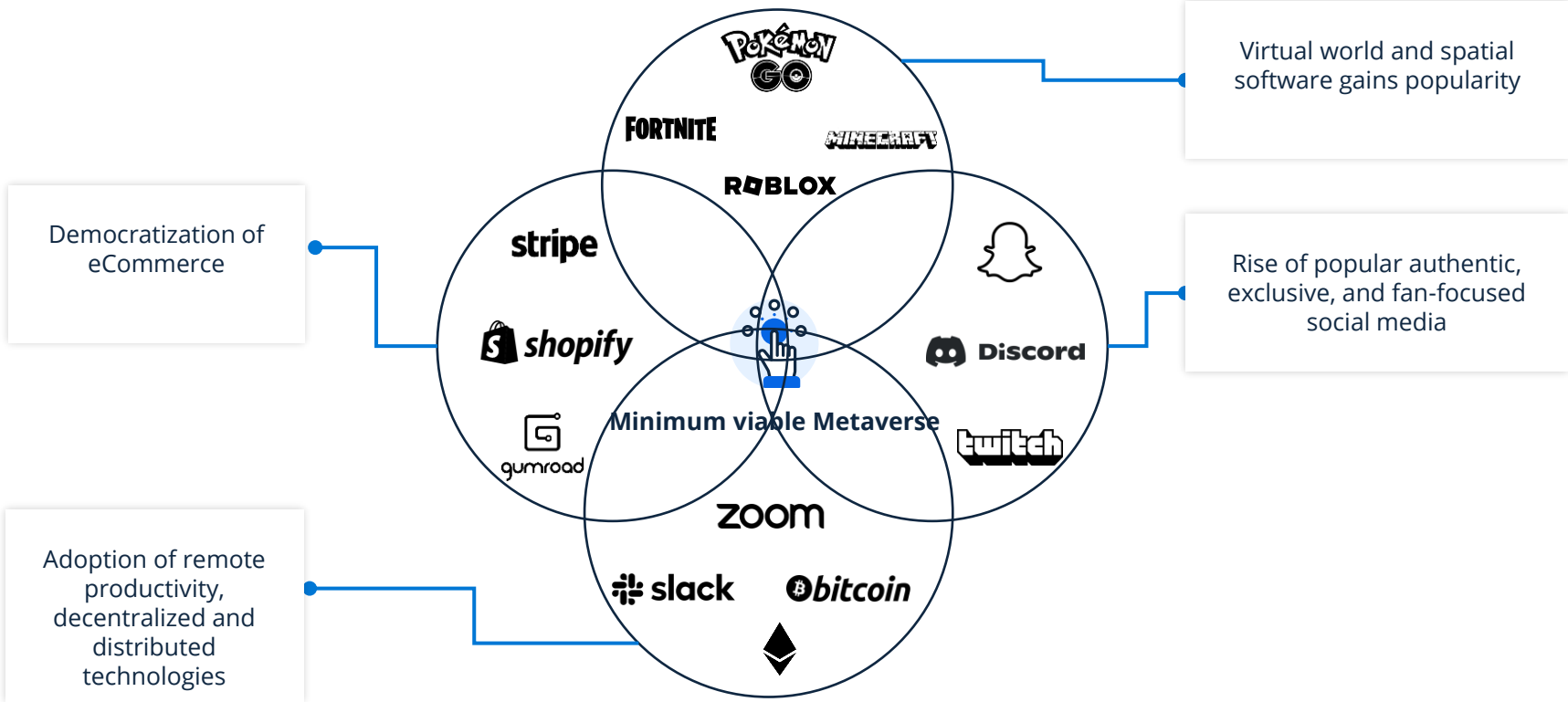
Democratization of eCommerce

Virtual world and spatial software gains popularity

Rise of popular authentic, exclusive, and fan-focused social media

Minimum viable Metaverse

Adoption of remote productivity, decentralized and distributed technologies

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Currently, the presence of the Metaverse dominates in gaming-based virtual worlds where creator-made content allows for monetization
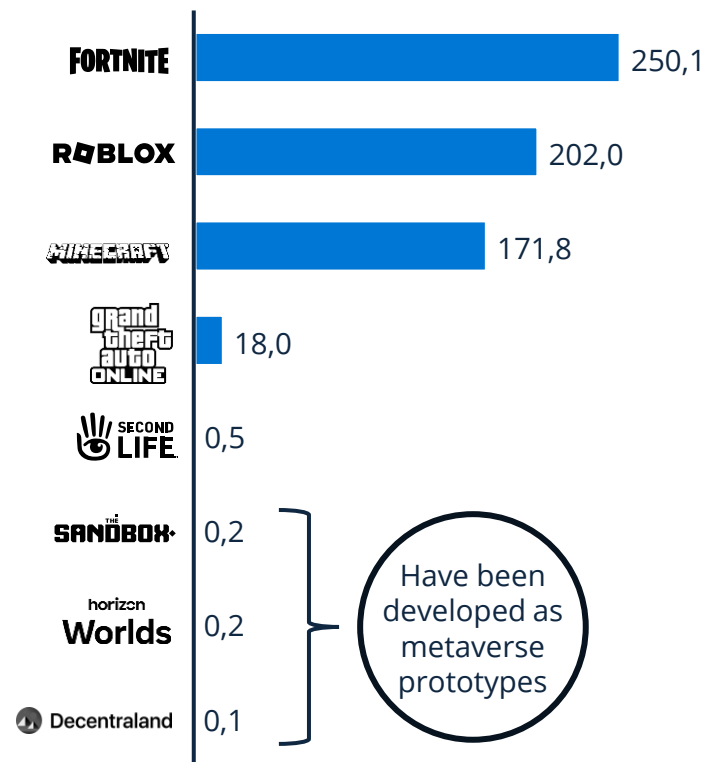
MAU[1] of selected virtual worlds in millions

- FORTNITE — 250,1
- ROBLOX — 202,0
- MINECRAFT — 171,8
- grand theft auto ONLINE — 18,0
- SECOND LIFE — 0,5
- THE SANDBOX — 0,2
- horizon Worlds — 0,2
- Decentraland — 0,1

Have been developed as metaverse prototypes

Roblox

Roblox is a platform-like multiplayer game that hosts a variety of user-made experiences. Creators can earn royalties for sales of items they create.

Fortnite

Fortnite is a 100-player battle royale online game featuring developer-made as well as creator-made environments.

Four quadrants of virtual world economies

Externalized

"Mashup Ecosystems"   "Sandboxes"

READY PLAYER ME   THE SANDBOX

UNDERTALE   Decentraland

MINECRAFT   d20 system

MUDs[2]

Closed ← → Open

EverQuest   ROBLOX

FORTNITE   SECOND LIFE   VR CHAT

WORLD WARCRAFT   horizon Worlds   REC ROOM

UltimaOnline   Neverwinter Nights

CS:GO

"Theme Parks"   "Walled Gardens"

Internalized

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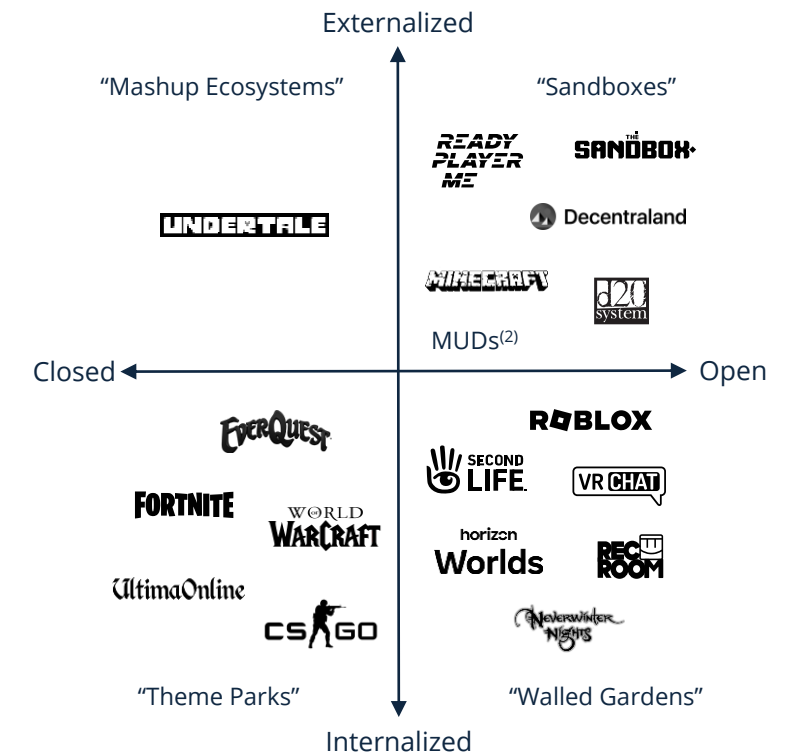
The Metaverse is built on seven foundational layers that are powered by emerging trends and technologies working across these layers

Seven layers and technologies within the Metaverse

Experience
The Metaverse presents a plethora of three-dimensional visuals and two-dimensional experiences that we are currently unable to experience.

Discovery
Inbound (research on the web) and outbound (ads/marketing) discovery systems continue to exist in the Metaverse ecology.

Creator Economy
Number of web/content creators increase rapidly with the advancement of web applications that do not require technical skills.

Spatial Computing
Spatial computing refers to technology that combines VR[1] and AR [2].

Decentralize
Products built leverage the online scalable ecosystem powered by microservices, distributed computing, and blockchain networks.

Human Interface
In this layer, users receive information about their surroundings, use maps, and have shared AR[2] experiences.

Infrastructure
This layer includes technologies that enable devices, keep them connected, and deliver content.
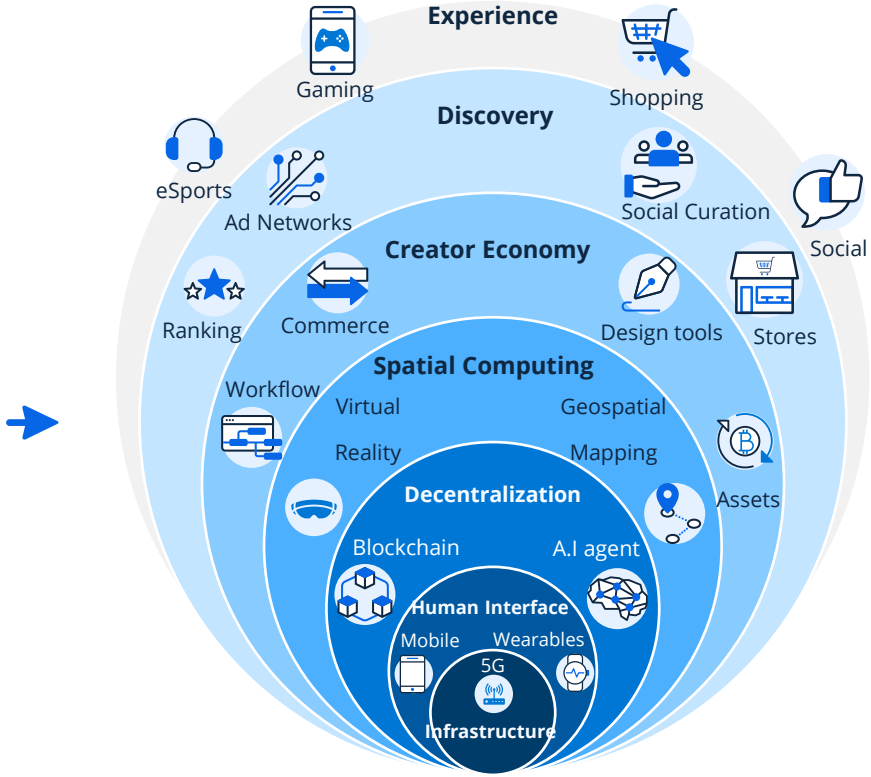
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The Metaverse is projected to become the user-friendly interface that powers the decentralized Web 3.0 ecosystem

The stages of evolution of the Web
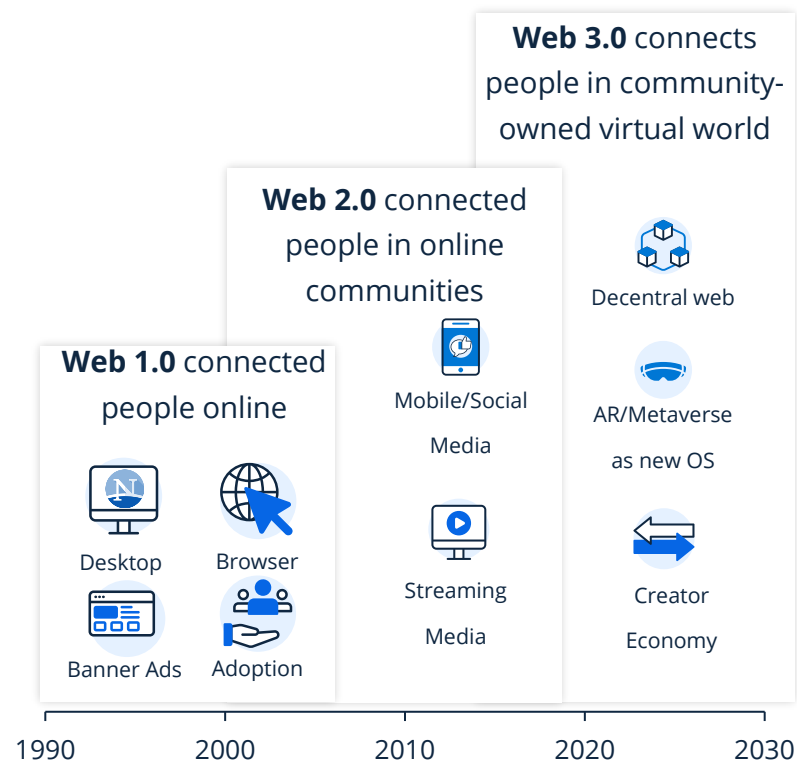
Metaverse as new operating system for Web 3.0

Web 3.0 connects people in community-owned virtual world

Web 2.0 connected people in online communities

Web 1.0 connected people online

Desktop

Browser

Banner Ads

Adoption

Mobile/Social Media

Streaming Media

Decentral web

AR/Metaverse as new OS

Creator Economy

1990   2000   2010   2020   2030

Web 3.0 will be built on the foundation of decentralized networks and applications using blockchain technology, coupled with machine learning and artificial intelligence (AI) that would help build more intelligent and adaptive ecosystems

Elements of the Metaverse

Elements of Web 3.0

Identity

Social interactions

Immersive experience

Digital Twin

Economy

MR[1]

The Metaverse can provide a user interface that integrates complex web 3.0 elements

Blockchain/ decentralized networks

Artificial Intelligence

Cryptocurrencies

NFTs[2]

DeFi[3]

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Nearly all big tech players are working on being more vertically integrated into the Metaverse supply chain to gain long-term competitive advantages

Metaverse supply chain overview
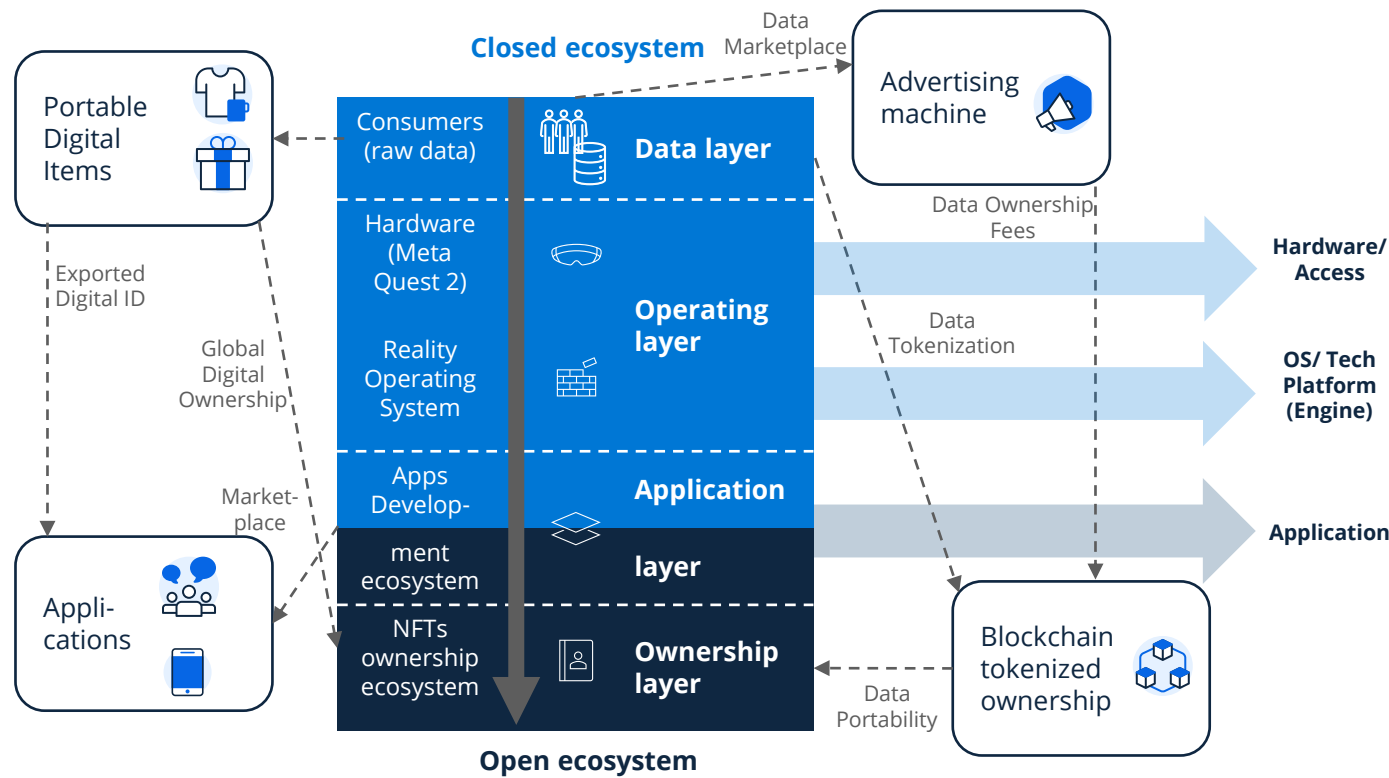
Selected big tech players and their stakes in the Metaverse's supply chain

Closed ecosystem

Data Marketplace

Portable Digital Items

Consumers (raw data) — **Data layer**

Advertising machine

Data Ownership Fees

Hardware (Meta Quest 2) — **Operating layer**

Reality Operating System

Data Tokenization

Exported Digital ID

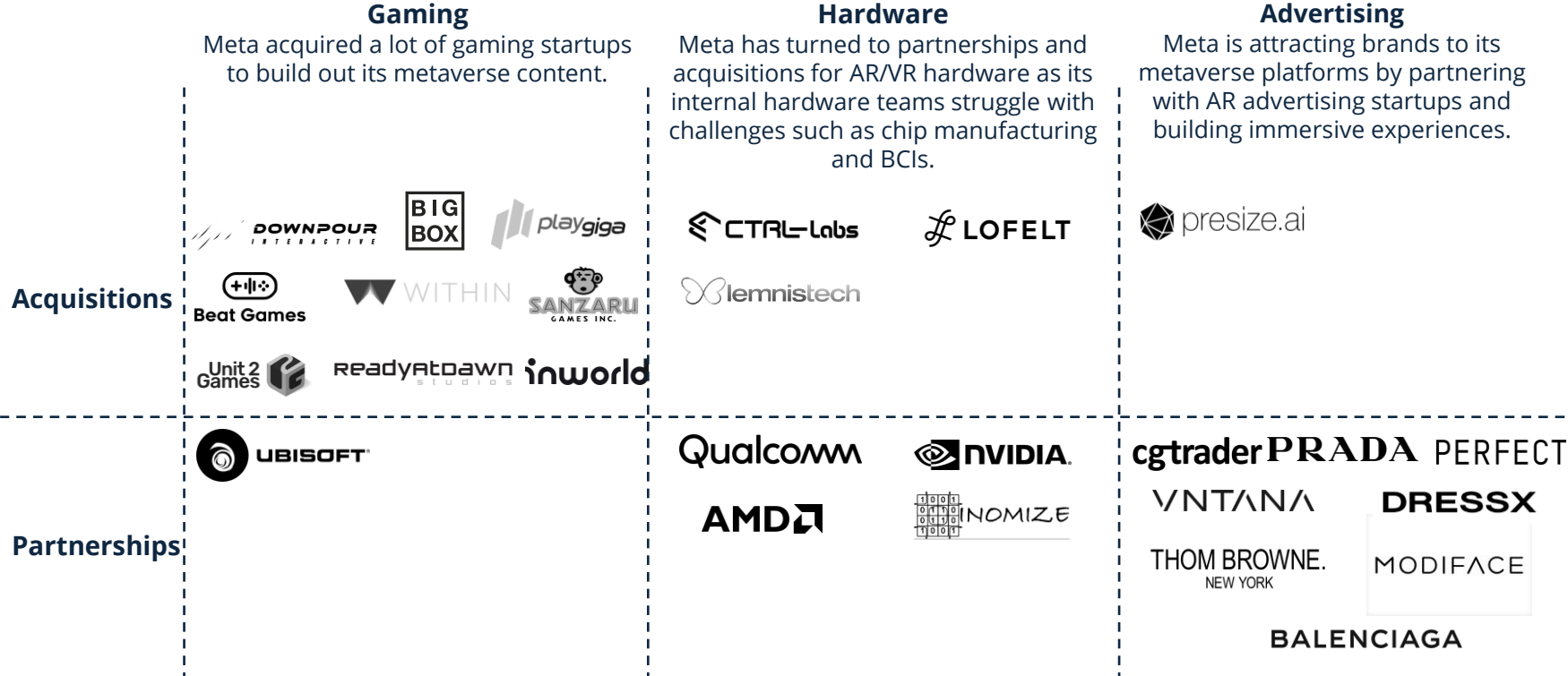Global Digital Ownership

Apps Development ecosystem — **Application layer**

Market-place

Appli-cations

NFTs ownership ecosystem — **Ownership layer**

Blockchain tokenized ownership

Data Portability

Open ecosystem

Hardware/ Access

OS/ Tech Platform (Engine)

Application

	Meta	Apple	Microsoft	Google	Tencent 腾讯	ByteDance 字节跳动
Hardware/ Access	Oculus	Apple Glasses	HoloLens	Speech recognition / Google Glasses	TenVR	Pico
OS/ Tech Platform (Engine)	Development and Presence Platform	ARKit framework iOS	Tool Software Operating System	Google Daydream Android OS	Game Engine (Unreal)	Game Engine (Restart the World)
Application	Gaming, Social (Horizon Worlds), Fitness, Workplace	?	Gaming (Activision Blizzard, Minecraft), Workplace	Gaming, Video (Youtube VR)	Gaming (START), Social	Gaming, Social (Reboot World)

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Meta's strategy to dominate the Metaverse focuses on immersive social worlds and the purchase of as many VR hardware and software companies as possible

Meta's Metaverse strategy overview

∞ Meta

- Investment in the Metaverse so far US$36b

- Meta is taking its social media platforms and extending them into the VR space. AR virtual try-on or branded filters have been incorporated into Instagram and Facebook.

- Meta is the leading company in VR with 15 million Oculus VR headsets sold since 2020. Meta is pushing VR experiences in the form of games and virtual worlds such as their flagship metaverse app Horizon Worlds.

- Horizon worlds has drawn criticism for its quality and lack of users

- Other building blocks of the Metaverse vision include Horizon Home, the virtual living room, and Horizon Workrooms
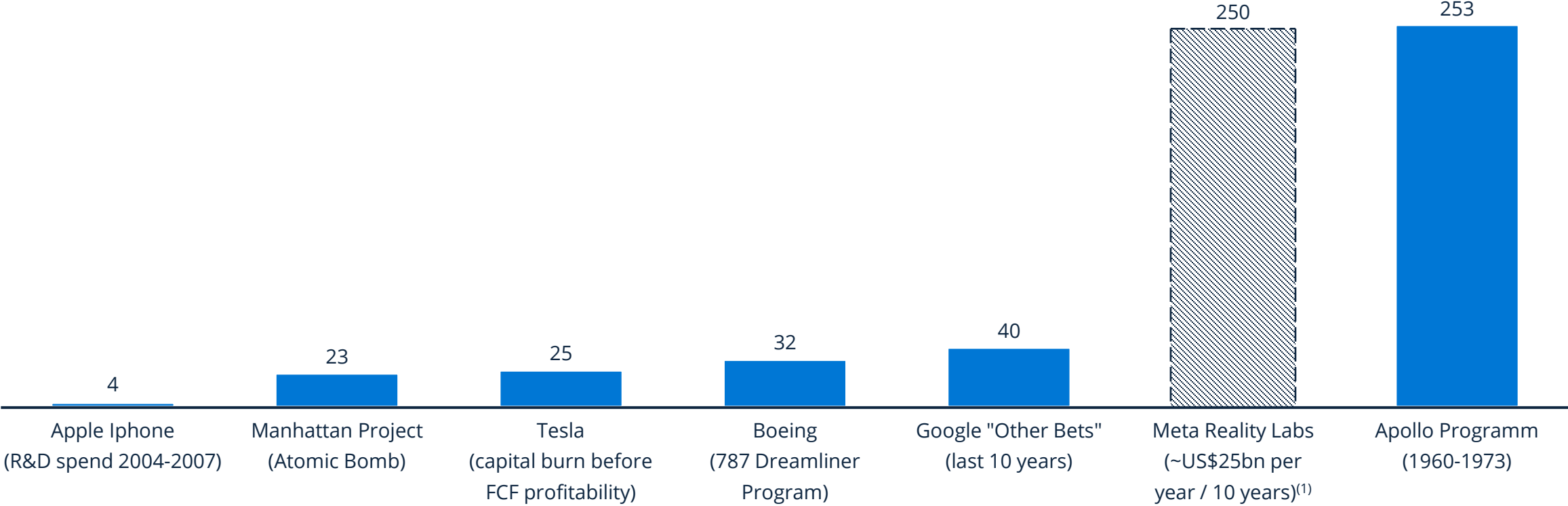
	Gaming Meta acquired a lot of gaming startups to build out its metaverse content.	**Hardware** Meta has turned to partnerships and acquisitions for AR/VR hardware as its internal hardware teams struggle with challenges such as chip manufacturing and BCIs.	**Advertising** Meta is attracting brands to its metaverse platforms by partnering with AR advertising startups and building immersive experiences.
Acquisitions	DOWNPOUR INTERACTIVE, BIG BOX, playgiga, Beat Games, WITHIN, SANZARU GAMES INC., Unit 2 Games, READYATDAWN STUDIOS, inworld	CTRL-Labs, LOFELT, lemnistech	presize.ai
Partnerships	UBISOFT	Qualcomm, NVIDIA, AMD, INOMIZE	cgtrader, PRADA, PERFECT, VNTANA, DRESSX, THOM BROWNE. NEW YORK, MODIFACE, BALENCIAGA

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Meta's huge bet on the Metaverse is shown in their Reality Labs program, which is estimated to cost as much as the Apollo Space Program

Selected multi-year spending programs compared to Meta's Metaverse bet in billion US$

Program	Value
Apple Iphone (R&D spend 2004-2007)	4
Manhattan Project (Atomic Bomb)	23
Tesla (capital burn before FCF profitability)	25
Boeing (787 Dreamliner Program)	32
Google "Other Bets" (last 10 years)	40
Meta Reality Labs (~US$25bn per year / 10 years)[1]	250
Apollo Programm (1960-1973)	253

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Apple does not seek to build its own Metaverse, but with its strategy to improve AR technology, it may become Meta's biggest rival

Apple's metaverse strategy overview

- Apple started experimenting with AR & VR applications over a decade ago, as shown by its patent activity. In 2017, Apple launched its ARKit framework, which enabled developers to build AR applications (so far used by 14,000 apps with over 13 million total downloads).

- It appears that Apple is planning the launch of AR glasses and/or a mixed reality headset in 2023. Moreover, they are working on a finger-mounted input system for iPhones alongside new sensors for iPhone Pros.

- Unlike Meta, Apple has not been clear about its Metaverse ambitions, but its continued investment in AR & VR companies points to more immersive digital environments and hardware that may be released soon.

- Mark Zuckerberg stated that Apple and Meta are in a "very deep, philosophical competition" to build the metaverse, competing to determine "what direction the internet should go in." Since the introduction of Apple's App Tracking Transparency (ATT) in 2021, the company's rivalry with Meta has escalated.

AR & VR
So far Apple invested in smaller companies with AR & VR background to increase their patent portfolio, setting the foundation for its future AR products.

Acquisitions
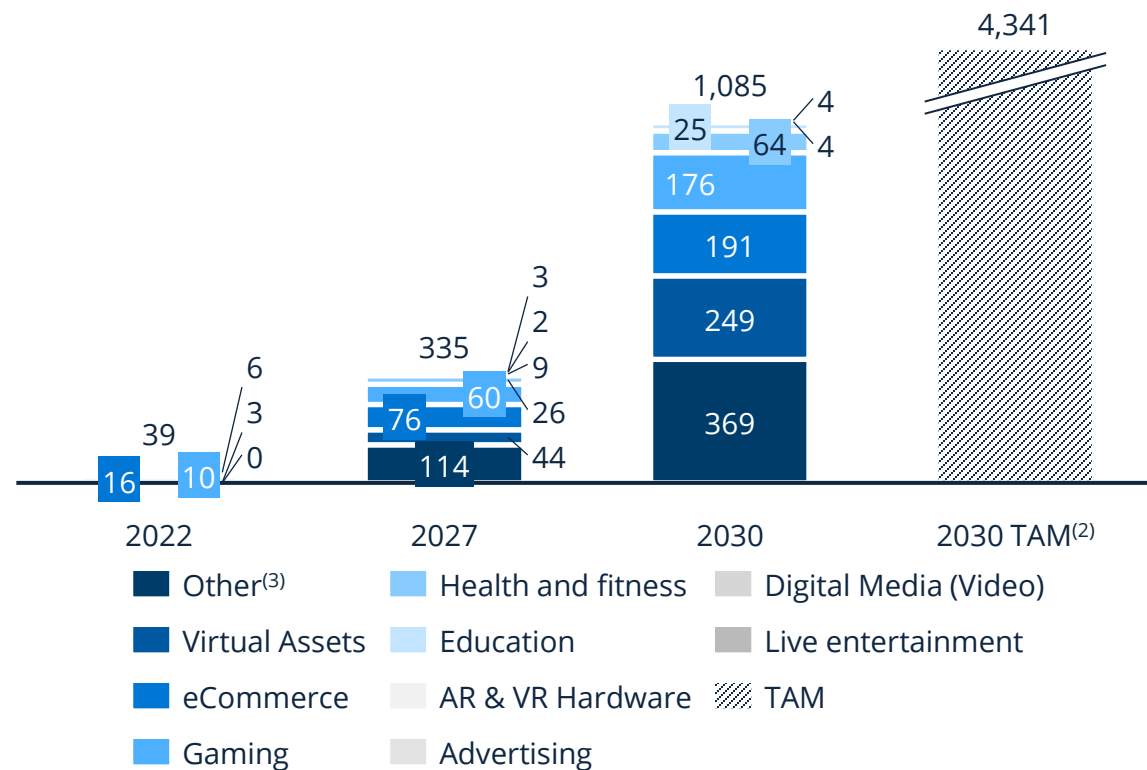

Partnerships

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Big tech and gaming players will expand their competencies across several elements of the Metaverse

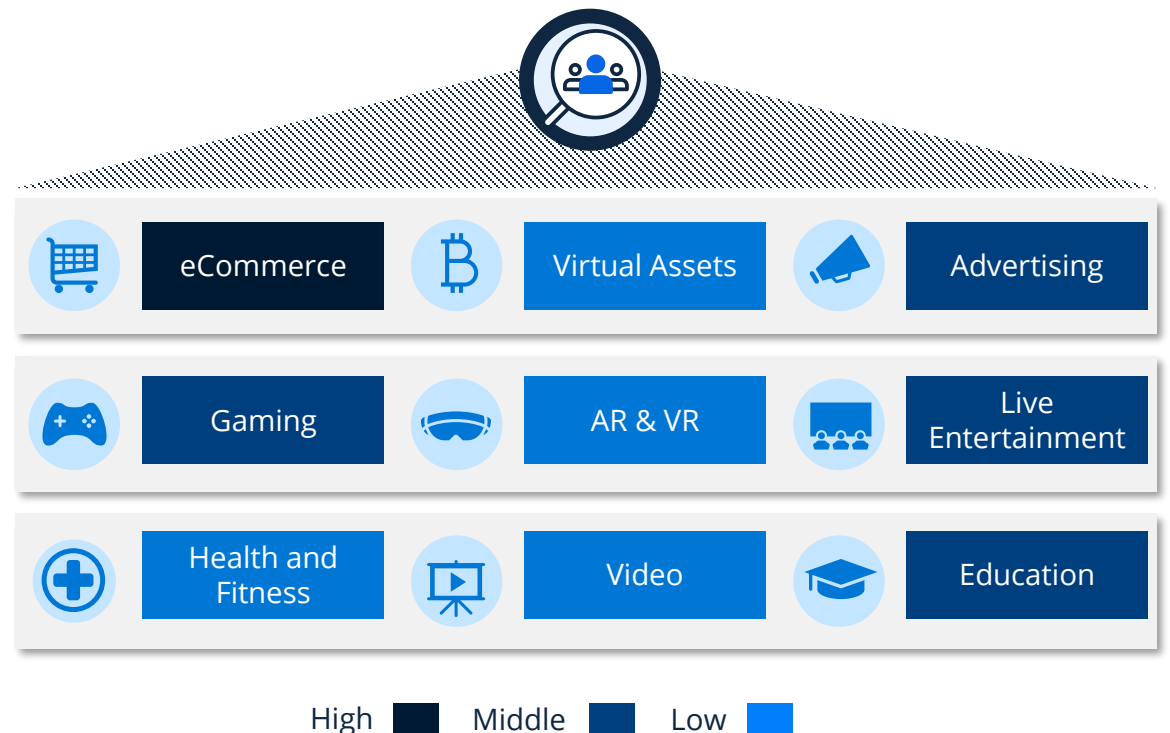**Selected key players presence in Metaverse ecosystem**

Key player	Immersive experiences	Mixed Reality VR	Mixed Reality AR	Social Interaction	Creation & Agency	Identity	Digital Twins	Virtual Ownership
amazon	prime gaming / luna	prime video vr	amazon View in your room	twitch	twitch / Amazon Sumerian		aws IoT TwinMaker	aws NFT appli-cations
Apple		NEXTVR	Glasses ?	iMessage	ARKit / Reality Composer	Memoji		NFT Trading Cards ?
Google		GLASS / Google Lens / Google Maps	YouTube VR / Google Earth VR	Project Starline	YouTube VR / ARCore	Chrome Avatars	Google Cloud Supply Chain Twin and Pulse	
Meta	horizon Worlds / FACEBOOK GAMING / BEAT SABER	FACEBOOK REALITY LABS / Meta Quest Pro	FACEBOOK REALITY LABS / horizon Worlds 2	Instagram / horizon Worlds / Messenger	Meta Spark	3D Avatars		NFT Sharing on Instagram/ Facebook
Microsoft	MINECRAFT / XBOX / Mesh / ACTIVISION BLIZZARD	AltspaceVR / Mesh HP Reverb G2	Microsoft HoloLens / Mesh	MINECRAFT / Mesh / LinkedIn / Microsoft Teams	MINECRAFT	Microsoft Teams / Mesh Avatars	Azure Digital Twins	NFTs Windows 11
SONY	PlayStation / PlayStation Plus / BUNGIE	PlayStation VR	KRAMER		dreams	DESTINY Guardian Creation		
Tencent 腾讯	Tencent Games	ultraleap	ultraleap	QQ	Super QQ Show		Tencent Cloud	Testing NFT Profiles
EPIC GAMES	FORTNITE		CapturingReality	FORTNITE PARTY ROYALE	FORTNITE Creative / UNREAL ENGINE	FORTNITE Avatars	UNREAL ENGINE	NFT Games via Epic Games Store

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The Metaverse is facing immense potential in the future, with eCommerce and Virtual Assets are expected to witness the highest growth rates

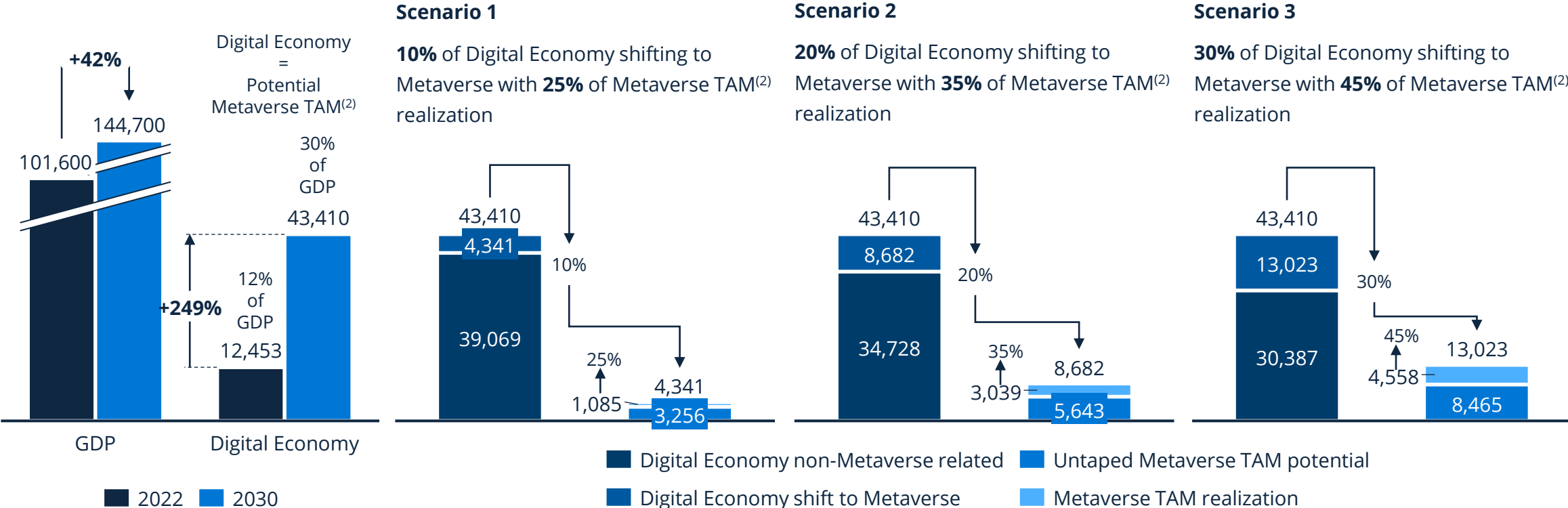**Metaverse market development for selected segments in billion US$[1]**

Bar chart data:

2022: 16, 10, 39, 6, 3, 0

2027: 114, 76, 60, 335, 3, 2, 9, 26, 44

2030: 369, 249, 191, 176, 64, 25, 1,085, 4, 4

2030 TAM[2]: 4,341

Years: 2022, 2027, 2030, 2030 TAM[2]

Legend:
- Other[3]
- Virtual Assets
- eCommerce
- Gaming
- Health and fitness
- Education
- AR & VR Hardware
- Advertising
- Digital Media (Video)
- Live entertainment
- TAM

Relative use case potential for consumers[4]

- eCommerce
- Virtual Assets
- Advertising
- Gaming
- AR & VR
- Live Entertainment
- Health and Fitness
- Video
- Education

High | Middle | Low

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Metaverse market opportunities vary wildly, from incremental change to dramatic shifts in industry structures in transition from Web 2.0 to 3.0

**Scenario analysis of potential Metaverse market opportunity in billion US\$ in 2030[1]**

Scenario 1

10% of Digital Economy shifting to Metaverse with **25%** of Metaverse TAM[2] realization

Scenario 2

20% of Digital Economy shifting to Metaverse with **35%** of Metaverse TAM[2] realization

Scenario 3

30% of Digital Economy shifting to Metaverse with **45%** of Metaverse TAM[2] realization

Digital Economy = Potential Metaverse TAM[2]

+42%

101,600
144,700

30% of GDP
43,410

+249%

12% of GDP
12,453

43,410

GDP   Digital Economy

■ 2022   ■ 2030

Scenario 1
43,410
4,341
39,069
10%
25%
1,085
4,341
3,256

Scenario 2
43,410
8,682
34,728
20%
35%
3,039
8,682
5,643

Scenario 3
43,410
13,023
30,387
30%
45%
4,558
13,023
8,465

■ Digital Economy non-Metaverse related   ■ Untaped Metaverse TAM potential

■ Digital Economy shift to Metaverse   ■ Metaverse TAM realization

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Compared to other digital segments, Metaverse users are expected to have the highest growth reaching over 1.7 billion users by 2027

User numbers of selected metaverse and blockchain connected areas in million
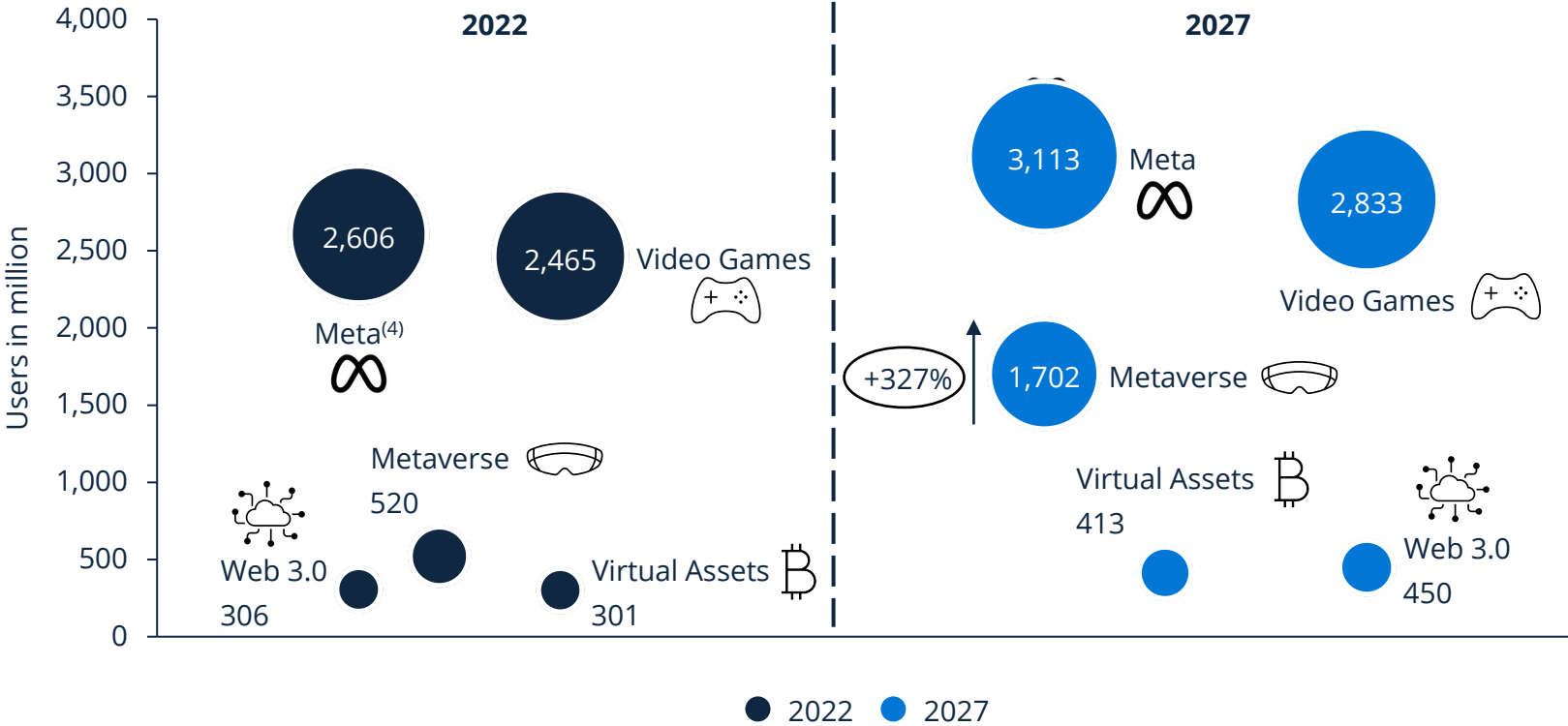
Definition of Metaverse, Virtual Assets and Web 3.0 users

- **Metaverse users** can be described as users who access VR [1] and MR [2] worlds through a browser or headset and are able to have real-time interactions and experiences across distance. However, specific headsets are not necessary to engage in activities, e.g., Fortnite players.

- **Virtual Assets** users include cryptocurrency and NFT users/owners.

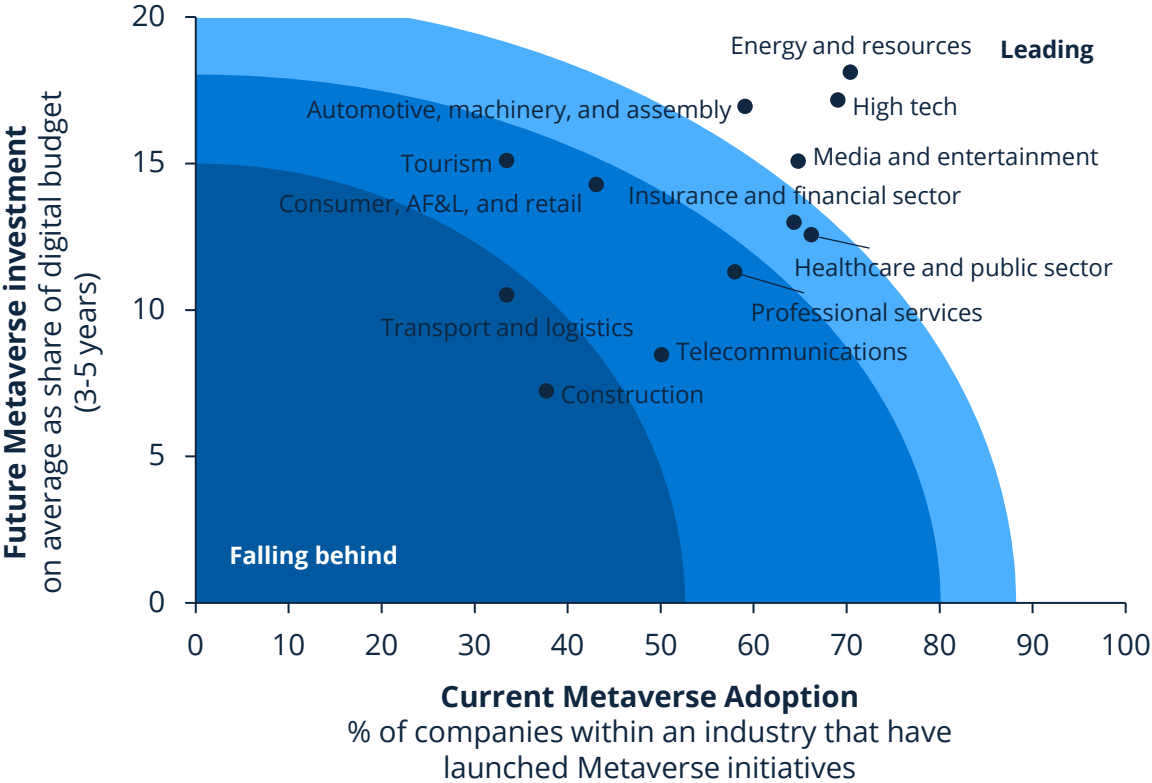- **Web 3.0 users** include virtual assets and DeFi [3] users.

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A diverse ecosystem of companies is involved in and could benefit from developments in the Metaverse

Metaverse ecosystem overview

Metaverse Ecosystem

Games & Virtual Spaces
Animal Crossing · Decentraland · The Sandbox · FORTNITE · REC ROOM · Meta Horizon · ROBLOX · MINECRAFT

Developers & Publishers
EPIC GAMES · EA · ACTIVISION BLIZZARD · Tencent · Nintendo · T2 · SURVIOS · UBISOFT

Media
Walt Disney · COMCAST · Nielsen · FOX · Paramount · NETFLIX · WARNER BROS. DISCOVERY · amazon

Communication & Computing
Apple · Microsoft · amazon · AT&T · HUAWEI · verizon · NVIDIA · Google

AR & VR
Unity · oculus · NIANTIC · htc · VALVE · SONY · Magic Leap · Snap Inc.

Digital Property & NFTs
THE SANDBOX · AXIE INFINITY · OpenSea · UPLAND · Rarible · EARTH 2

Crypto & Payments
Alipay · PayPal · coinbase · stripe · Pay · G Pay · BINANCE · venmo

eCommerce
amazon · JD.COM · shopify · Alibaba.com · ebay · Pinduoduo

Social & Messaging
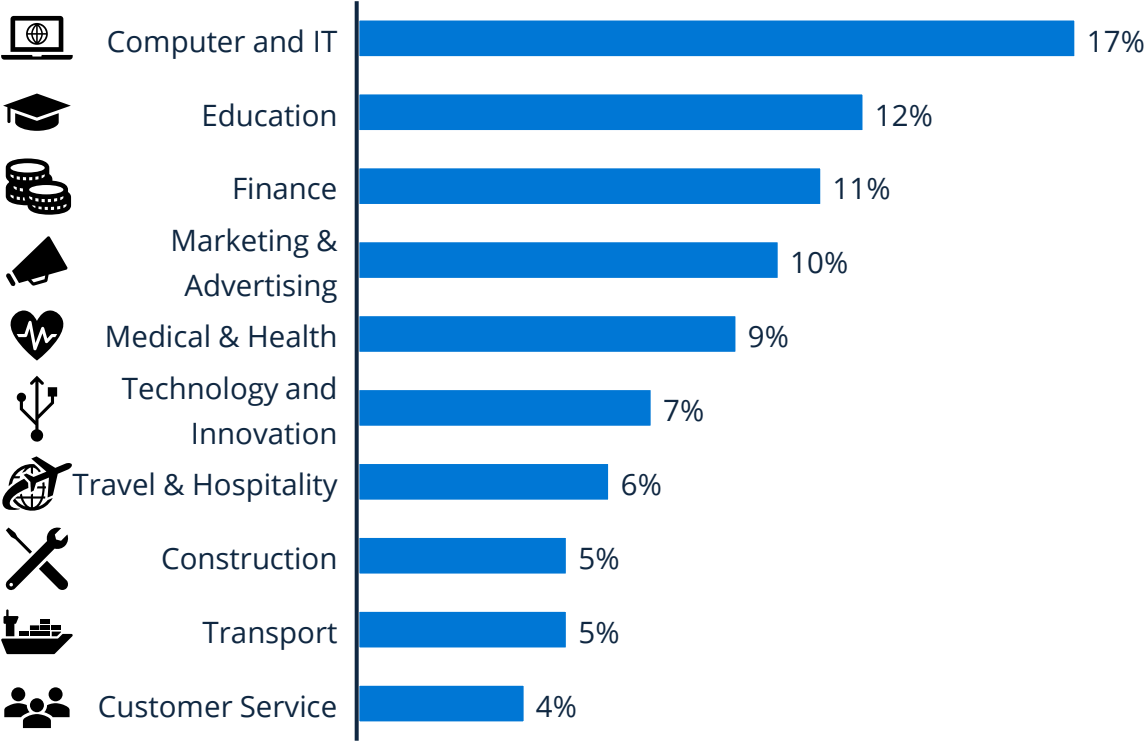Discord · WhatsApp · TikTok · twitch · WeChat · Meta · Telegram

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While some industries are leading the proliferation of strategies for the Metaverse, others are falling behind

Metaverse adoption in relation to Metaverse investments
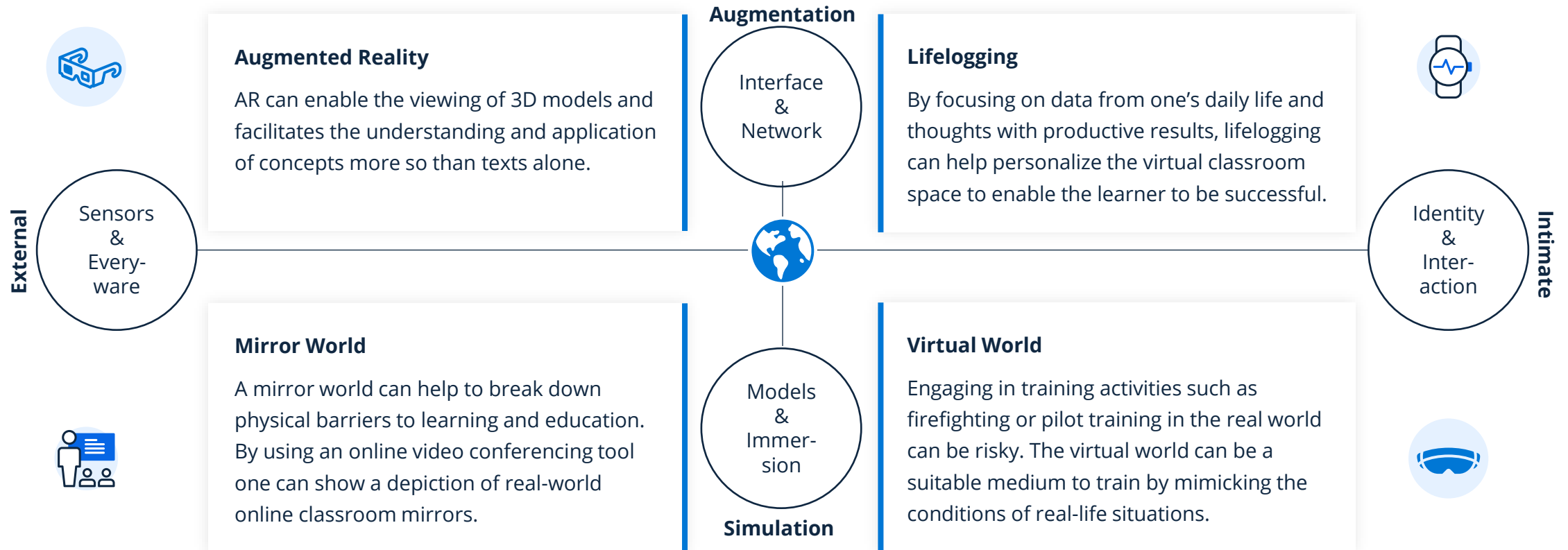

Future Metaverse investment on average as share of digital budget (3-5 years)

Leading

Energy and resources
High tech
Automotive, machinery, and assembly
Media and entertainment
Tourism
Insurance and financial sector
Consumer, AF&L, and retail
Healthcare and public sector
Transport and logistics
Professional services
Telecommunications
Construction

Falling behind

Current Metaverse Adoption
% of companies within an industry that have launched Metaverse initiatives

Top 10 business sectors that have invested in the Metaverse

Sector	Percentage
Computer and IT	17%
Education	12%
Finance	11%
Marketing & Advertising	10%
Medical & Health	9%
Technology and Innovation	7%
Travel & Hospitality	6%
Construction	5%
Transport	5%
Customer Service	4%

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The education industry can benefit from each aspect of the Metaverse

Augmentation

Augmented Reality

AR can enable the viewing of 3D models and facilitates the understanding and application of concepts more so than texts alone.

Lifelogging

By focusing on data from one's daily life and thoughts with productive results, lifelogging can help personalize the virtual classroom space to enable the learner to be successful.

Interface & Network

External

Sensors & Every-ware

Identity & Inter-action

Intimate

Mirror World

A mirror world can help to break down physical barriers to learning and education. By using an online video conferencing tool one can show a depiction of real-world online classroom mirrors.

Models & Immer-sion

Virtual World

Engaging in training activities such as firefighting or pilot training in the real world can be risky. The virtual world can be a suitable medium to train by mimicking the conditions of real-life situations.

Simulation

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Educational institutions will only need the wearable device in order to enter the Metaverse for an immersive learning experience

The Metaverse in educational structures

Learner + **Wearable Devices** → Enter

The Metaverse

Intelligent NPCs	Learning Logging
Learning Scene	Learning Analysis
Learning Resource	Learning Authentication

Support

Technological Infrastructure

Communication & Networks	Computing Technologies	Analytical Technologies	Interaction Technologies
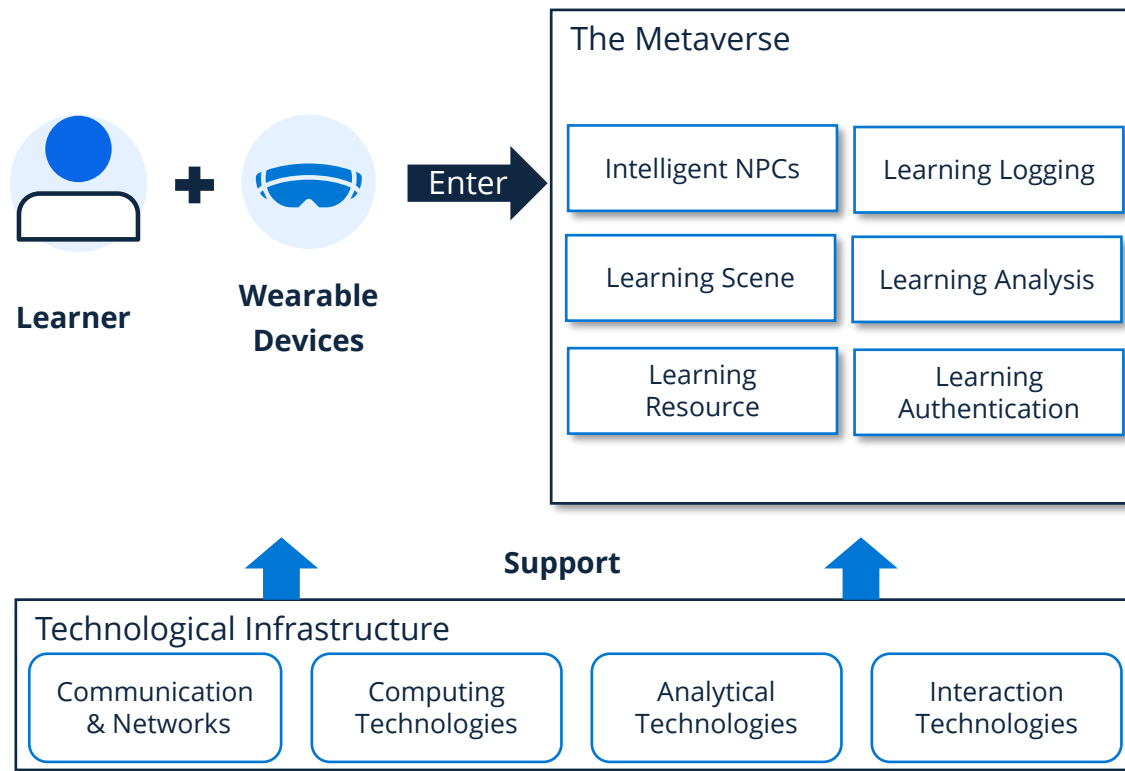
Global online education market development in the Metaverse in billion US$

- 2022: Online Education 146.9; Online Education Metaverse 1.8; Metaverse Education TAM 10.9
- 2030: Online Education 296.2; Online Education Metaverse 25.2; Metaverse Education TAM 151.4

+1,294%

■ Online Education
■ Metaverse Education TAM
■ Online Education Metaverse

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From skills development to team collaboration, the workplace is also being revolutionized by the potential of the Metaverse

Companies providing workplace solutions in the Metaverse

HR Hiring and Onboarding

> Hirect conducted a successful job fair in the Metaverse. Attendees were able to create their own avatars and joined via VR headsets. The advantage for recruiters is that they can interview and evaluate candidates in real time.

Team Collaboration

> Microsoft Mesh uses avatars to create a sense of presence in the virtual workspace. Here, coworkers can gather and attend meetings using Mesh for Teams.

Digital Twins PixelMax

> With Pixelmax, companies can build anything, use in-build data capture and analytics to pinpoint potential problems as soon as possible, and take action quickly.
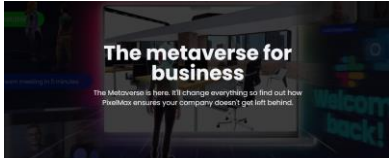
Skills Development MEDIVIS

> The medical technology company Medivis uses HoloLens technology to train medical students through interaction with 3-D anatomy models.

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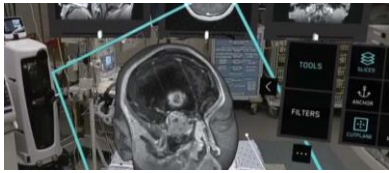
From museums to sports betting, the entertainment industry holds real promise for the Metaverse, and many developments have already taken place

Recent developments of entertainment companies in the Metaverse

Concerts
The Sandbox, a decentralized virtual world, entered a partnership with Warner Music Group in January to create a music-themed world within the Metaverse of the gaming platform.

Sports Betting & Gambling
Entain, Europe's leading sports betting company, plans to invest US$133 billion into a center that creates an immersive experience for its customers.

Museums
Musee Dezentral is the world's first decentralized NFT museum, housing 222 NFT frames that are unique and provable random collectibles.

Theme Parks
Disney's chief executive revealed that the company plans to leverage metaverse capabilities to deliver personalized entertainment experiences.

Entertainment in market development of the Metaverse in million $US

+93%

	2022	2030
Entertainment	65	90
Entertainment Metaverse	244	368
Metaverse Entertainment TAM	1.464	2.822

■ Entertainment
■ Entertainment Metaverse
■ Metaverse Entertainment TAM

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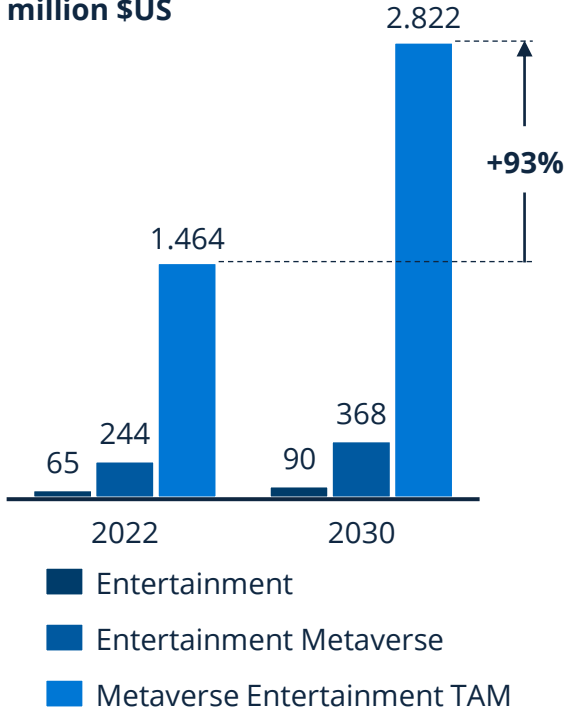
There is vast development potential within eCommerce: by 2030, it will comprise more than 50% of the market size of the Metaverse

Market development eCommerce and eCommerce in the Metaverse in bn US$

7,830.00

3,610.00

16.27   97.78

190.73   1,144.39

+1,070%

2022   2030

■ eCommerce   ■ eCommerce Metaverse   ■ Metaverse eCommerce TAM
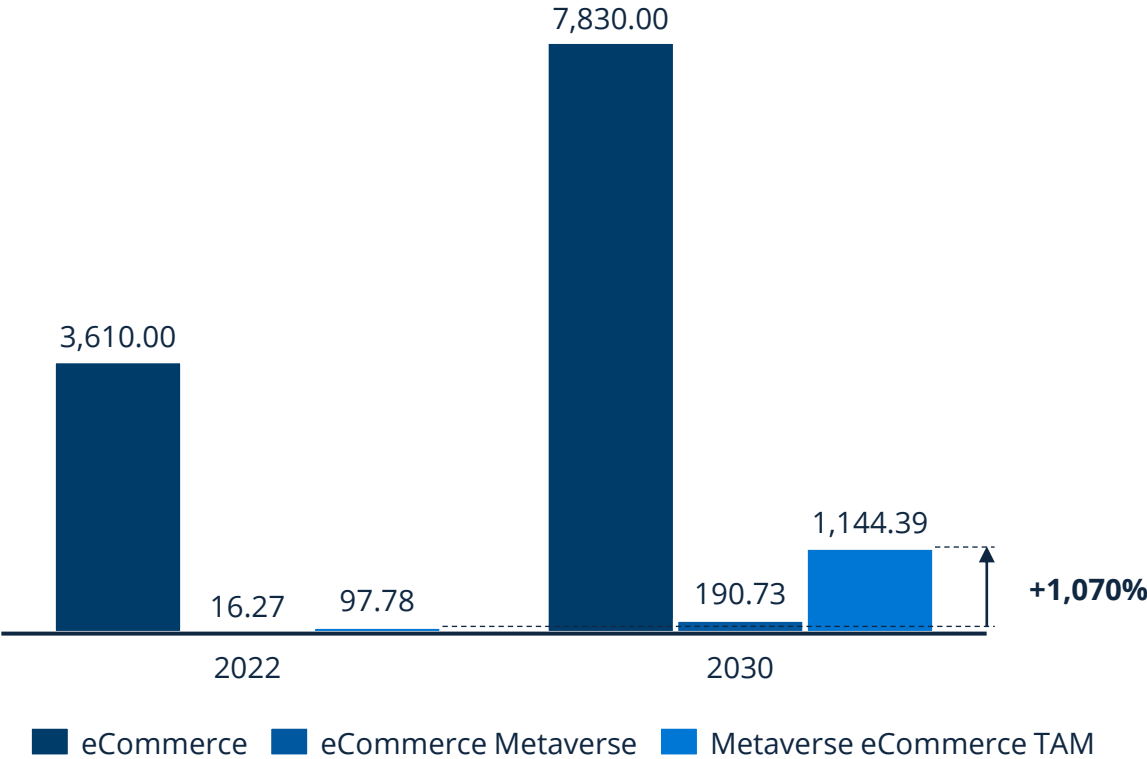
Metaverse influence on eCommerce

3D assets (NFTs) and virtual try-ons supported by AR and blockchain will pave the way to customized on-demand apparel-making and products

In conversational commerce, brands and retailers leverage direct messaging platforms to interact on a personal level with shoppers

Brands that integrate cryptocurrency options into their eCommerce platforms can enable faster payments with a broader (global) customer reach

Retailer websites that leverage AI technology can provide individualized recommendations to customers based on their shopping profiles

In headless commerce, brands optimize their approaches for reaching customers by maximizing the number of interfaces such as smartphones, smart speakers, apps, and social media

As brands seek ways to improve customer engagement, virtual stores in the Metaverse present a unique opportunity for retailers to provide their shoppers with immersive experiences

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Fashion brands are entering the Metaverse through established virtual worlds and introducing their digital collections as NFT[1] assets

Opportunities for fashion brands in the Metaverse
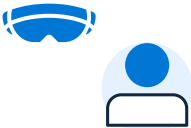
The Metaverse opens many opportunities for fashion brands to widen their audience. The most natural entry point is providing digital clothing for the user's avatar. In 2021, Roblox introduced its users to digital clothing and accessories by Gucci and Stella McCartney. In March 2022, Decentraland hosted a Metaverse Fashion Week featuring more than 60 brands including Estée Lauder, Tommy Hilfiger, Dolce & Gabbana, and Forever 21.

Fashion brands can opt to sell their digital items as NFTs or non-fungible tokens. This NFT approach caught the industry's attention in 2021 when RTFKT studios, a purely digital shoe company, sold out their collection of 600 artistic NFT sneakers in just 6 minutes, garnering a profit of $3.1 million. By the end of 2021, Nike had acquired RTFKT studios.

Many fashion companies are starting to use 3D garment creation software such as Clo3D and Browzwear to realistically simulate garments and speed up physical production. It is a natural and practical step to convert these 3D designs into sellable digital clothing.

Luxury Fashion Brands in the Metaverse

Popular Fashion Brands in the Metaverse

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Digital fashion brands such as Auroboros are gaining traction and catching the industry's attention

Though many traditional fashion brands are expanding into the metaverse, a new generation of digital-first fashion brands such as Auroboros have also appeared. Unconstrained by the limits of physical fabrics, their collections express new frontiers of creativity and imagination. Co-founder and creative director Alissa Aulbekova answered a couple of our questions.

Auroboros was one of the digital fashion brands that really caught the media's attention in 2021. What made you decide to start a digital-native fashion brand instead of going the more traditional route?

I've been working in digital fashion before there was digital fashion, with 3D scanning and everything else. When I met our company's co-founder Paula, we were excited to combine her designs with our digital vision. We're both fans of video games and we're always looking toward the future, so we've taken it upon ourselves to create our vision of the future. Digital is also inclusive, whether it is in the gender, size, or shape of the people that wear our fashion. As you know, AR clothing can adapt to anybody, any of the outfits would fit you perfectly.

How do you see your company influencing fashion in the metaverse?

I think we've already influenced the fashion world, both traditional and in the metaverse. As a brand, we have a very strong identity and recognizable aesthetic. So just as you may recognize a piece of clothing from Chanel or Balenciaga, you can also recognize our clothes in the digital space. As a luxury fashion house, we have a very large focus on precision, detail, and craftsmanship, you'll always see something interesting. We also build our collections very emotively, with a narrative and story that we want to tell. And I think this has brought us great success already because a lot of people can connect.

What are your upcoming plans for 2023?

We're launching Auroboros Academy in partnership with top fashion universities like Parsons and Oxford. It's an educational-social space hosting a program to provide highly sought-after Web3/Digital expertise and tools for digital fashion. We are currently in a fundraising phase and open to investors.

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Traditional fashion designers are discovering the creative potential of 3D fashion and some are even making a complete transition

Anna Liedtke is a fashion designer who worked at Hugo Boss in several traditional roles before completely switching to 3D fashion. She now works at the Amsterdam-based digital fashion house, The Fabricant, as Fashion Design Director. We discussed her personal thoughts on digital fashion.

You've worked for a long time in traditional fashion and made the switch to digital fashion around a year ago. In your experience, what advantages does digital fashion have over traditional fashion?

For me, as a creative person, I took the chance to explore the opportunities that you have when you don't work physically. I was easily able to extend my portfolio with creations I made in my free time. I started this three years ago. It's possible to create digital productions and editorial shoots just with one person. The publishing on social media also helps me to connect and find people to collaborate with. In general, working with digital software creates a new genre of fashion design, which is fun to explore and which can bend reality.

What do you think is the best way/strategy for traditional fashion companies to enter into the metaverse?

There is a new generation of customers who are not necessarily keen on physical products. Applications and games are already a big market with high revenue content. But companies should start thinking differently. Giving customers the chance to become part of the revenue stream is a new way to bond a community. Stop one-directional thinking and build long-term term partnerships with young people through a "play to earn" system or tokenomics.

Another way is to integrate digital development in production. Digital prototyping is already a sustainable process that reduces resources. It can support digital showroom set-ups and enables emotional communication with digital product shoots. Augmented reality integration could attract customers and reduce the number of returns.

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The Metaverse is set to accelerate the market development of virtual assets in the future

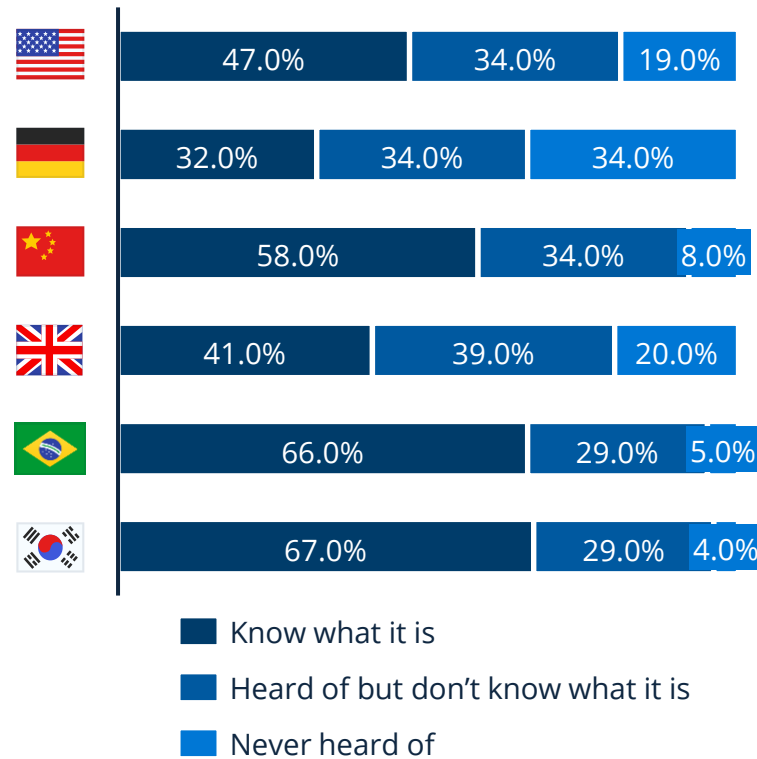## Types of virtual assets owned as NFTs[1] in the virtual world

Virtual lands

Virtual Assets

Avatar & Social events

In-game assets

Art & Collectibles

Owning virtual real estate as NFTs [1] in the metaverse is gaining popularity, facilitated by players such as Sandbox and Decentraland.

3D avatars owned as NFTS [1] are being used to interact in the Metaverse. Meanwhile, NFT passes are used to access virtual events and concerts.

In-game collectibles are now dropped as NFTs [1] and owned as digital assets among players.

Assets like digital art & collectibles are now being sold on NFT [1] marketplaces.

Virtual assets market size and virtual assets in the Metaverse in billion US$

1.494

249

114

37

3

15

+9.765%

2022

2030

■ Virtual Assets   ■ Virtual Assets Metaverse   ■ TAM Metaverse

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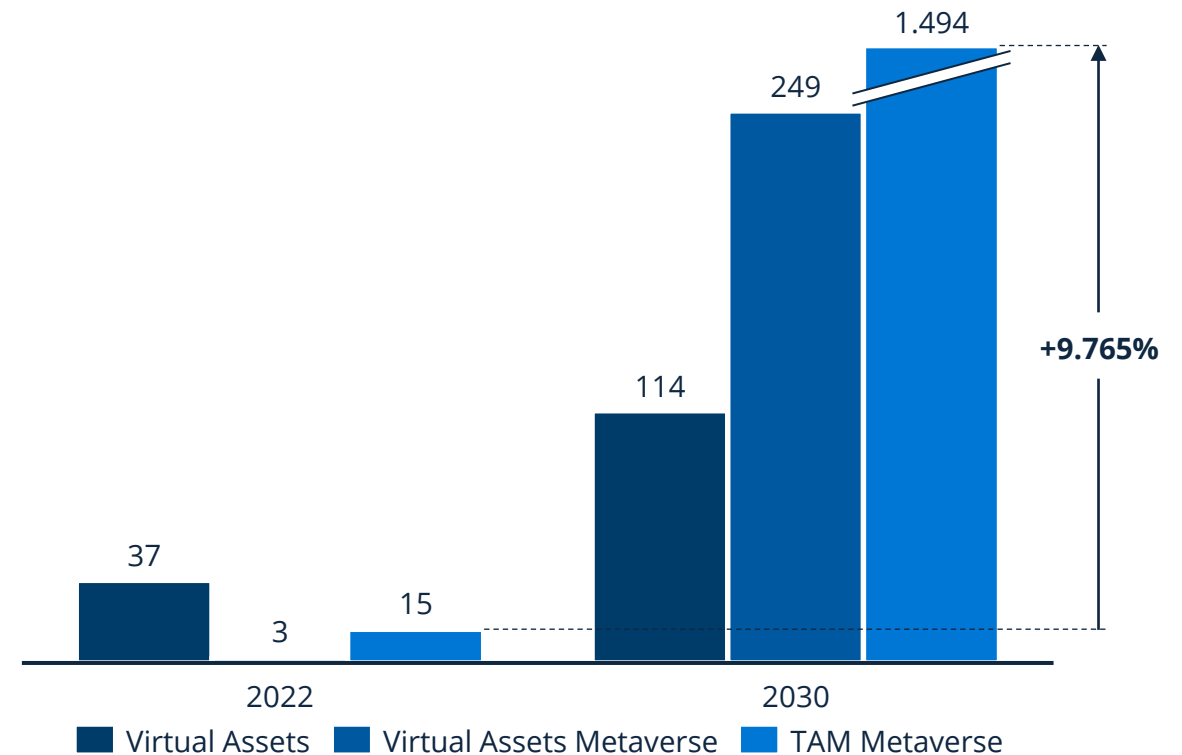
There is still a lot of uncertainty about the Metaverse because many people are unfamiliar with the concept and virtual assets have recently been struggling

Knowledge about the Metaverse in top countries[1]

US: 47.0% | 34.0% | 19.0%

Germany: 32.0% | 34.0% | 34.0%

China: 58.0% | 34.0% | 8.0%

UK: 41.0% | 39.0% | 20.0%

Brazil: 66.0% | 29.0% | 5.0%

South Korea: 67.0% | 29.0% | 4.0%

■ Know what it is
■ Heard of but don't know what it is
■ Never heard of

NFT[2] sales since January 2021 in billion $US

Jan. 2021	Juni 2022	Jan. 2022	Juni 2022
0.1	0.7	12.6	1.0

-92.1%
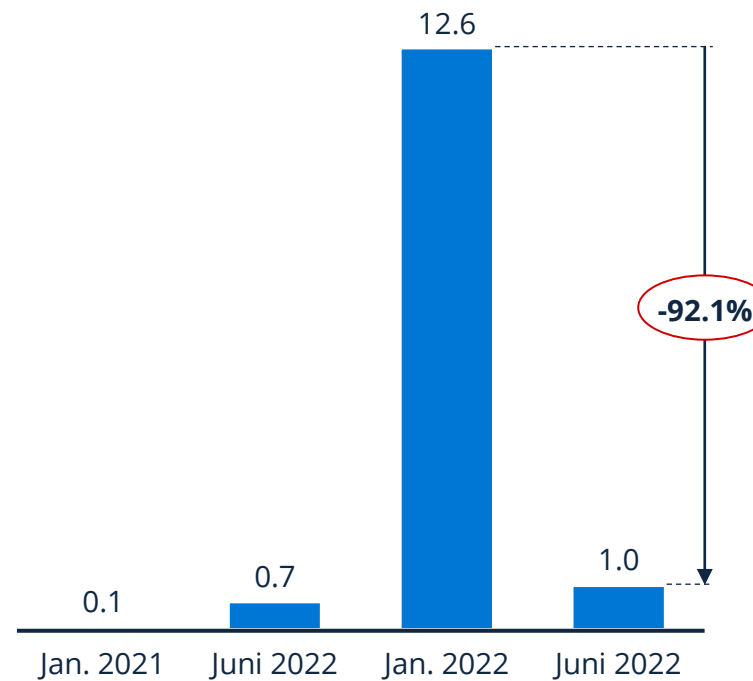
- Many people still don't know exactly what the Metaverse is or have simply never heard of it
- Levels of perception about the Metaverse vary widely and because the concept is difficult to isolate, people have trouble understanding it
- Additionally, NFTs, classified as one of the currencies within the Metaverse, reached an all-time-low in sales in June 2022
- As a result, several applications experienced user losses, including, Meta's Horizon Worlds, which lost 100,000 users in 8 months
- Decentraland, one Metaverse application, only has 650 daily active users, whereas Sandbox has experienced steady user growth, with 300,000 users in April 2022

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The next steps for improving the technology in the Metaverse center around three pillars

Internet of Everything

The Internet of Everything (IoE) is a concept that goes beyond the Internet of Things (IoT). Contrary, it combines not only devices, but also data, processes, and people. However, in order to function properly, it needs data. Communication will be between people using devices, wearables, cameras, and machine learning.

In the **future,** the Internet of Everything will allow experts to create digital twins and lays the foundation for future developments.

Digital twins

A digital twin is a dynamic virtual copy of a physical asset, process, system, or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes to enable the prediction of potential performance outcomes and issues with the real-world product.

In the **future,** digital twins will enable accessibility to cars, the design of smart cities, or medical training.

Artificial intelligence

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. AI can contribute to several aspects of the Metaverse economy, such as user experience, intelligent networking, and creative inspiration.

In the **future,** artificial intelligence in the Metaverse will contribute to building differential and inclusive experiences.

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Digital twins can shift the experience of the Metaverse to a new level and enable various new use cases

Digital twins market size by industry in billion US$

Industry	2020	2025
Manu-facturing	0.59	6.69
Automotive	0.49	5.06
Aviation	0.43	5.09
Energy and Utilities	0.34	3.83
Healthcare	0.29	3.81
Logistics and Retail	0.23	2.26
Others	0.28	2.83

■ 2020 ■ 2025

A digital twin is a dynamic virtual copy of a physical asset, process, system, or environment that looks like and behaves identically to its real-world counterpart. A digital twin ingests data and replicates processes to enable the prediction of potential performance outcomes and issues with the real-world product.

Digital twins market share in 2025 by industry

- Others 10%
- Logistics and Retail 8%
- Healthcare 13%
- Energy and Utilities 13%
- Aviation 17%
- Automotive 17%
- Manufacturing 23%

In the **future,** digital twins will enable accessibility to products, equipment, factories, buildings, cities, and more. Within the Metaverse, real-time 3D will unlock new possibilities by shaping the experience of the Metaverse and taking it to the next stage. Examples include 3D marketing, 3D eCommerce sales, designing smart cities, and medical training.

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The question of whether the Metaverse can shape new ways for consumers to perceive real and virtual worlds is wide open at the moment

Metaverse selected use cases summarized

The Metaverse could replace physical offices, e.g., Horizon Workrooms which is part of Horizon Worlds

The Metaverse could enhance education as students have more possibilities to learn, e.g., surgeons can practice virtually

The Metaverse economy could become as important as the real-world economy, e.g., Bitcoin's average trading volume is US$24.73 bn.

The Metaverse could help planning infrastructure/traffic solutions in cities to reduce commuting time, e.g., using digital twins

The Metaverse could replace in-person physical interaction to an extent, e.g., experience concerts or gaming

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Cybersecurity: fighting the formidable foes of the internet

Originally released in November 2022 (as Chapter 4)

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Table of contents

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Cyber-resilience: the need of doing the ordinary extraordinarily well

Cybersecurity is becoming increasingly important as companies, governments, and individuals depend on the Internet for communication and data storage. This digital transformation has made security a priority for organizations of every size. Companies in all industries face increasing cyberattacks due to their reliance on IT systems, which are vulnerable to malicious actions. This was especially evident during the COVID-19 pandemic, when companies rushed to enable workers to work remotely. Moreover, there are different types of cyberattacks, and each one requires a distinct approach to prevent damage to a company and its operations, revenues and employees. The cybersecurity market is expected to reach approximately US$262 billion in revenues by 2027.

From an enterprise perspective, six technology trends are crucial, and each represents a movement from an existing paradigm to a new way of thinking

Overview of trends shaping the future of enterprise technology

Technology trend	From...	To...	Implications	
			IT	**Business**
Interaction explosion	Mobile app	Multiverse of digital interactions	Build for immersion and many devices	Bring rich engagement to your customers
Connected intelligence	Big-data models	AI agents	Embed machine learning in every application	Personalize every customer episode, optimize every process
Distributed meaning	Murky data lakes	Open data fabrics	Mesh data together, leave it where it is	Know more and participate in the data economy
Limitless modularity	Integrated apps	Decoupled components	Compose applications from available resources	Plan for constant evolution
Cybersecurity arms race	Technology protection	Resilience and robustness	Engage the enterprise in building for resilience	Invest in the stability of your business
Perpetual motion	Agile DevOps	Automated business engineering	Engineer with business units and automate	Expect to change faster

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The increasing reliance on computer systems, the Internet, and wireless network standards has led to a critical need for cybersecurity

Cybersecurity has grown in importance due to several factors: the internet, an increased reliance on computer systems, the growth of smart devices that constitute the Internet of Things (IoT), and wireless network standards such as Bluetooth and Wi-Fi. With its combination of politics and technology, cybersecurity has become a major challenge for governments as well as companies.

The beginning of the Internet

Reaper: The first Cybersecurity program

The spread of the Vienna virus ⇔ The first antivirus

- "Melissa" caused US$80 million damage
- ILOVEYOU infected > 50 million computers

Antiviruses started utilizing Big Data

EU enforced GDPR

Cybersecurity industry experienced a boom due to the impact of COVID-19

1969   1971   1973   1983   1987   1988   1990s   1999   2001   2003   2010   2012 2013   2014   2018   2020   2021

The first computer worm

I'M THE CREEPER, CATCH ME IF YOU CAN!

The official birthday of the Internet. Prior to this, the various computer networks could not communicate with each other

Morris worm: First major attack on the Internet

Anti-virus industry explodes

The first national cyber security strategy was issued by the U.S. government

First weaponized malware program

Yahoo's data breaches affected all 3 billion user accounts

The rise of the connected device

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Cybersecurity challenges come to organizations in many forms but have one thing in common: the swift exploitation of security gaps

Selected cyberattack categories

Malware

Malware refers to malicious software that is designed to disrupt or steal data from a computer, network, and/or server.

Ransomware

A type of malicious software is designed to block access to a computer system until a sum of money is paid

Phishing

A fraudulent message is sent to trick a person into revealing sensitive information to the attacker or to deploy malicious software on the victim's infrastructure

SQL injection

A web security vulnerability that allows an attacker to interfere with the queries that an application makes to its database

XSS attacks

The attacker aims to execute malicious scripts into websites and web applications for the purpose of running on an end user's device

DoS & DDoS attack

A targeted network resource is made unavailable to its users by temporarily/indefinitely disrupting services of host connected to network.

Man in middle attack

An attacker secretly intercepts and relays messages between two parties who believe they are communicating directly with each other.

Zero-day exploit

A zero-day exploit is a cyberattack targeting software or systems with a previously unknown vulnerability

DNS tunneling

DNS tunneling exploits the DNS protocol to tunnel malware and other data through a client-server model

Cryptojacking

A criminal secretly uses a victim's computing power to generate cryptocurrency.

Social engineering

An attacker uses human interaction (social skills) to obtain information about company or computer systems

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Not only are organizations at risk for cyberattacks, but cybercriminals can use any internet-connected device as a weapon

Selected facts about cybersecurity

58% of adults are more worried than ever about being a victim of cybercrime

78% of consumers are concerned about data privacy

22% of consumers have detected malware on an internet-connected device

53% of people distrust IoT devices to protect their privacy and handle their information
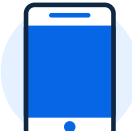
70% of online fraud is accomplished through mobile platforms

83% of organizations that have has more than one data breach

Social engineering is the most successful means to a data breach

Phishing was reported to the FBI more than any other internet crime in 2021

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The losses to cyber crime increased significantly, a development which can be connected to the great financial losses in 2021

Global financial cybercrime losses in million US$ in 2021
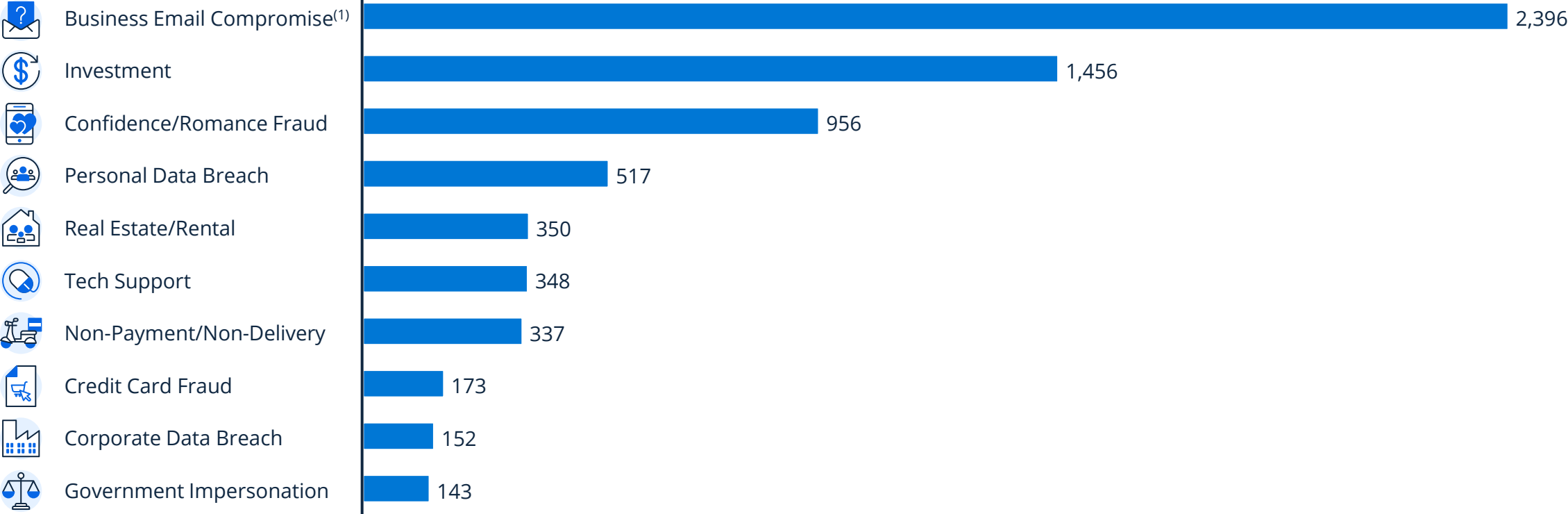
Category	Value
Business Email Compromise[1]	2,396
Investment	1,456
Confidence/Romance Fraud	956
Personal Data Breach	517
Real Estate/Rental	350
Tech Support	348
Non-Payment/Non-Delivery	337
Credit Card Fraud	173
Corporate Data Breach	152
Government Impersonation	143

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Major data breaches have continued to increase in severity over the past few years

Selected data breaches with amount of records affected in million

Records affected (in Millions)

Company	Records	Compromised Information
dailymotion	85	Email, Passwords, Username
Uber	57	Contact, Driver's License, Name
EQUIFAX	143	Driver's License, Personal, SSN
Marriott	500	Passport, Personal, Travel
CATHAY PACIFIC	9	Passport, Personal, Travel
Facebook	50	Interests, Personal
Quora	100	Login, Linked Networks
BLANKMEDIA	8	Contact, Payment, Personal
Quest Diagnostics	12	Payment, Personal, SSN
Facebook	600	Passwords
笨鸟社交 www.socialens.com	885	Driver's License, Payment, SSN
Capital One	106	Payment, SSN
Microsoft	250	Personal
ESTĒE LAUDER	440	Email
Whisper	900	Personal
新浪微博	538	Email
wattpad	268	Contact, Login, Personal
Facebook	533	Contact, Personal
experian	220	Personal
First American	200	Contact, Linked Networks
BONOBOS	12	Contact, Passwords, Personal
1 MORE LEAD	126	Contact, Contact, Email
PowerApps	38	Contact, Email, SSN

Timeline: 2016 · 2017 · 2018 · 2019 · 2020 · 2021

Compromised Information

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As the scope of cyberattacks and their potential to create havoc has increased, the effort required to execute them has dropped sharply

Cyberattack complexity compared to cost of attack execution over time

Labels (left to right / bottom to top):

Password guessing · Self-replicating code · Password cracking · Burglaries · Disabling audits · Backdoors · Exploiting known vulnerabilities · Sweepers · Hijacking sessions · Sniffers · Packet spoofing · GUI · Network management diagnostics · Denial of service · "Stealth"/advanced scanning techniques · World wide web attacks · Cross-site scripting · Distributed attack tools · Staging · Remote control · Web app/database · 3G/GSM attacks · Critical infrastructure attacks · Supply chain · Web app/database · Ransomware · Password spraying · Feint (diversion) attacks · E-skimming · Cryptomining · Double extortion ransomware · Industrial control safety system attacks · AI/ML augmented attacks · Voice phishing · Deepfake videos

Axis: High / Low; 1980, 1990, 2000, 2010, 2020

Legend: - - - - - Cost to execute attack   ——— Complexity of attack

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The COVID-19 pandemic accelerated global cybersecurity spending and compelled many organizations to prioritize cybersecurity

COVID-19 impact on global IT vendor spending in 2020

Category	Increase	Stay the same	Decrease
Cybersecurity	84%	13%	3%
Hybrid or multicloud	74%	19%	7%
Automation	66%	22%	13%
AI	59%	26%	15%
5G	49%	41%	10%
IoT[2]	43%	41%	16%
AR/VR[3]	38%	40%	22%
Blockchain	27%	49%	24%

Legend: Increase · Stay the same · Decrease

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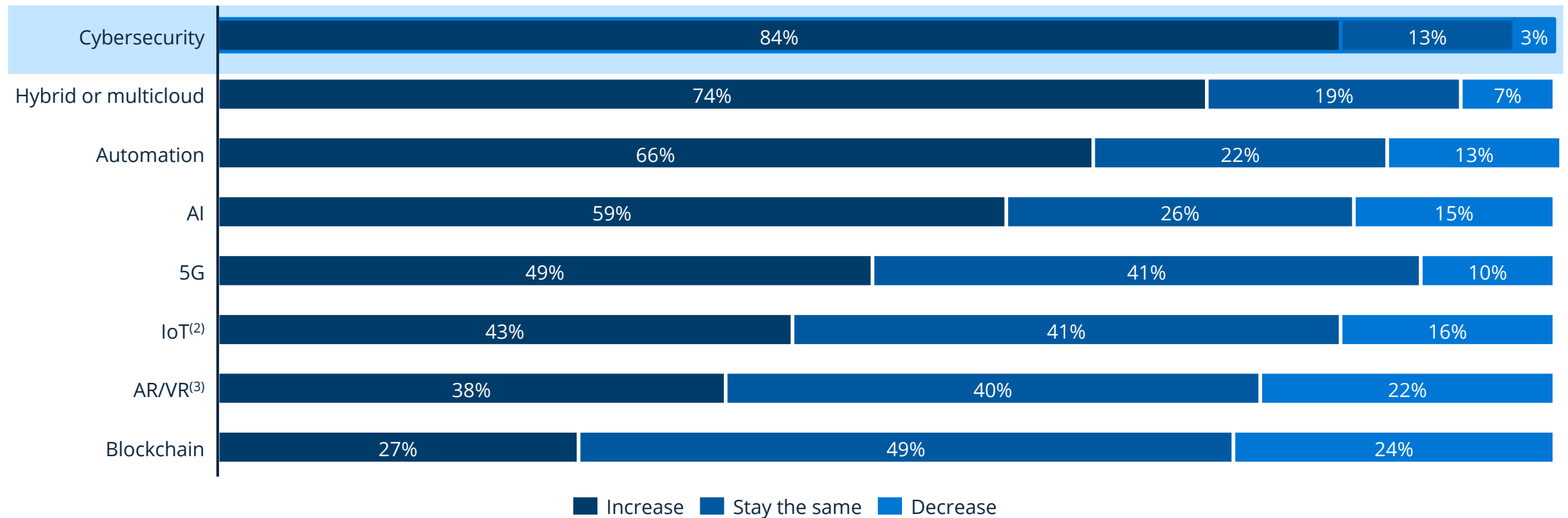
The post-pandemic cybersecurity market rebounded significantly and set sail for growth

Global cybersecurity market revenue development

After an initial shock from the pandemic, the cybersecurity market bounced back and is predicted to reach another peak due to the Russia-Ukraine war in 2022

Revenue

Growth rate

Revenue values: 83 (2016), 90 (2017), 103 (2018), 115 (2019), 122 (2020), 139 (2021), 156 (2022), 173 (2023), 192 (2024), 213 (2025), 237 (2026), 262 (2027)

Growth rate values: 12% (2018), 12% (2019), 6% (2020), 14% (2021), 12% (2022), 11% (2023)

■ Revenue (in billion USD)   —○— Growth rate (in percent)

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The general increase of cyberattacks, long-term impacts of COVID-19 and the introduction of new technologies are driving the Cybersecurity market
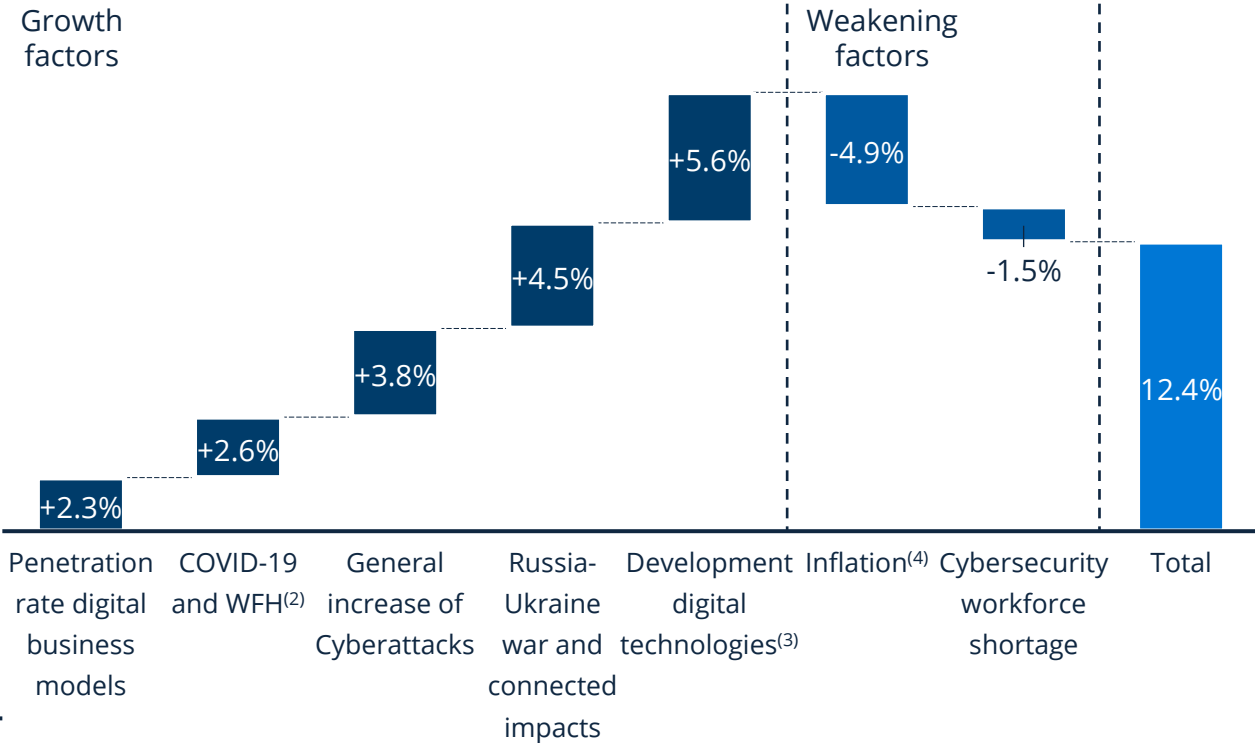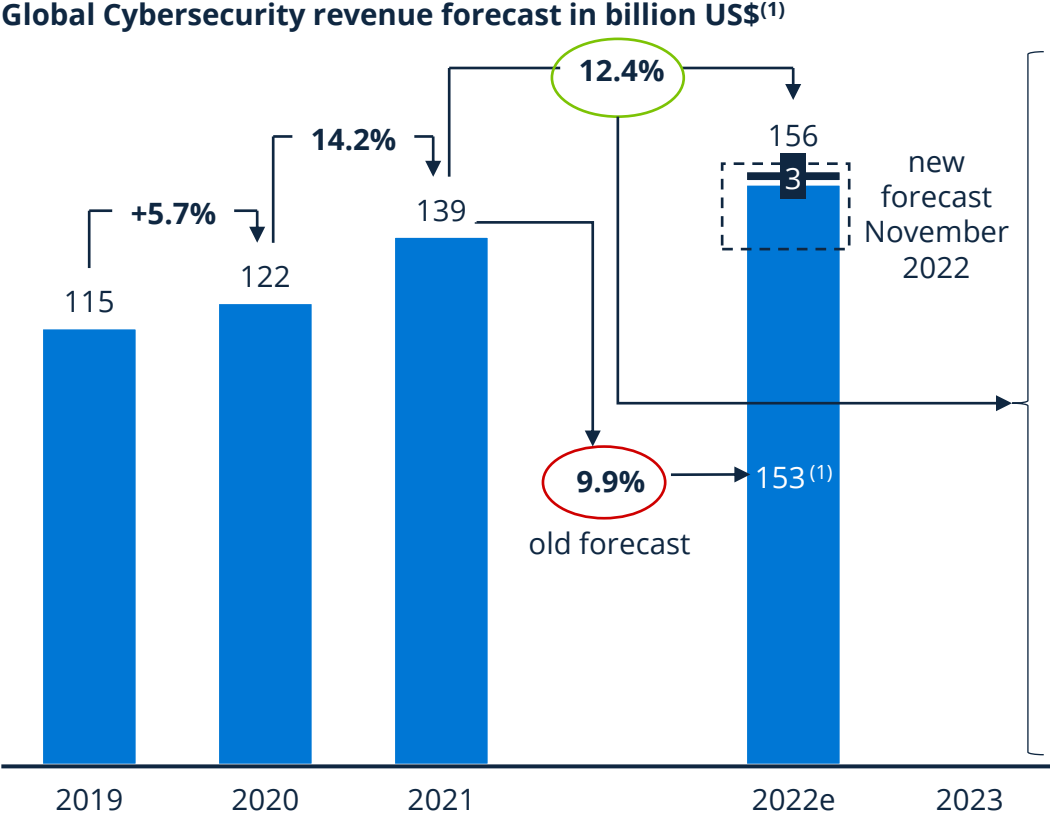
Global Cybersecurity revenue forecast in billion US$[1]

Growth factors

Weakening factors

Penetration rate digital business models: +2.3%
COVID-19 and WFH[2]: +2.6%
General increase of Cyberattacks: +3.8%
Russia-Ukraine war and connected impacts: +4.5%
Development digital technologies[3]: +5.6%
Inflation[4]: -4.9%
Cybersecurity workforce shortage: -1.5%
Total: 12.4%

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Due to the activity of various hacker groups and information thieves, China faced high cybercrime activity in 2021 and lost an estimated US$574 billion

Global cyber threat risk index map(1)

Darker = Higher risk   Insufficient data
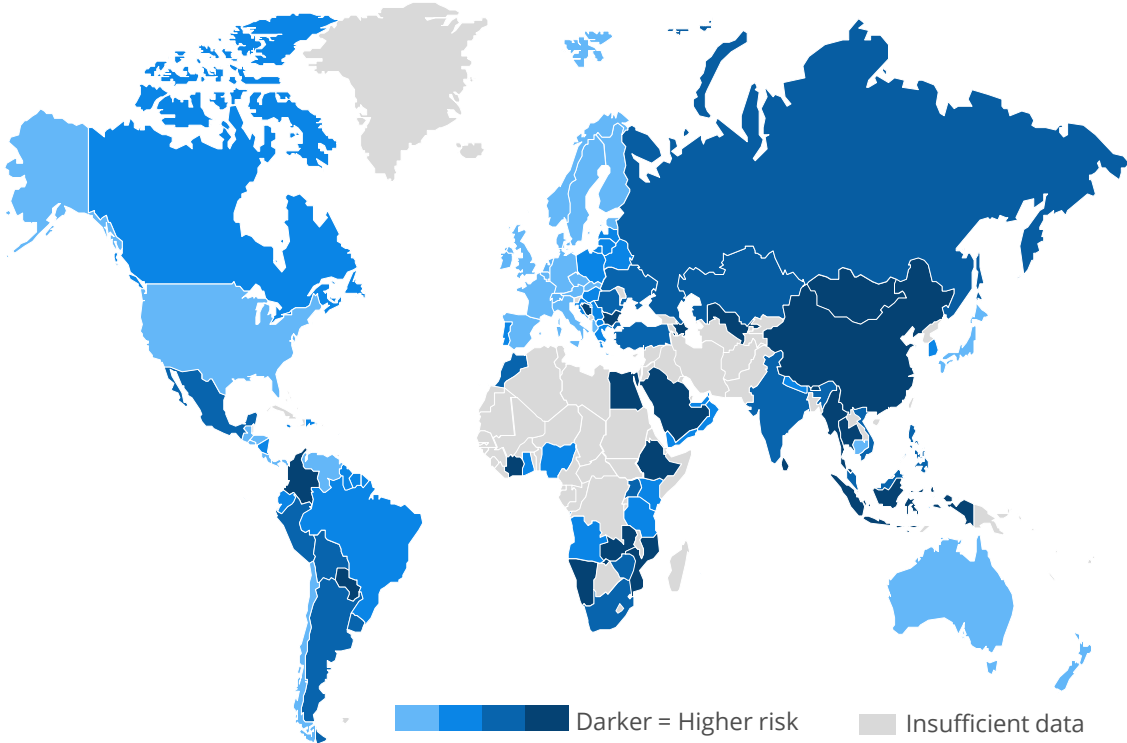
Selected countries showing losses due to cybercrime in billion US$ in 2021
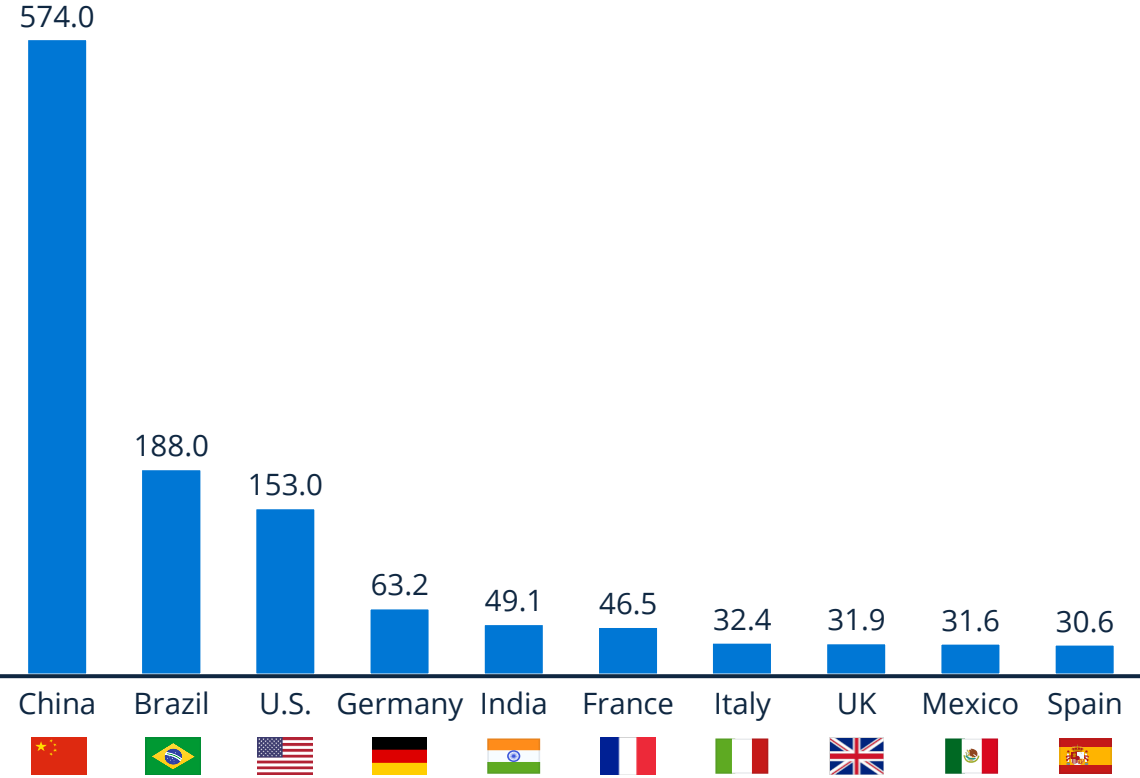
China	Brazil	U.S.	Germany	India	France	Italy	UK	Mexico	Spain
574.0	188.0	153.0	63.2	49.1	46.5	32.4	31.9	31.6	30.6

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The cybersecurity market in China is predicted to grow the most with an estimated increase of 14.5% between 2022 and 2027

Total cybersecurity revenue forecast in billion US$
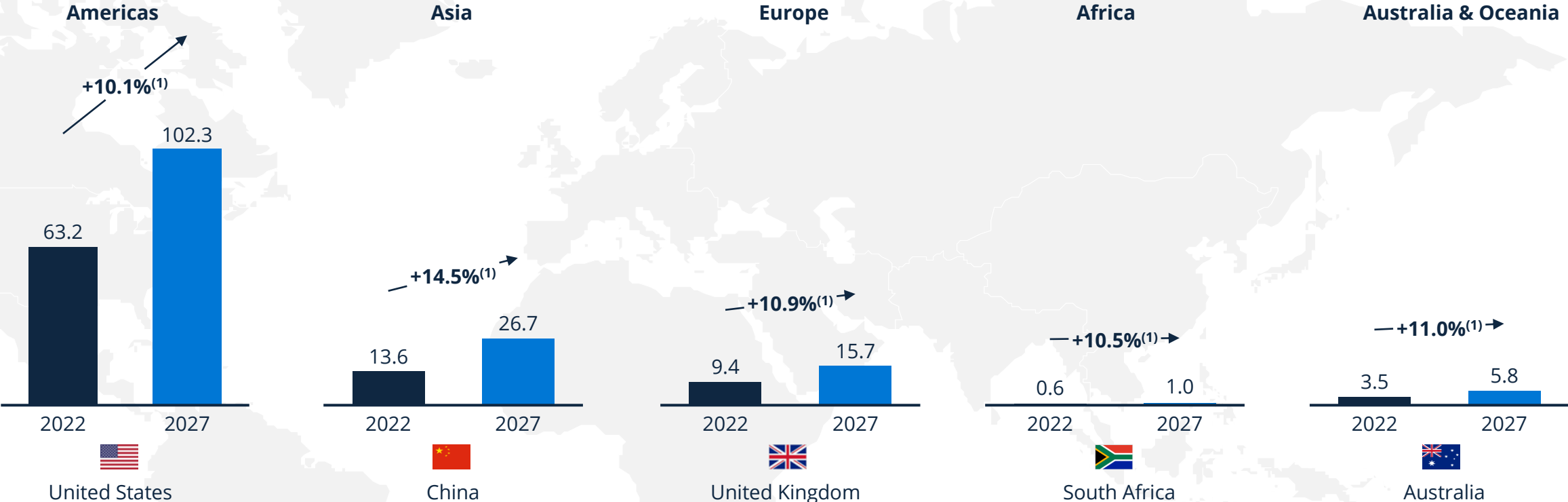
Americas	Asia	Europe	Africa	Australia & Oceania

Americas

+10.1%[1]

63.2 (2022)
102.3 (2027)

🇺🇸 United States

Asia

+14.5%[1]

13.6 (2022)
26.7 (2027)

🇨🇳 China

Europe

+10.9%[1]

9.4 (2022)
15.7 (2027)

🇬🇧 United Kingdom

Africa

+10.5%[1]

0.6 (2022)
1.0 (2027)

🇿🇦 South Africa

Australia & Oceania

+11.0%[1]

3.5 (2022)
5.8 (2027)

🇦🇺 Australia

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There is still ample opportunity for growth: with US$2 trillion, the total addressable market is approximately ten times the size of the vended market

Global cybersecurity market size in trillion US$ in 2021

10x

1.5-2.0

0.14-0.15

Vended market

Total addressable market
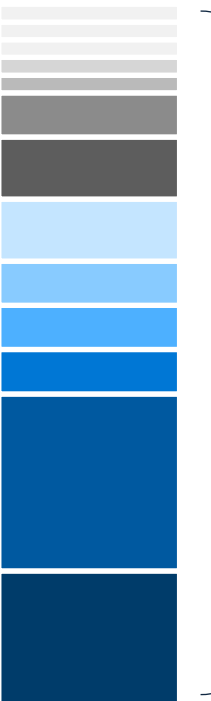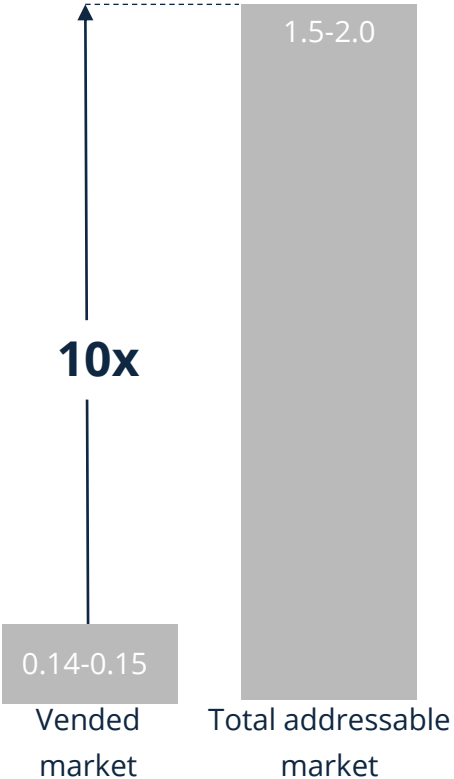
Segment	Total addressable market in billion US$	Current segment penetration
Data protection	50-100	30-35%
Governance, risk, and compliance	50-100	30-35%
Email security and awareness	50-100	10-15%
Cloud security	50-100	1-5%
Network security	50-100	15-20%
Identity and access management	50-100	20-25%
Security consulting	100-200	15-20%
Web security	100-200	5-10%
Iot/OT [1]	100-200	1-5%
End point security	100-200	5-10%
Application security	100-200	1-5%
Security and operations management	400-500	1-5%
MSSP/outsourcing[2]	400-500	5-10%

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Growing cybermarket challenges and unsolved opportunities are shaping an industry on the rise

The business of cybersecurity is attractive, lucrative, and highly competitive. Cybersecurity companies enjoy high-profit margins due to rapid growth and the potential for rapid expansion. The cybersecurity industry has been becoming ripe for consolidation, especially with the support of the top players and the prevalence of full-time hackers. Yet in this already fragmented market, a chasm formed that was radically accelerated by the pandemic. COVID-19 drove a rapid development toward digital transformation. As digital transformation grows, the security market grows with it. What's clear is that there is a huge demand for cybersecurity solutions in the post-pandemic market, which will give rise to a surge of cybersecurity unicorns.

With sophisticated cyberthreats on the rise, the challenges and unsolved opportunities for cybersecurity providers are numerous

Selected challenges and opportunities for cybersecurity companies

Visibility gap	Technology-fragmentation challenge	Talent gap	Cybersecurity ROI[1]
Problems			
• Without visibility into their own digital infrastructure, it will be difficult for companies to recognize when, where, or why there is a problem	• Enterprises grapple with the challenge of timing technology decisions (how to balance agile-best integrated options with fragile, fragmented, best-of-breed options) since different applications and providers are used • Often, a company may have more than 100 third-party security tools.	• The number of unfilled cybersecurity jobs grew by around 315%, from 1 million positions in 2013 to 3.12 million in 2021. • More than 3.5 million jobs in cybersecurity are predicted to be unfilled in 2025; the talent shortage is a massive problem	• Organizations today struggle with understanding how to measure the return or value of a dollar spent on cybersecurity, as well as how to communicate its value to internal stakeholders, such as C-suite and board members
Solutions			
• Rethink the 'pay by the drink' approach (such as pay per log) to volume-based pricing models • Identify the missing puzzle pieces to building a 360° view • Reduce false positives, forcing the organization to approach cyberthreats proactively, not reactively	• Produce offerings that allow for seamless simplification of sprawl • Use cloud and software-as-a-service adoption or updates as an opportunity for tool rationalization • Engage all stakeholders, make business-based simplification decisions, and don't put all the cybersecurity burden on the CISO.	• More one-shop and full-stack-service providers (such as 'infra in a box') • Impact of delivery preferences on customers' key buying factors • Recruiting realistically by, for example, looking beyond traditional places, finding individuals with similar skill sets that can be trained, and looking beyond formal education	To have a true security proposition, there are at least three dimensions that the cybersecurity provider community should consider: • Business value • Customer value • Market value

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The large strategic and economic value of cybersecurity can be observed based on stock performance of key players in the sector

Top cybersecurity companies stock performance in 2021

FÜRTINET	zscaler	paloalto NETWORKS
↑ **147%**	↑ **62%**	↑ **59%**
McAfee	mimecast	RAPID7
↑ **54%**	↑ **40%**	↑ **33%**
NortonLifeLock	DARKTRACE	SentinelOne
↑ **27%**	↑ **23%**	↑ **19%**
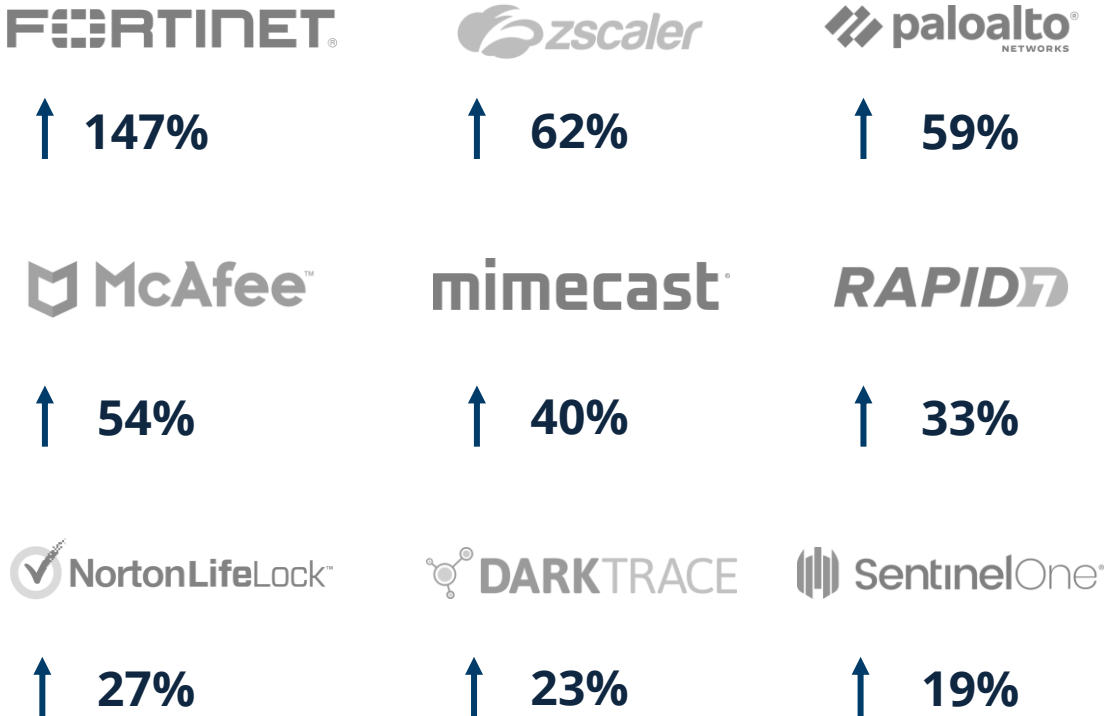
Top 20 IT security companies by market capitalization in US$ billion in 2022[1]

Company	Value
Palo Alto Networks	45.53
Fortinet	39.33
CrowdStrike	28.55
Zscaler	17.14
Check Point Software	15.98
Leidos	14.59
NortonLifeLock	14.41
Akamai	14.15
Cloudflare	13.08
Avast	8.70
F5 Networks	8.03
Okta	7.23
Trend Micro	6.72
SailPoint	6.18
CyberArk	5.92
Mandiant	5.39
SentinelOne	4.34
KnowBe4	4.33
Qualys	4.30
Tenable	3.90

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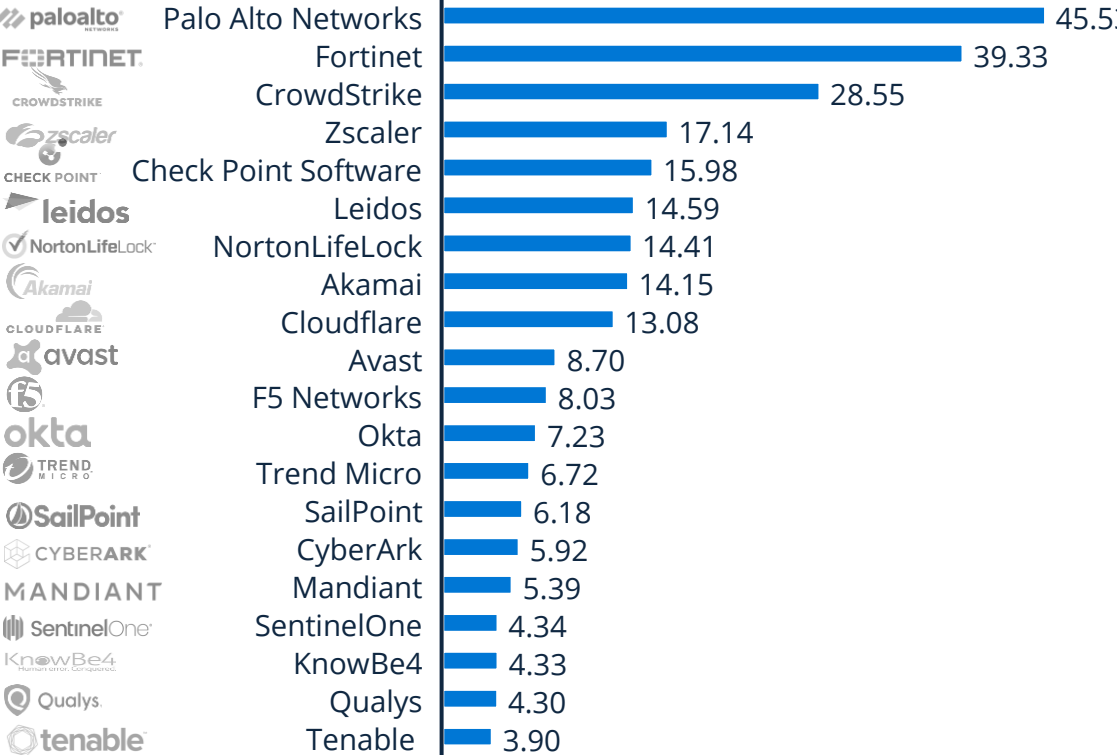
Cybersecurity companies are high performers and recorded an average profit margin of over 70% over the past five years

Selected cybersecurity players gross profit margin range for the past 5 years

90.2%
87.8%
86.4%
86.8%
81.1%
78.3%
78.6%
78.0%
75.1%
75.8%
74.5%
74.8%
73.0%
71.4%
73.4%
68.0%
68.2%
59.0%

ø 76.2%

— Min — Max • Average
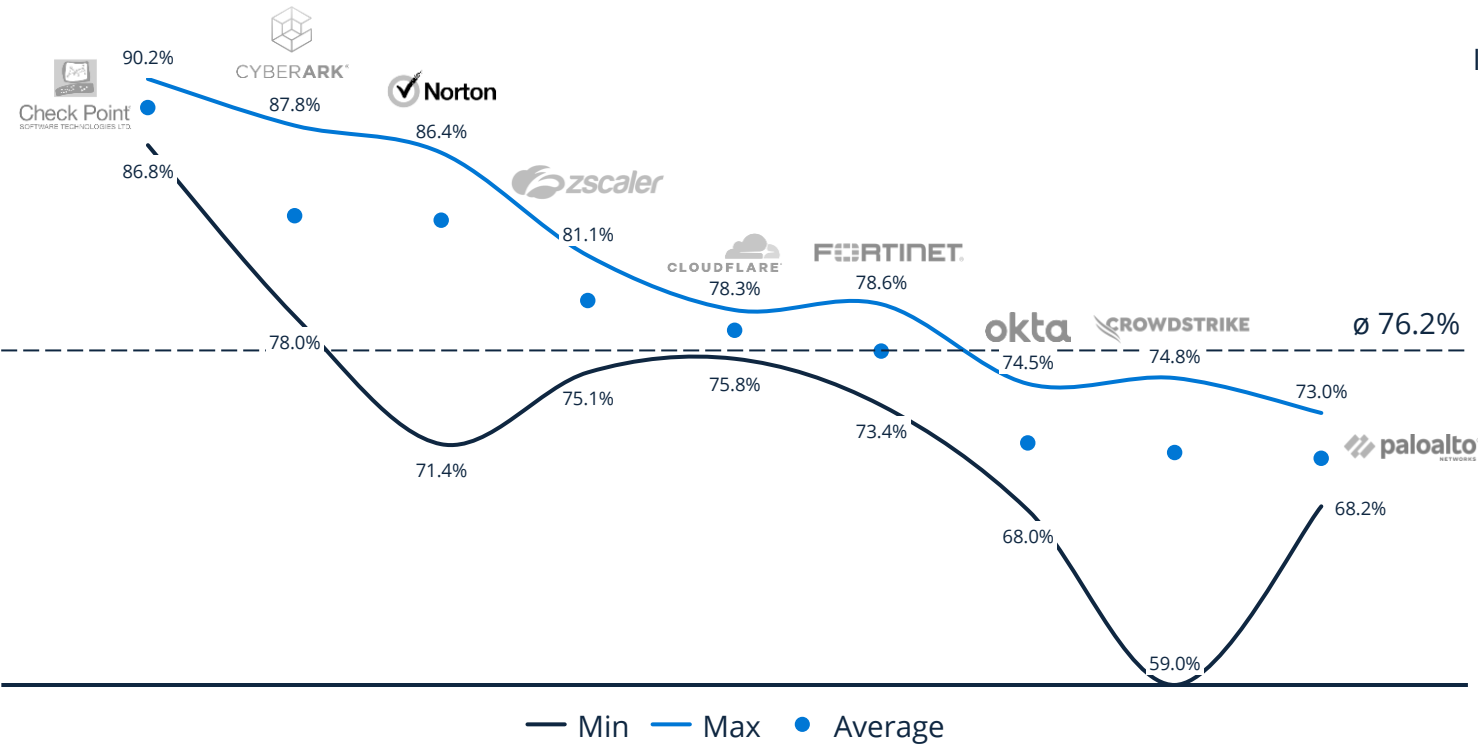
Average industry gross margins in the U.S in 2022[1]

Industry	%
Software (System & Application)	72%
Investments & Asset Management	69%
Drugs (Pharmaceutical)	67%
Green & Renewable Energy	63%
Tobacco	63%
Healthcare Products	59%
Apparel	53%
Entertainment	42%
Computers/Peripherals	37%
Restaurant/Dining	32%
Advertising	26%
Retail (Automotive)	22%
Transportation	21%
Air Transport	1%

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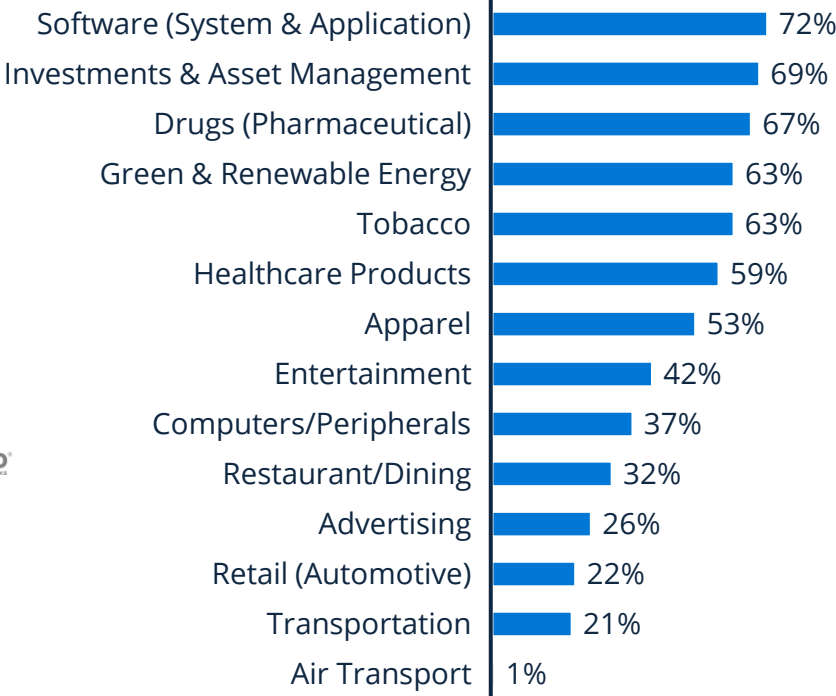
In 2021, US$21.8 billion was invested globally in cybersecurity companies, with 80% raised by U.S.-based businesses

Global cybersecurity funding and number of deals

Total funding in billion US$

Number of deals per year

The cybersecurity market in the U.S. has experienced a sharp increase in investment since the significant growth of this market was predicted after the first year of the COVID-19 crisis

+145%

Year	2017	2018	2019	2020	2021
Number of deals	737	774	743	769	686
Total	5.1	5.9	8.3	8.9	21.8

2020: ROW 2.0, U.S. 6.9
2021: ROW 4.4, U.S. 17.4

— Number of deals ■ Total invested ■ ROW(1) ■ U.S.

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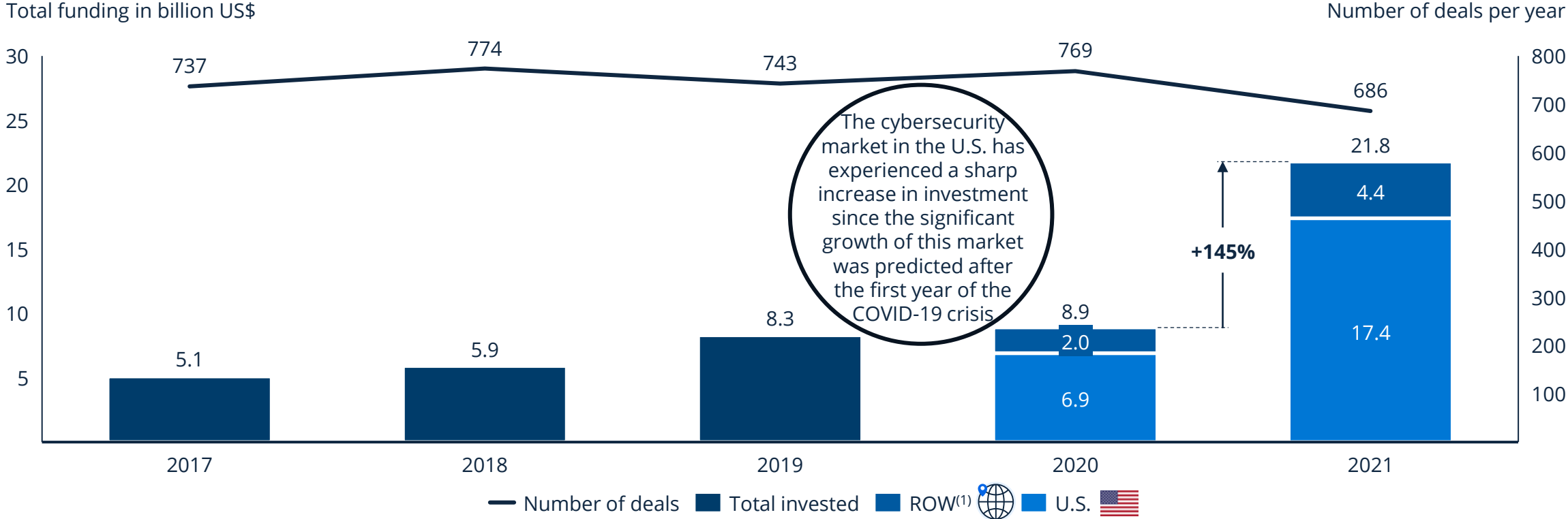
2021 has been a year for cybersecurity start-ups to achieve unicorn status with an average development period of four years

Most funded topics for cybersecurity start-ups

Cloud security

Overall funding

Application security

Data security & privacy

New startups

Vulnerability & risk management

IoT
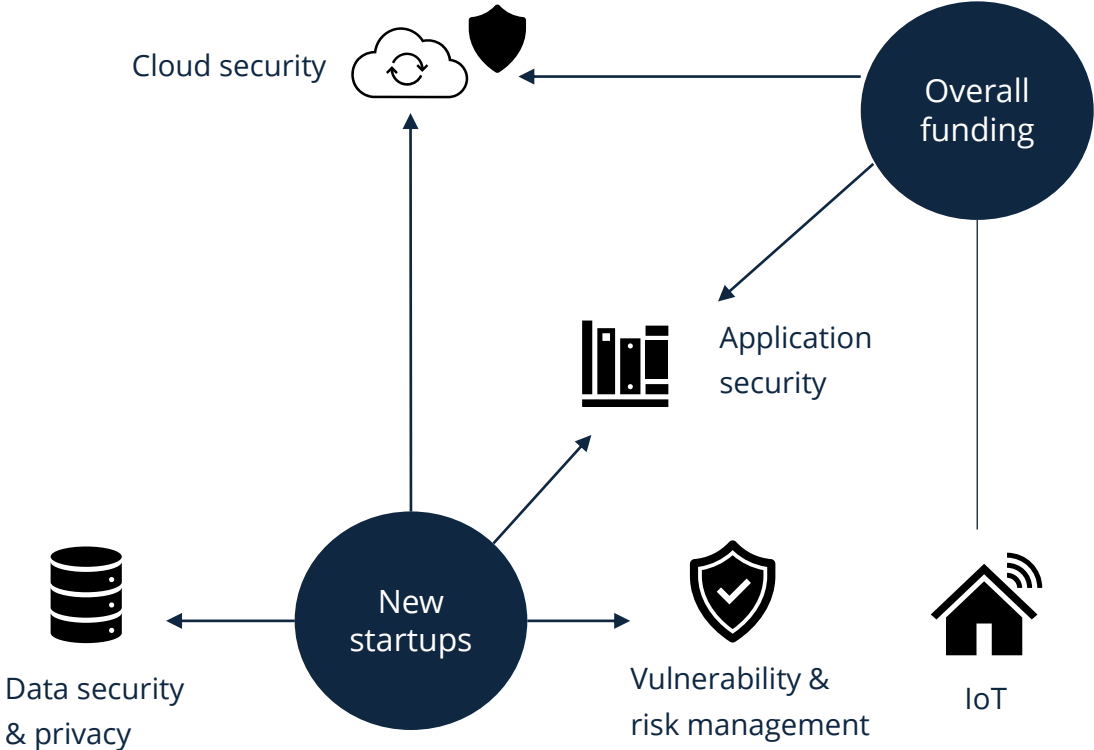
Average time to achieve unicorn status in the cybersecurity industry
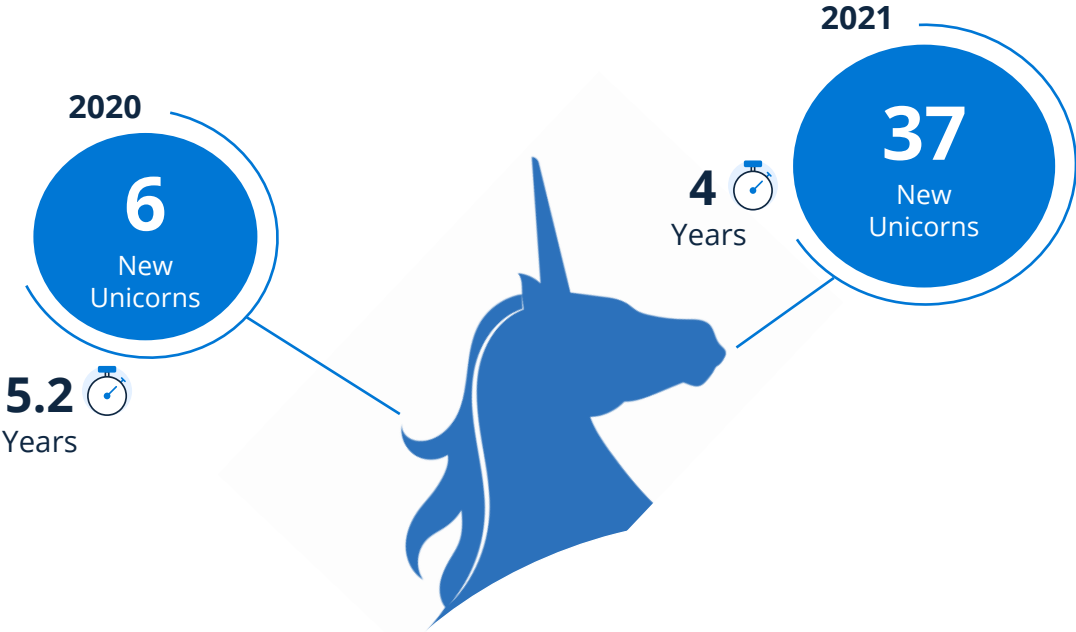
2020

6
New Unicorns

5.2
Years

2021

37
New Unicorns

4
Years

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The cybersecurity market in North America, particularly in the United States, has seen significant growth for new unicorns in recent years

Private cybersecurity companies valued at >1$ billion by region[1]

Europe

Acronis

Asia

WIZ CATO NETWORKS

4Paradigm 第四范式 TONGDUN www.tongdun.cn

North America

TANIUM DRATA LACEWORK incode panther CERTIK eXpel BITSIGHT The Standard in SECURITY RATINGS

CONTRAST SECURITY snyk DRAGOS AURA ALLOY persona sift VECTRA

jumpcloud Fireblocks Transmit security HashiCorp Trulioo exabeam Socure BigID

1Password CLAROTY orca security Chainalysis aqua riskified SentinelOne

Signifyd OneTrust ID.me Plume Coalition feedzai SecurityScorecard

Own{backup} illumio FORTER rubrik Auth0 druva cybereason

noname Acronis Venafi ARCTIC WOLF netskope Kaseya AXONIUS SALT

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In 2021, four cybersecurity companies that recently became unicorns were valued at more than US$8 billion

Latest unicorn valuations in US$ billion[1]

Company	Valuation
TANIUM	9.0
snyk	8.5
LACEWORK	8.3
Fireblocks	8.0
netskope	7.5
1Password	6.8
WIZ	6.0
CONTRAST SECURITY	5.3
Socure	4.5
ARCTIC WOLF	4.3
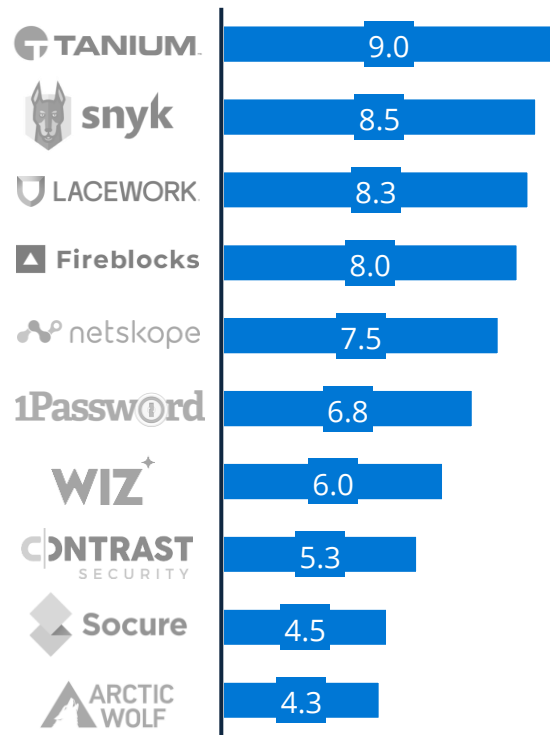
Selected cybersecurity unicorns

TANIUM

Tanium uses next-generation security analytics and automation technologies for enterprises to identify potential threats on their infrastructure.

US$9bn[1] valuation
2015 founded
2,200 employees
17 investors

Genpact saves 75% of networking and hosting costs with Tanium Cloud

It's time f converge
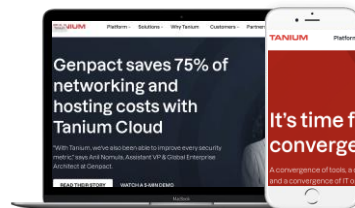
snyk

Snyk offers security analysis tools to identify, monitor, and fix vulnerabilities in open source code to ensure that applications are built securely from the start.

US$8.5n[1] valuation
2020 founded
1,400 employees
30 investors

Developer loved, Security trusted.
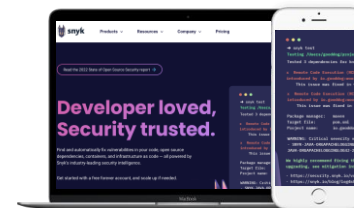
LACEWORK

Lacework is an automated compliance plug-in for cloud creators that protects your infrastructure from vulnerabilities and security threats.

US$8.3bn[1] valuation
2021 founded
1,120 employees
19 investors

Security is knowing truth from the chaos

See us in action

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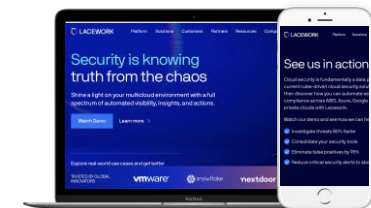
Transmit and Lacework raised more than US$500 million in one funding round and became unicorns in 2021

Global cybersecurity unicorn by funding round at the time it joined the unicorn club[1]

Size of funding round when joined the unicorn club

700
600
500
400
300
200
100
0

transmit $543M

LACEWORK $525M

rubrik $180M

netskope $169M

OneTrust PRIVACY, SECURITY & GOVERNANCE $200M

HashiCorp $100M

Lookout $150M

TANIUM $67M

ARCTIC WOLF $200M

Fireblocks $310M

CONTRAST SECURITY $150M

orca security $200M

WIZ $130M

1Password $100M

Acronis $147M

snyk $150M

2014   2015   2016   2017   2018   2019   2020   2021

Year joined the unicorn club

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Modern warfare is moving from land, sea, and air into a new cyberspace arena

The internet's global pathways mean that cyberactivities erase much of the longstanding protection provided by borders, walls, and oceans. With Russia's invasion of Ukraine, cyberattacks are like a war before the war. Russia began its assault with hidden, massive, disruptive cyberattacks before sending troops to the Ukrainian border in February.

There is an expected increase in Russian cyberattacks as retaliation for sanctions imposed on the country in the aftermath of this invasion. The U.S. government also warned about possible Russian cyberattacks on infrastructure such as the electrical grid, water treatment plants, and hospitals.

After the cybersecurity boom from the COVID-19 pandemic, the war of Russia against Ukraine will continue to drive the rapid growth of this market.

The borderless nature of cyberspace leads to a potential large-scale spread of cyberwarfare

Main types of cyberwarfare attacks

Propaganda Attacks

Propaganda attacks involve trying to control the minds of the people living in or fighting for the targeted country by exposing embarrassing truths or spreading lies that cause people to lose faith in their country.

Electrical Power Grid

Attacking the power grid allows attackers to disable critical systems and disrupt infrastructure. Attacks on the power grid can also disrupt communications and render services such as text messages and communications unusable.

Espionage

Espionage refers to spying on another country to steal secrets by using a botnet or spear-fishing attack to gain a foothold in a computer before extracting sensitive information.

Economic Disruption

Most modern economic systems depend on computers to function. Attacking the computer networks of financial facilities like stock markets, payment systems, or banks can give hackers access to funds or prevent their targets from getting their money.

Sabotage

Sabotage is a form of military attack, often conducted in conjunction with espionage, that aims to neutralize, frustrate, or destroy the enemy's military capabilities by destroying its logistical base, including attacks on civilians and civilian objects.

Denial-of-service Attacks

A denial-of-service (DoS) attack could be used to cripple a critical website used by citizens, military personnel, safety personnel, scientists, or others to disrupt critical operations and/or systems.

Number of reported cyberattacks directed against the U.S. government by attack vector in 2020
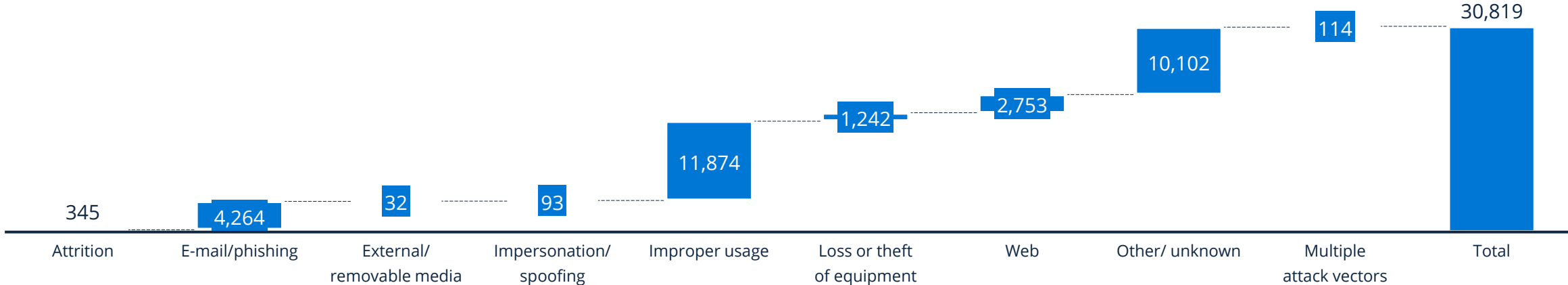
Attribution	E-mail/phishing	External/ removable media	Impersonation/ spoofing	Improper usage	Loss or theft of equipment	Web	Other/ unknown	Multiple attack vectors	Total
345	4,264	32	93	11,874	1,242	2,753	10,102	114	30,819

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The threat of cyberwar and its purported effects are a source of great concern for governments and militaries around the world

Selected cyber warfare events since 2010

Year	Event
2010	• Stuxnet: the first genuine cyberweapon was designed to inflict physical damage
2014	• Russian DDoS attack against Ukraine • Russian-based hacking group took down Ukraine's election commission
2015	• Russian hackers infiltrated computer network of German Bundestag • Chinese hackers stole 21.5 million records from the U.S. Office of Personnel Management
2016	• The second Russian-induced power outage in Ukraine
2017	• WannaCry: Ransomware Cryptowarm • NotPetya: the frist major instance of weaponized ransomware
2018	• The heist of $3.4 billion worth of secrets and data proved to be connected to Iranian-based Mabna Institute
2019	• Trump administration retaliated against Iran's downing of a U.S. drone with a cyberattack on a Revolutionary Guard (IRGC) database used to plan attacks on tankers
2020	• A group backed by the Russian government penetrated thousands of organizations globally including multiple parts of the United States federal government, leading to a series of data breaches
2021	• According to Microsoft, suspected Russian cyber engineers gained access to the networks of several different Ukrainian energy and IT providers in late 2021

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Full-scale cyberwarfare has been a component of Russia's invasion of Ukraine in 2022

Military

24th: Russia invades Ukraine, and tanks advance into Sumy city center

3rd: Sumy suffers widespread electricity outages, including blasts at power stations; Russia's army occupies Ukraine's largest nuclear power station

11th: First Russian strikes in Dnipro hit government buildings

1st: Missile strikes Kyiv TV tower

6th: Russia forces launch eight missiles at Vinnytsia airport

16th: Russian rockets strike TV tower in Vinnytsia

3rd: Russian airstrikes hit fuel depots and processing plants around Odessa

FEB **MAR** **APR**

Cyber

14th: Infrastructure in Odessa compromised

17th: Critical infrastructure networks breached in Sumy

23rd: Data erased in hundreds of government, IT, energy, and financial-sector systems

24th: Tens of thousands of Viasat modems crippled in Ukraine and Europe

28th: Kyiv-based media company compromised

1st: Kyiv-based media companies' data stolen and deleted

2nd: Network of Ukrainian nuclear-power company breached

4th: Government network in Vinnytsia compromised

11th: Dnipro government agency targeted with destructive implant

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Cybersecurity leaders need to improve their protection strategies to slow down the constant evolution of cyberthreats

Cybersecurity predictions for the next two years

Through 2023, government regulations requiring organizations to provide consumer privacy rights will cover 5 billion citizens and more than 70% of the global GDP.

Through 2025, 30% of nation states will pass legislation that regulates ransomware payments, fines and negotiations, up from less than 1% in 2021.

By 2025, 80% of enterprises will adopt a strategy to unify web, cloud services, and private application access from a single vendor's SSE platform.

By 2025, 60% of organizations will use cybersecurity risk as a primary determinant in conducting third-party transactions and business engagements.
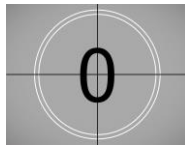
60% of organizations will embrace Zero Trust as a starting point for security by 2025. More than half will fail to realize the benefits.

Latest cybersecurity trends by regions

— Global — Europe — Asia — Oceania — Africa — America

Policy development
100
80
60
40
20
0

Threat analysis
Military operations
Education
Cybercrime prevention
Global efforts
Crisis management
Digital services
Incident response
Essential services
eID & TS

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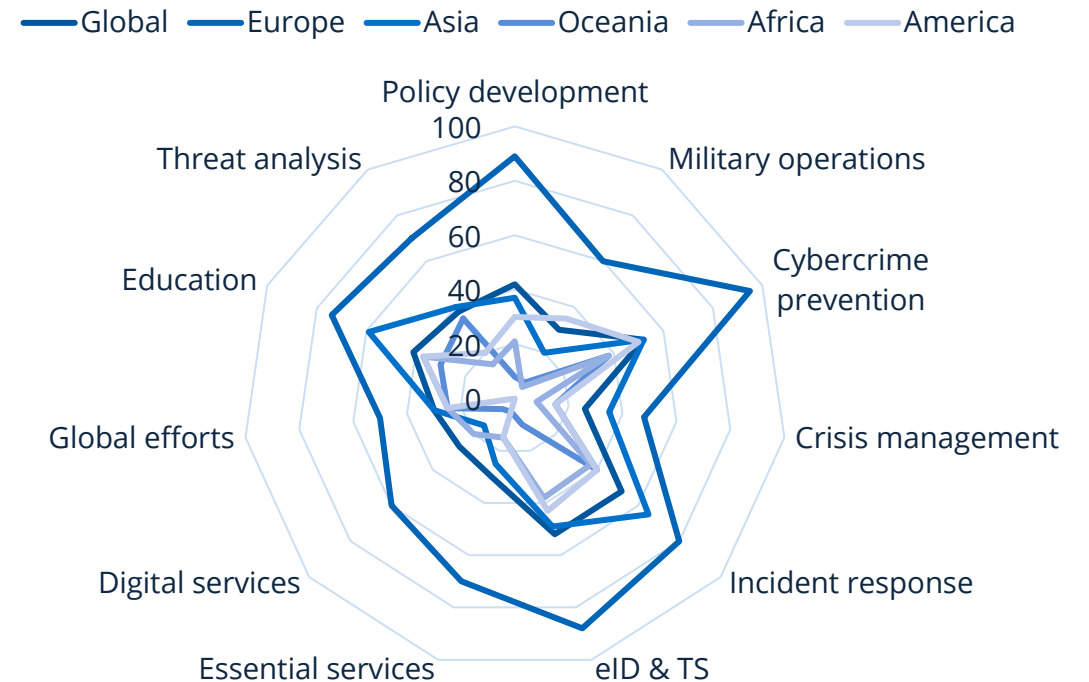
Smart Mobility – The future is digital, greener, and more efficient

Originally released in October 2022 (as Chapter 3)

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Table of contents

Smart Mobility – The future is digital, greener, and more efficient

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Smart Mobility: Its pressing challenge of reducing emissions remains

The world event of the COVID-19 pandemic unleashed difficulties with supply chains and components produced by original equipment manufacturers (OEMs) in the mobility sector. In particular, chip production, which is a crucial component of modern mobility technologies, experienced a supply gap. In addition, the recent beginning of the Russia-Ukraine war wreaked additional havoc on the economic situation for manufacturers, as production costs and inflation rose. Nevertheless, due to its many opportunities, smart mobility remains a hot topic. For instance, the reduction of greenhouse gas emissions is a core goal of many countries worldwide. As transportation accounts for roughly 30% of global GHG emissions, greener mobility solutions are in high demand. Additionally, the tackling of congestion by reducing car ownership via mobility services promises a potential increase in life quality, especially for highly urbanized areas. Therefore, if current challenges can be overcome, smart mobility opens the door to a range of futuristic opportunities in the coming years.

Smart Mobility will modernize mobility in many ways

Smart Surveillance & Road Safety
- Cameras and other traffic monitoring devices
- Connected security network

Integrated Ticketing System
- Provision of easy-to-use multimodal services
- Integration into local services

Automated Toll Collection
- Automatic payments

Smart Mobility Benefits

Real-time Information Systems
- Data collection
- Monitoring and management

Predictive Maintenance
- Maintenance of processes in advance

Intelligent Parking Management
- Data collection from sensors and other connected devices
- Analysis of parking slot availability

Intelligent Traffic Management
- Traffic monitoring and management
- Avoidance of traffic jams and congestion

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The most pressing issue within smart mobility is the reduction of emissions, mainly coming from the transportation sector

Share of GHG[1] emissions by sector in the U.S. and the EU in 2020

U.S.

- 27% Transportation
- 25%
- 24%
- 11%
- 13%

EU

- 22% Transportation
- 26%
- 22%
- 12%
- 13%
- 3%
- 3%
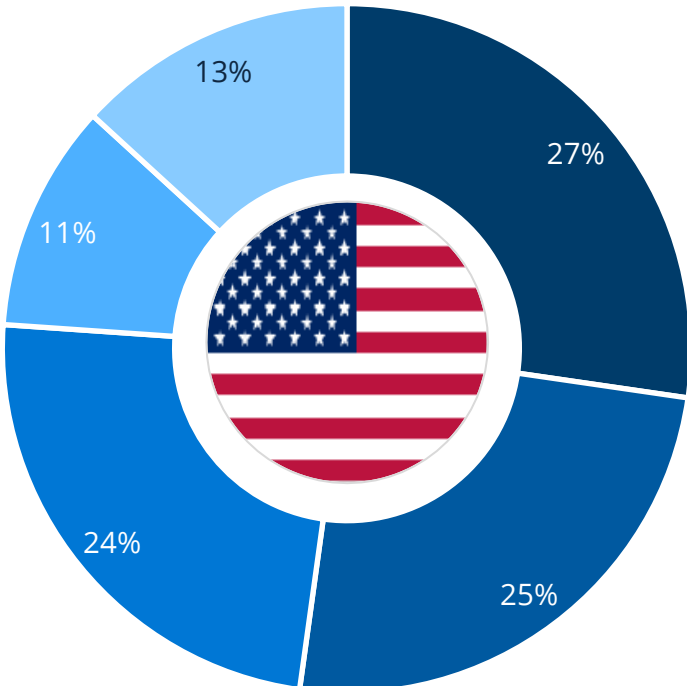
- Transportation accounts for an estimated 30% of global greenhouse gas emissions. The emission split does not vary significantly across different regions in the world.

- If we examine the development of greenhouse gas emissions over the past two decades, all sectors except the transportation sector were able to decrease their emissions.

- Since 1990, the transportation sector has been unable to decrease its greenhouse gas emissions and quite the opposite has happened: emissions have been increasing.
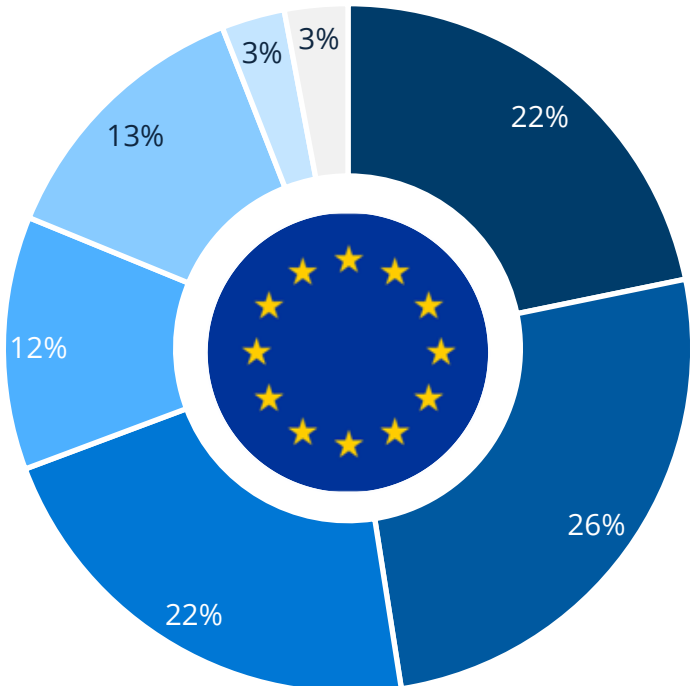
Legend: ■ Transportation ■ Energy supply ■ Industry ■ Agriculture ■ Residential/commercial ■ Waste □ Other combustion

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In 2022 car density is as high as ever, and cars remain our number one transportation mode for commuting

Motor vehicles per 1,000 inhabitants

Country	Value
U.S.	868
Finland	790
Italy	756
Australia	748
Canada	730
France	667
Germany	628
Spain	627
Japan	624
UK	594
Sweden	545
Ireland	535
South Korea	485
Brazil	366
Turkey	254
South Africa	232
Singapore	149
Indonesia	82
India	62
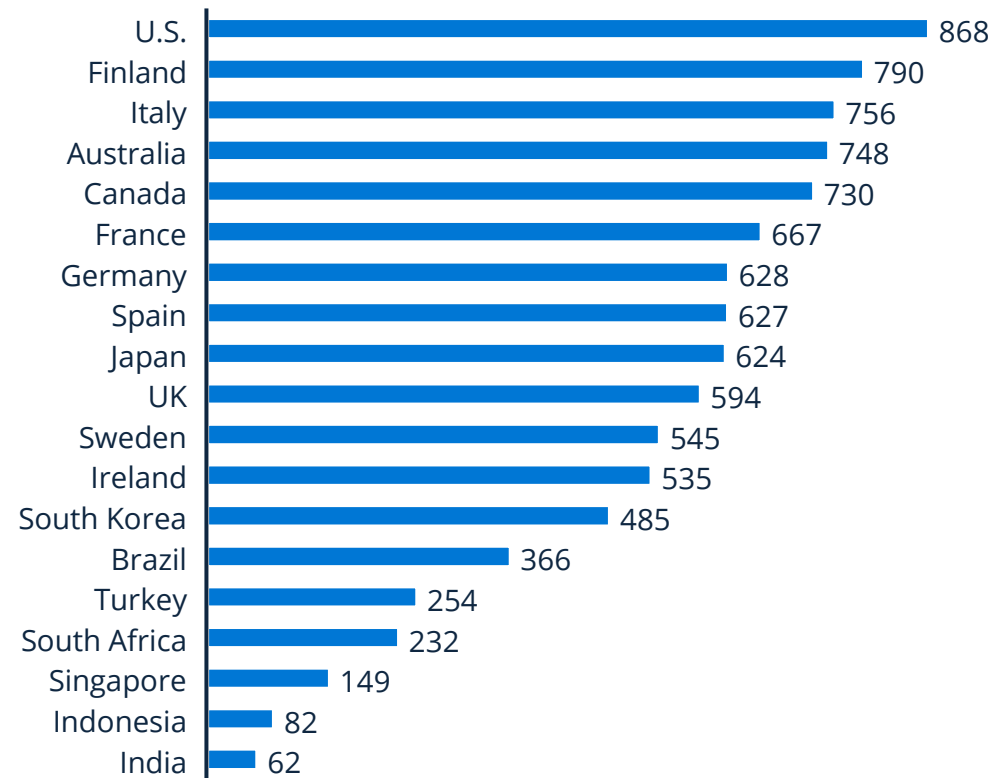
Modes of transportation for commuting in selected countries in % in 2022

	U.S.	Germany	China	UK
Bike sharing	4	2	10	2
Car sharing	5	1	5	2
E-scooter sharing	2	2	5	1
Motor scooter sharing	2	1	3	1
Own / household car	75	65	64	62
Own bicycle	10	23	16	13
Own motor scooter	3	3	4	2
Own motorcycle	5	4	5	2
Public transportation	12	27	21	24
Ride sharing/hailing	7	1	14	2
Taxis	5	2	12	6

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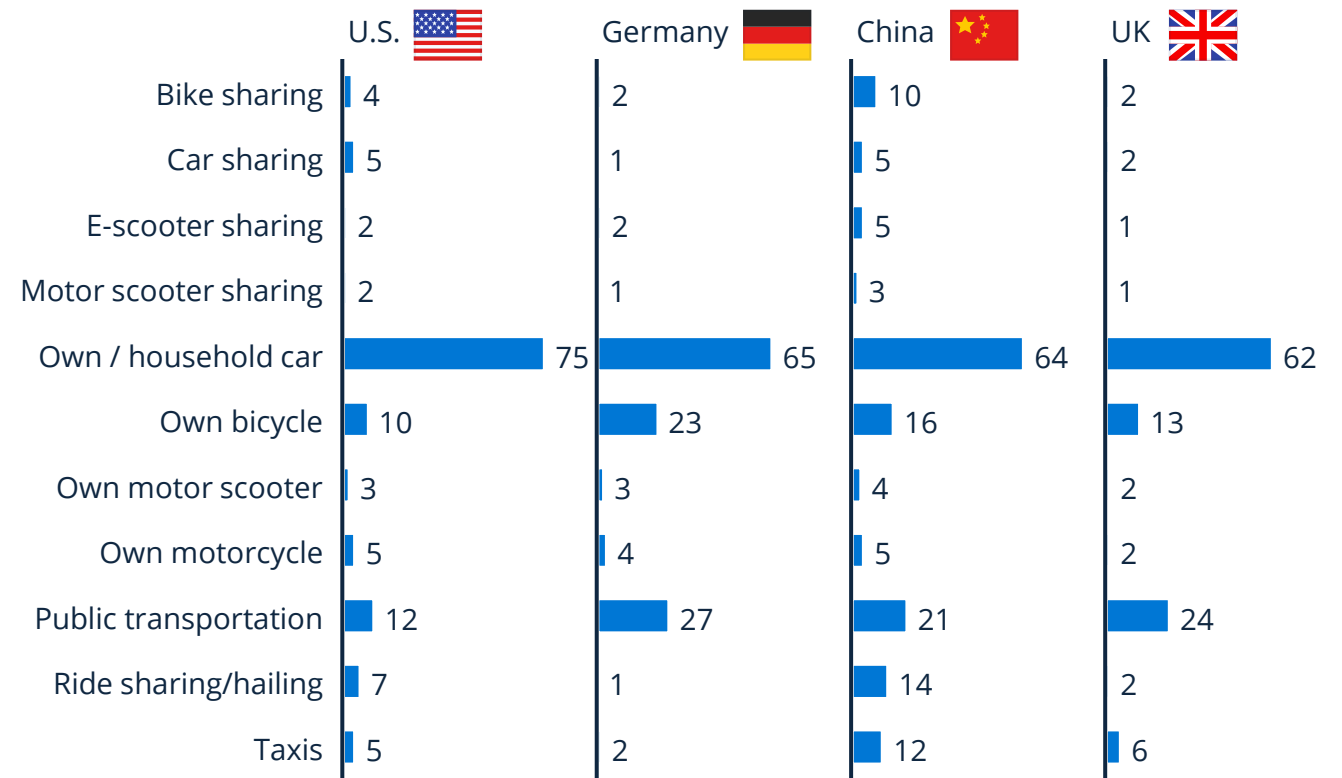
Road transportation with passenger vehicles such as cars, motorcycles, and buses is the biggest problem when it comes to CO_2 emissions

Global CO_2 emissions caused by the transport sector in 2021

9%
3%
11%
10%
68%
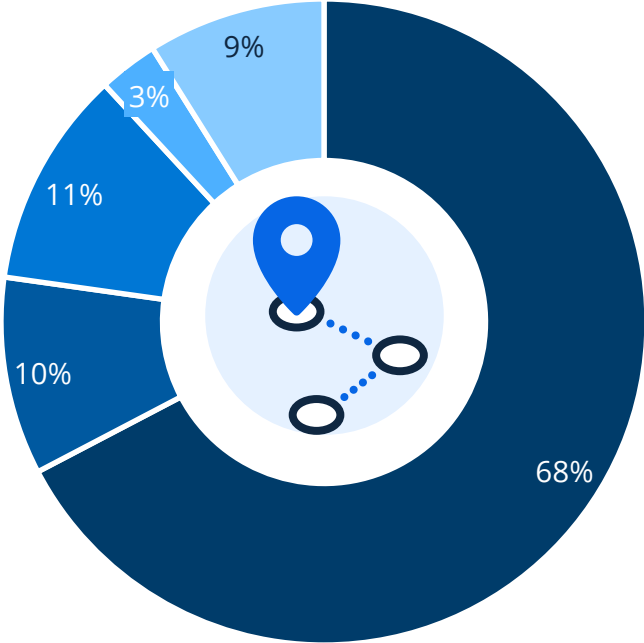
■ Road transportation ■ Aviation ■ Shipping ■ Rail ■ Buses[1]

Global road transport CO_2 emissions by sector in 2021

40%
60%
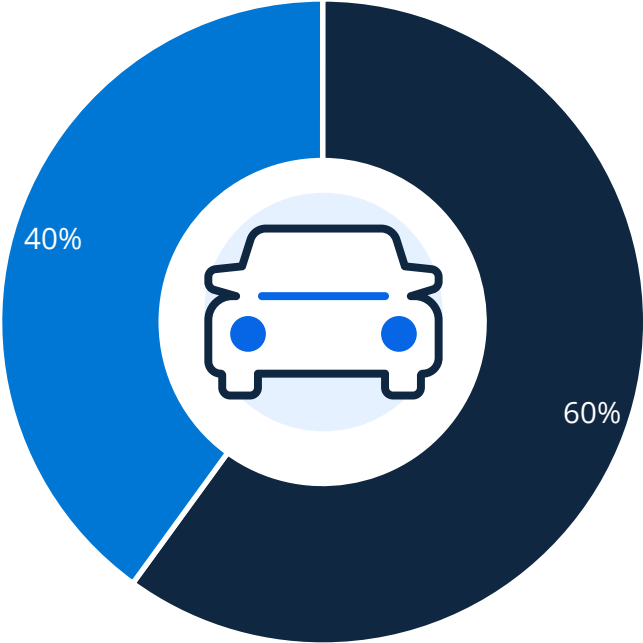
■ Passenger road vehicles ■ Road freight vehicles[2]

Notes: (1) Includes minibuses and two/three-wheelers (2) Includes medium- and heavy trucks and light commercial vehicles

Sources: IEA

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Compared to the entire life cycle of a passenger car, electric vehicles can reduce CO_2 emissions significantly

CO_2 emissions during the entire life cycle of a passenger car

Legend:
- ■ Operation, energy supply
- ■ Production, maintenance, disposal

Petrol:
- 2020: 233.0 (176.0 / 57.0)
- 2030: 212.0 (159.0 / 53.0)

Diesel:
- 2020: 212.0 (155.0 / 57.0)
- 2030: 195.0 (140.0 / 55.0)

Electric:
- 2020: 162.0 (72.0 / 90.0)
- 2030: 123.0 (38.0 / 85.0)

-30%
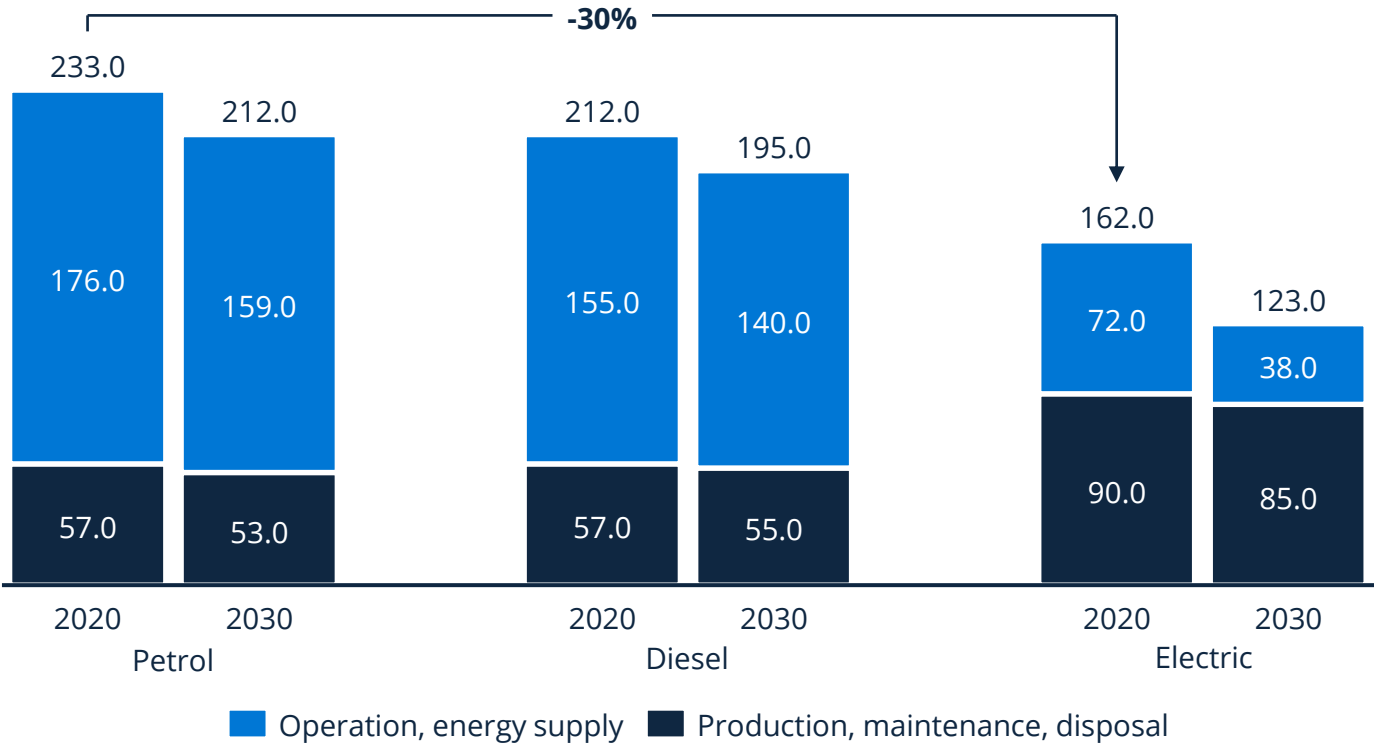
- Compared to conventional vehicles, electric vehicles (EVs) offset the high emissions generated in their production stage after only two years

- Approximately half of a battery's emissions originate from electricity used in the manufacturing process

- Battery manufacturing emissions appear to be of similar magnitude to the manufacturing of an average internal combustion engine vehicle, which is approximately a quarter of an electric car's lifetime emissions

- Lithium-ion batteries and manufacturing techniques continue to improve as the electric vehicle and stationary storage industries grow

- Longer battery lifetimes will allow for longer vehicle lifetimes, fewer replacements, as well as longer and/or more powerful second lives in stationary applications

statista ⊿

Gasoline cars still constitute the majority of new car sales worldwide but will decrease to only 61% of all new passenger cars in 2026

Fuel or drive-type share on new passenger cars in 2021 and 2026

2026

5% | 1%
7%
14%
27%
1%

2021

1%
1%
1%
83%
61%

- ■ Gasoline
- ■ Electric
- ■ Diesel
- ■ Hybrid
- ■ Alternative
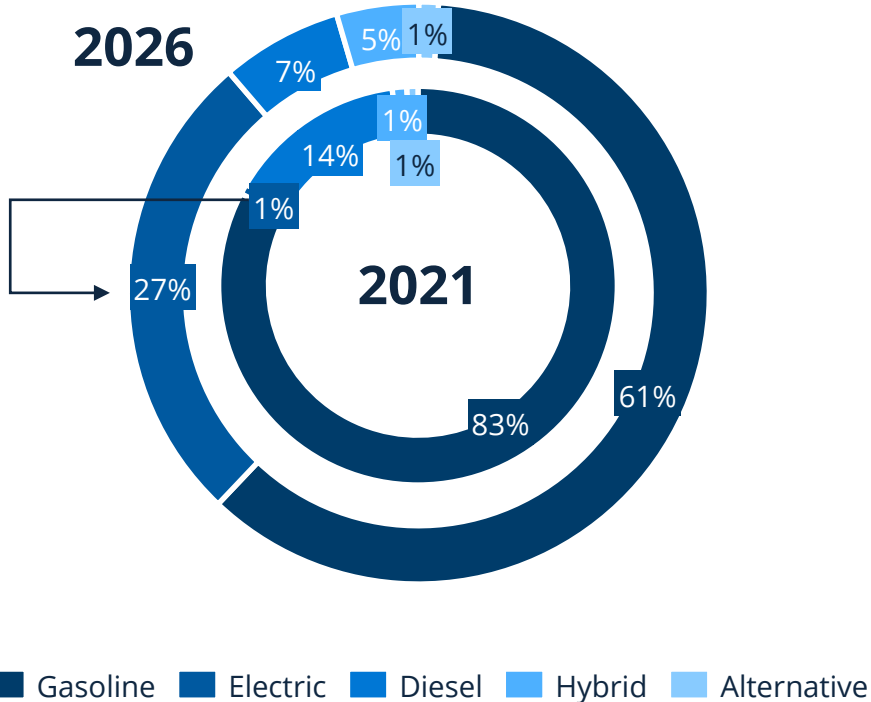
Electric vehicle sales in thousand vehicles

China
1,120
1,166
1,285
3,278
+193%

EU-27
240
387
1,046
1,739
+624%

U.S.
346
305
316
645
+86%

- ■ 2018
- ■ 2019
- ■ 2020
- ■ 2021

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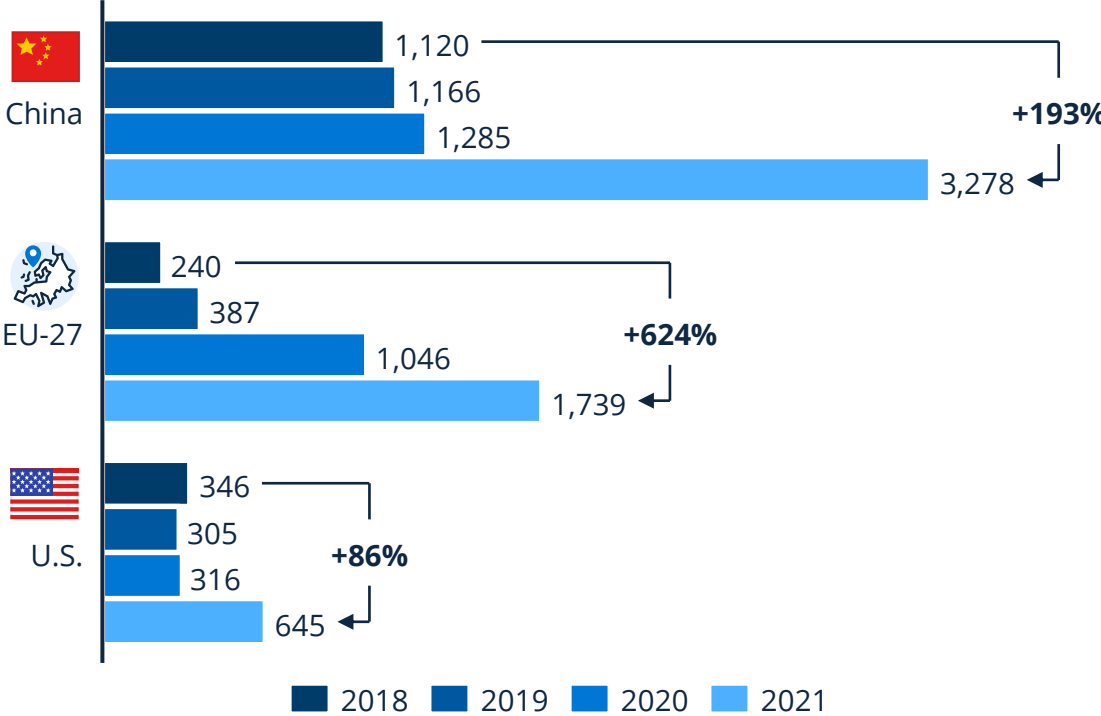
The Russia-Ukraine war will heavily impact global sales of passenger cars and electric vehicles in particular

Passenger cars market – volume sales

Year	Pre-war volume	Post-war volume	Change
2021	73.9	73.9	
2022	74.5	67.4	-10%
2023	74.6	67.4	-10%
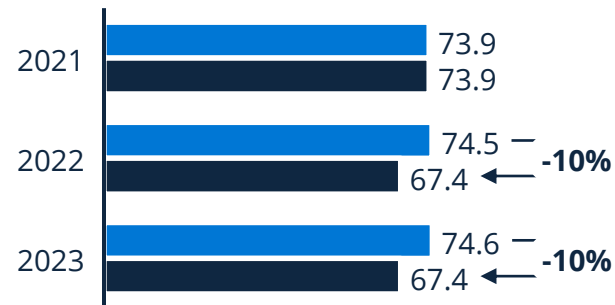
Electric vehicles market – volume sales

Year	Pre-war volume	Post-war volume	Change
2021	6.5	6.5	
2022	7.2	7.1	-1%
2023	8.4	8.6	+2%

■ Pre-war volume   ■ Post-war volume

Manufacturing PMI suppliers' delivery times[1]

Delivery times decrease ↑
Delivery times increase ↓

Europe
U.S.

01/2019   01/20   01/21   01/2022
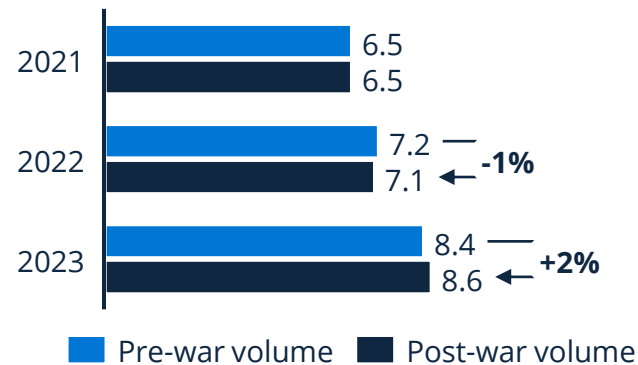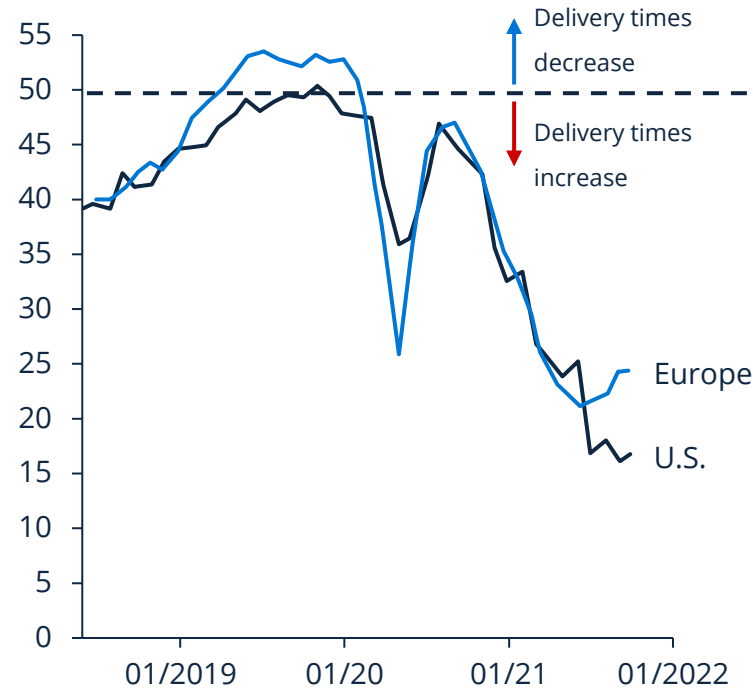
We estimate that the Russia-Ukraine war will have a heavy impact on the supply (and demand) for passenger cars and electric vehicles

- The most significant implications forecast not only cuts for the Russian and Ukrainian markets but also a global reduction due to supply chain problems
- Important components such as wiring harnesses, electrical cables, and others are manufactured by Ukrainian suppliers; a shortage of those components is imminent
- Both Russia and Ukraine function as suppliers of raw materials such as palladium, nickel, and iron, which are all needed in the production of all vehicle types
- In addition to the reduction of supply, the resulting economic crisis is also driving down consumer demand

statista

Scooters are really driving the electric vehicle (EV) revolution at the moment

EV revenue and share by country

381,485 (2022)
861,499 (2027)

Pie chart shares: 38%, 11%, 16%, 11%, 5%, 4%

ROW
UK
France
Germany
U.S.
China
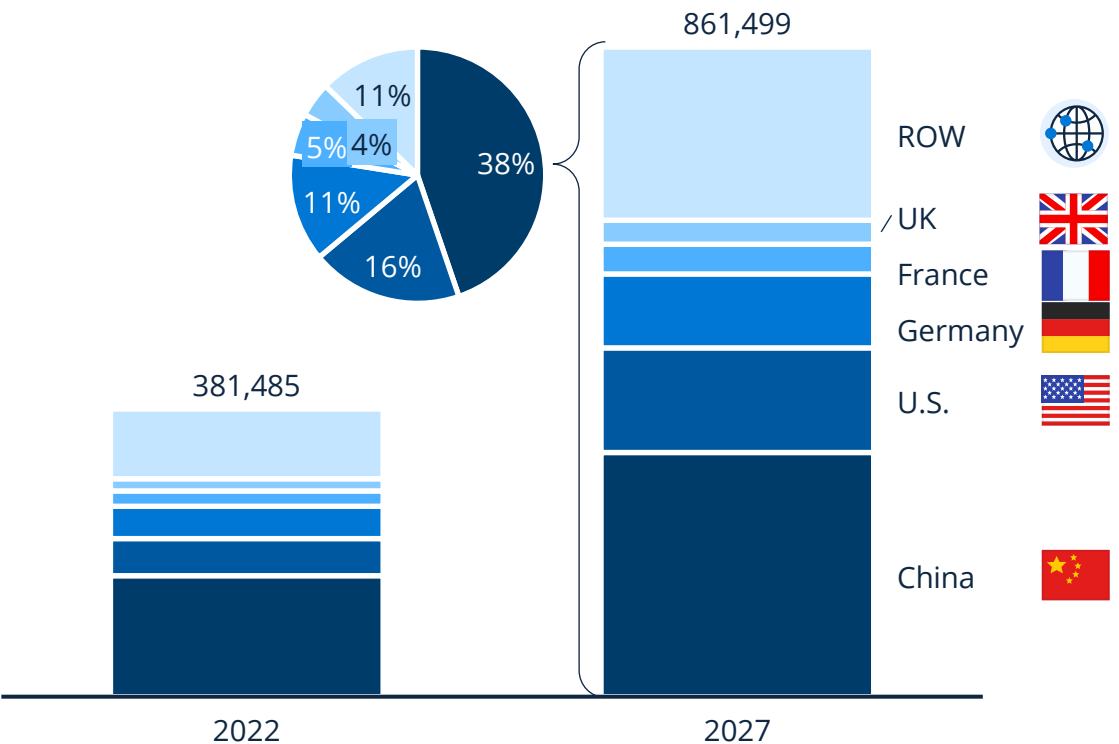
EV share of vehicle category sales and share of electric two-wheeler sales

Vans and trucks — 1%
Passenger cars — 9%
Buses — 44%
2- and 3-wheelers — 42%

Size of EV fleet

613,450   16,733,957   685,005   **274,767,231**

China
South Korea
Europe
India
U.S.

2018   2020   2022   2024   2026

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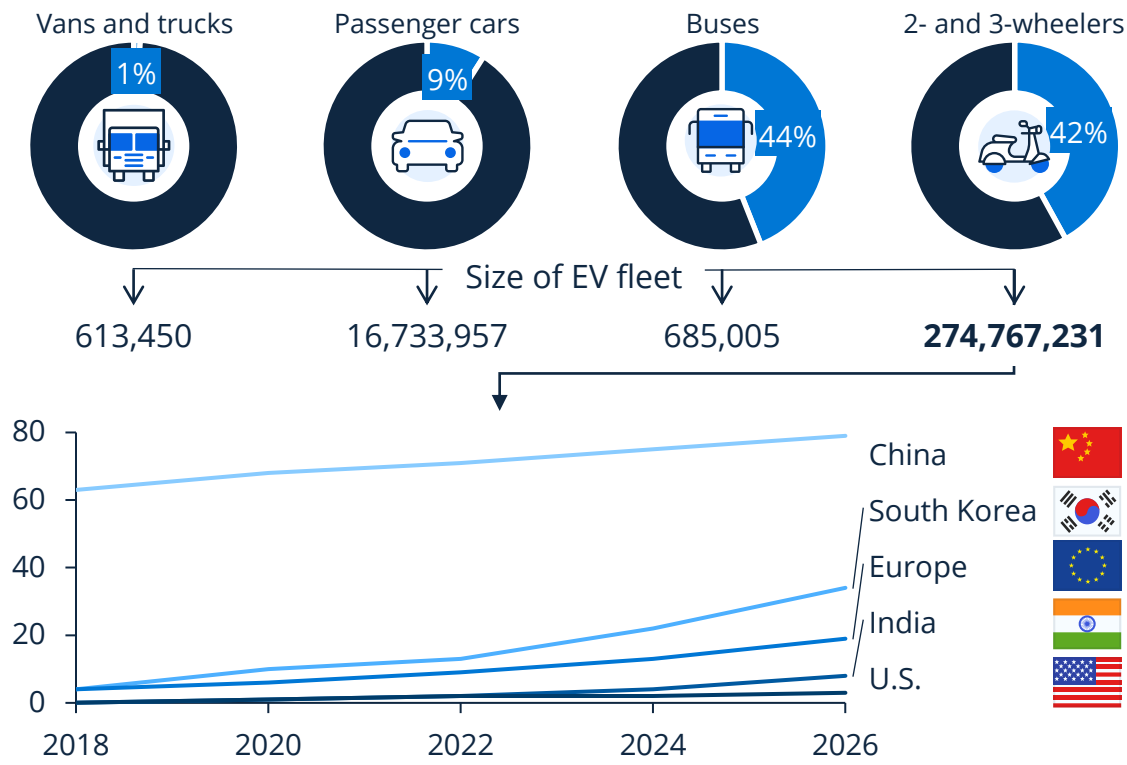
Charging infrastructures are a barrier for electric mobility, but the world is catching up with China, which is at the fore of EV fast-charger installations

Global number of public charging stations in thousands

Number of gasoline stations in 2021 in the EU-27: **113,322**

+25%(1)

Year	Value
2017	310
2018	372
2019	587
2020	809
2021	1,210
2022	1,430
2023	1,734
2024	1,990
2025	2,252
2026	2,521
2027	2,800
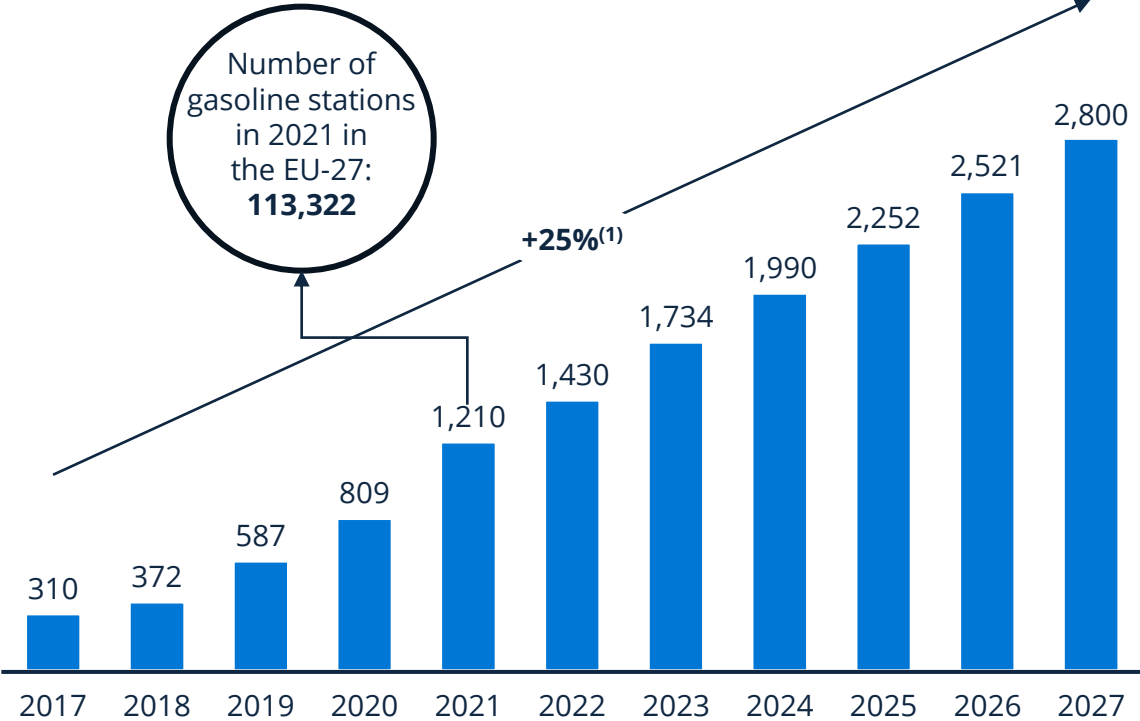
Direct current, fast-charger installations (50kW+) in thousands

+63%

+95%

2021: China 200, ROW 40
2022: China 390, ROW 65

China   ROW
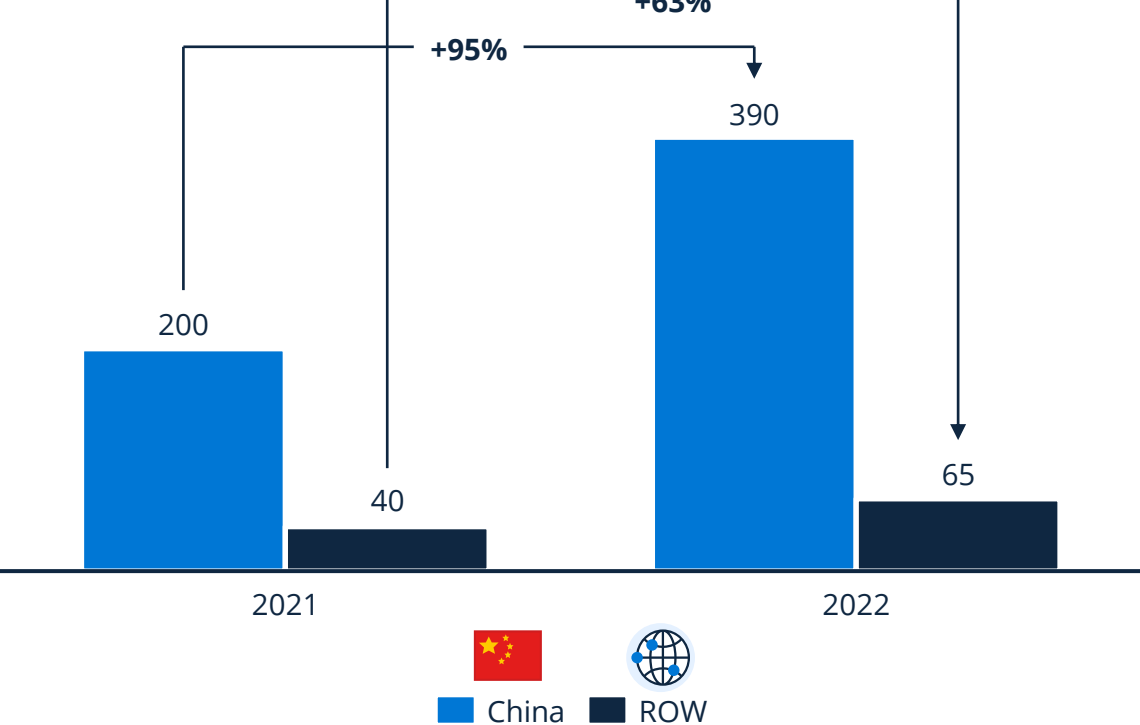
Notes: (1) CAGR: Compound Annual Growth Rate / average growth rate per year

Sources: Statista Mobility Market Outlook; BloombergNEF, China EV Charging Association

statista

Autonomous driving holds another potential for CO_2 reduction but is still far away from its breakthrough

Global penetration of autonomous driving levels in passenger cars

No attention needed + Driver is not accountable

Level 5: no driver's attention needed

Level 4: vehicle drives in ideal conditions

Level 3: no human interaction <60 km/h

Level 2: partial automation

Level 1: driver assistance

Level 0: no self-driving functions

Year	Autonomous 0	Autonomous 1	Autonomous 2	Autonomous 3
2019	25	54	21	
2020	23	54	23	
2021	21	53	26	
2022	19	53	28	
2023	18	52	30	
2024	17	51	31	1
2025	16	50	33	1
2026	15	49	34	2

■ Autonomous 0   ■ Autonomous 1   ■ Autonomous 2   ■ Autonomous 3

Net effects of vehicle automation on emissions across a variety of examples such as:

- Platooning
- Eco-driving
- Traffic-flow calming
- Collision avoidance
- Increase in ridesharing

show that automation could reduce GHG emissions and energy usage. A few studies have indicated that the positive emission changes may not be realized at a lower AV penetration rate, where the maximum emission reduction might take place within the 60–80% AV penetration rate.

statista

The main barriers to autonomous driving are data accessibility and insufficient digitalization

Policy & Legislation

29% of transportation data has an open license

- Autonomous-vehicle regulations
- Data-sharing environment
- Efficiency of legal system

Technology & Innovation

43% of open transportation data is machine readable

- Industry partnerships
- Availability of the latest technologies
- Cybersecurity
- Assessment of cloud computing, artificial intelligence, and internet of things
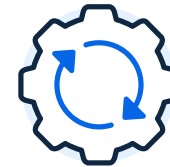
Infrastructure

4G LTE[1] coverage reaches 80% of the world, 5G 15%

- Electric-vehicle infrastructure
- Mobile-connection coverage
- Quality of roads
- Mobile-connection speed

Consumer acceptance

84% of consumers in the U.S. would not want to use a self-driving taxi

- Consumer digital savviness
- Willingness among consumers to adopt new technologies
- Perceived level of safety of autonomous vehicles
- Ethical dilemmas and challenges facing the programming of autonomous vehicles

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In an optimistic scenario, net-zero CO_2 emissions in the transport sector can only be achieved in 48 years

Global CO_2 emissions in transport by mode in the Sustainable Development Scenario

$GtCO_2$ per year

Two-/three-wheelers

Rail

Light commercial vehicles

Passenger cars, buses, and minivans

■ Rail	■ Two/three-wheelers
■ Passenger cars	■ Light-commercial vehicles
■ Buses and minibuses	■ Medium- and heavy trucks
■ Shipping	■ Aviation
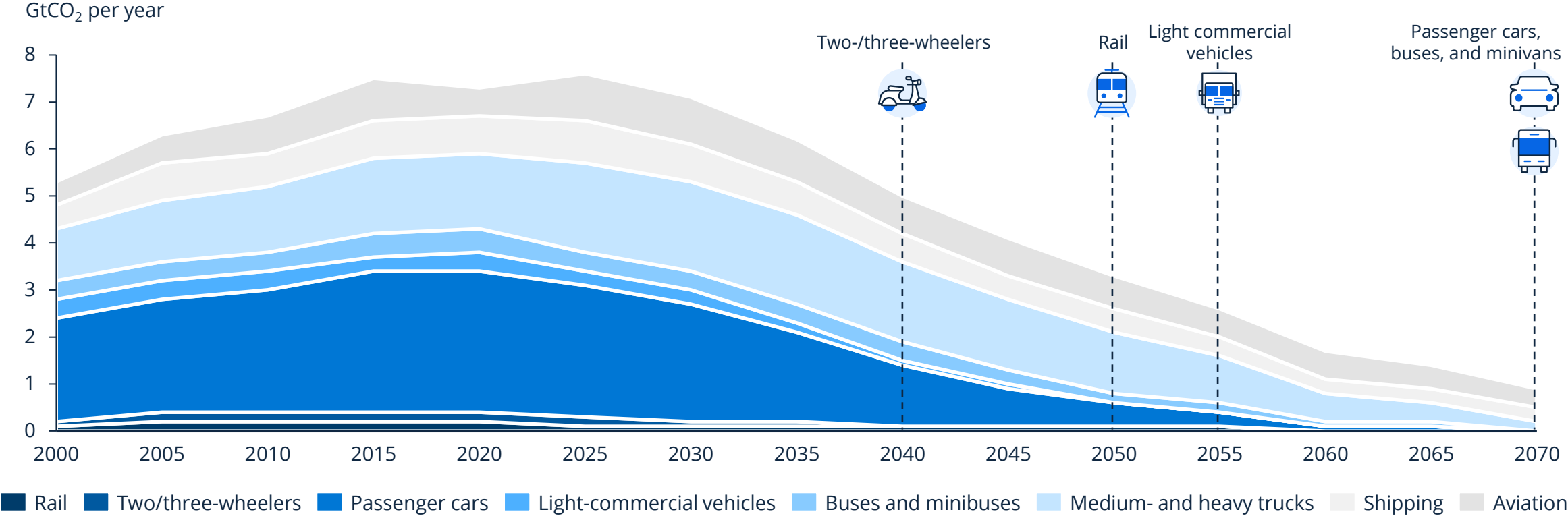
Notes: Dotted lines indicate the year in which various transport modes have largely stopped consuming fossil fuels and hence no longer contribute to direct emissions of CO2 from fossil fuel combustion. Residual emissions in transport are compensated by negative emissions technologies, such as BECCS and DAC, in the power and other energy transformation sectors.

Sources: IEA

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The Future of Mobility: Smart mobility in the 21ˢᵗ century will lift citizens off the ground or transport them beneath it

Compared to traditional mobility services, the advantage of air mobility is clear: reduced travel times, eco-friendliness, high scalability for additional air routes, and no congestion. Hence, in the long term, air mobility could crowd out current state-of-the-art mobility services. This technology is projected to be available as part of intermodal traffic by 2025. Although at this point in time, air mobility will be a luxury product only and not yet compete with traditional forms of mobility, this might change by 2035 when mass-market available services could change traffic drastically. While a lot of companies focus on air mobility, in congested urban areas, going underground could also help to unclog traffic.

Electric vertical take-off and landing aircrafts (eVTOLs) fit perfectly into the competitive field of regional and local mobility modes

Mobility Mode	Scope	Distance by Mode

Mobility Mode

- Walking
- Micromobility (e.g., bikes, e-scooters)
- Motorcycle
- Car
- Bus
- Train
- eVTOL[2]
- Helicopter
- Plane

Scope

local

regional

global

Distance by Mode

Distance in km [1]

0 2 4 6 8 10 20 40 60 80 100 400 800 1200 1600
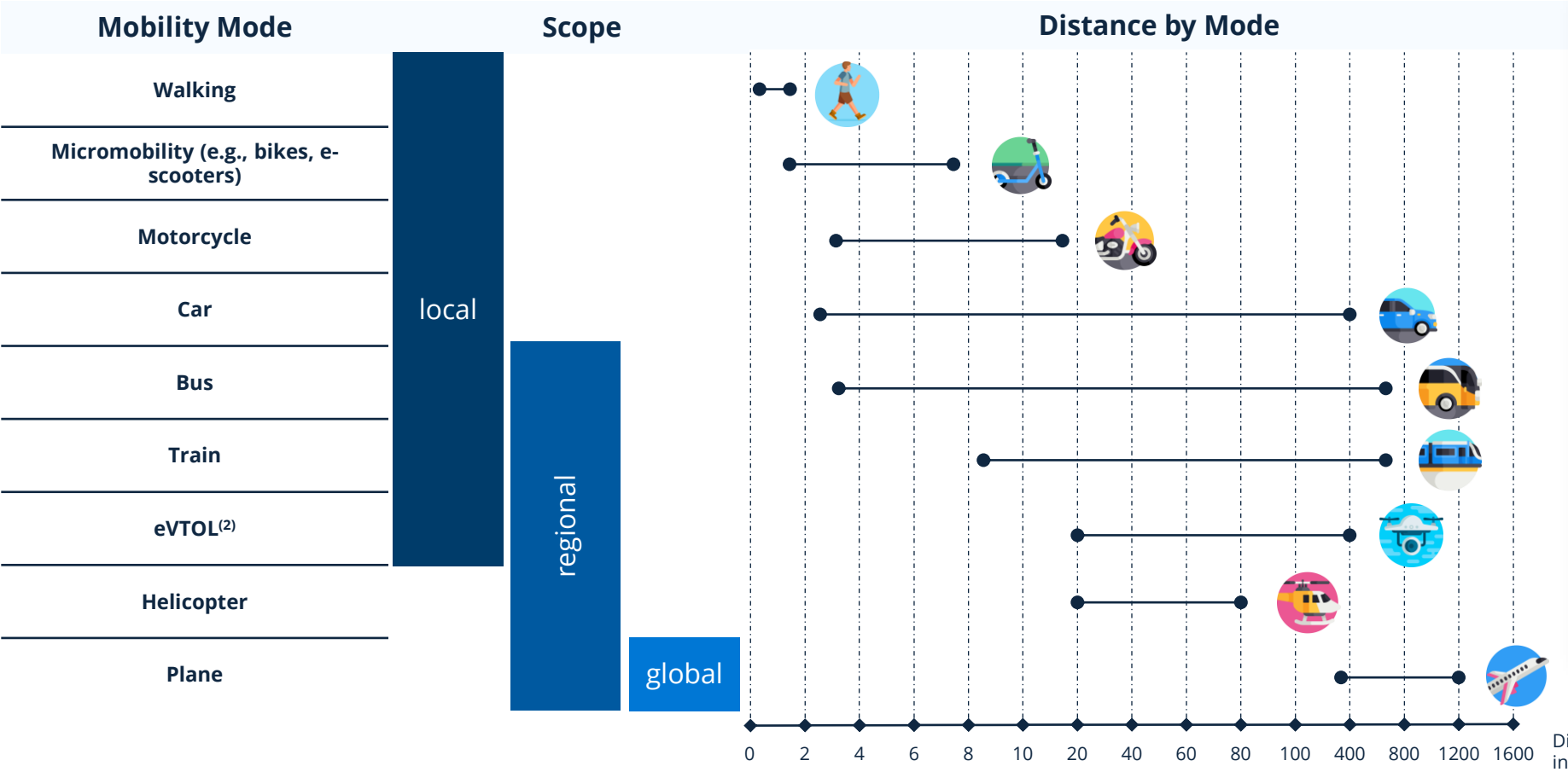
Mobility demand varies

When comparing different modes of mobility eVTOLs[2] can be used for local but also regional distances. Either intracity ports or city-to-city connections are a possible use case for air mobility services. Depending on its battery capacity, a distance of up to 400 km may be possible. This could improve overland travel times tremendously.

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Funding for air taxi startups has skyrocketed in the past years

Venture capital investments in air taxi startups in US$ million
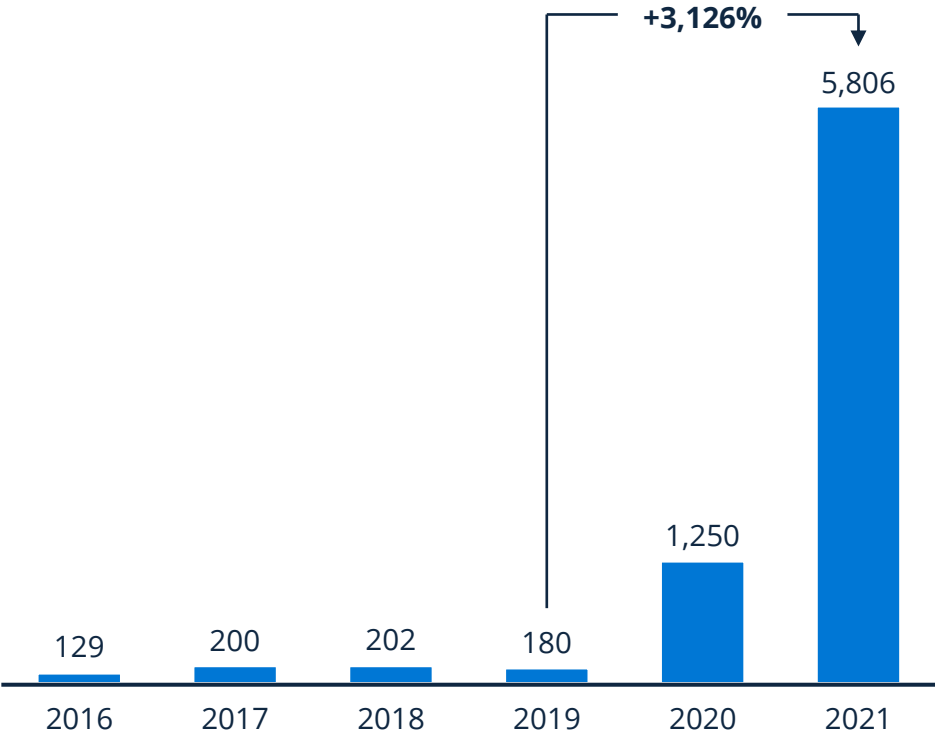
Share of total disclosed funding per startup in 2021

+3,126%

5,806

1,250

129   200   202   180

2016   2017   2018   2019   2020   2021

Other 12%

AutoflightX
RELIABLE ROBOTICS
AMPAIRE 1% 1% 1%
EHANG 亿航
Skyports 2% 2%
SHIELD AI 3%
Skyryse 3%
VOLOCOPTER 5%
BLADE Urban Air Mobility 5%
BETA TECHNOLOGIES 5%
VERTICAL 5%
XPENG 6%

Joby AVIATION 21%

LILIUM 16%

ARCHER 12%

statista
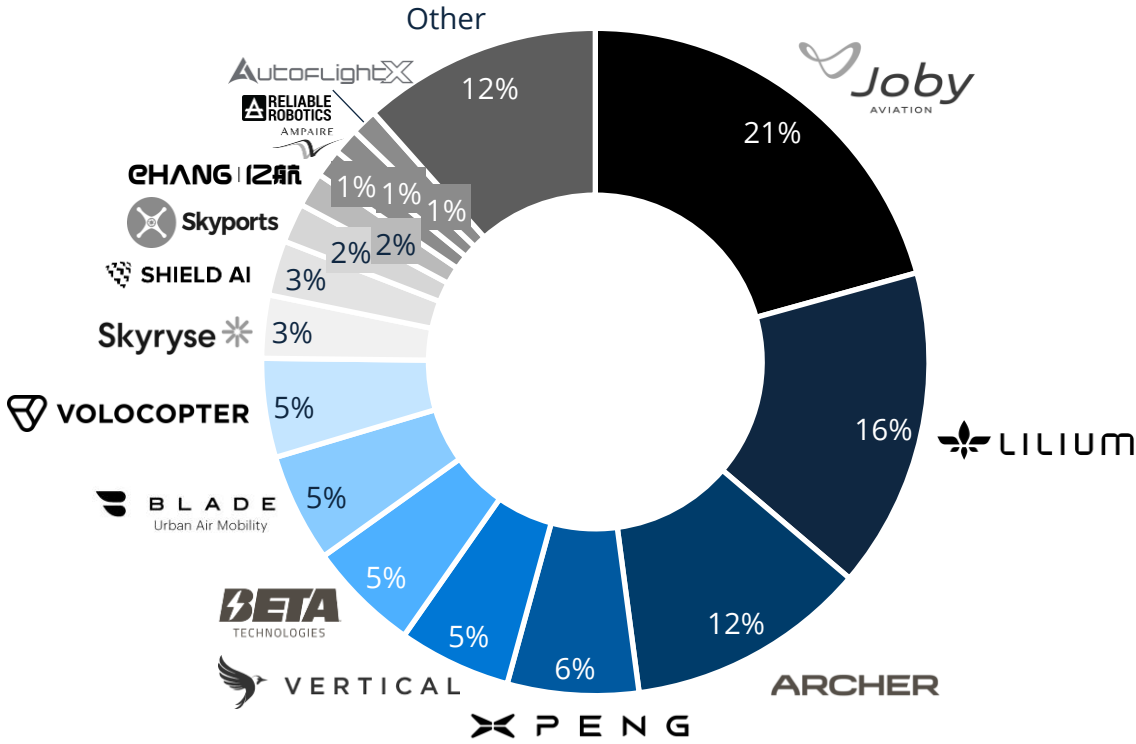
The challenges for vertical mobility solutions are as great as its opportunities

Profitability

One of the big difficulties with air mobility is rooted in acceptance. Without a demand for this technology, it will not be possible achieve the expected ROI. Therefore, one of the core concerns companies will need to manage is safety, as it is vital to attract customers.

Safety

In 2013 the Alaska-based air taxi service Rediske Air crashed, thus tainting the reputation of vertical mobility in the early stage of the market's development. Recovery quickly came as more and more reliable companies such as Uber, Porsche, and Boeing started to develop projects related to air mobility. This fostered trust in recent years that this technology can be applied with the same safety standards used in public transportation.

Demand

For the attractiveness of the service, performance and price play an important role. In order to ensure the large-scale rollout of this technology, low costs combined with highly demanded routes are important. Additionally, noise emissions and technological hurdles such as battery capacities need to be overcome to convince customers over the long term.

Applicability

Although air taxi technology is not expected to fully solve traffic problems in highly populated cities, accessible air taxis will function as an extra component of the entire mobility market if they reach acceptance.

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Space travel will be no science fiction and be an important part of mobility

Number of carrier rockets by type launched by SpaceX

SPACEX

Year	Total	Values
2013	3.0	
2014	6.0	
2015	7.0	1.0, 6.0
2016	9.0	1.0, 8.0
2017	18.0	13.0, 5.0
2018	21.0	9.0, 11.0, 1.0
2019	13.0	3.0, 8.0, 2.0
2020	26.0	5.0, 21.0
2021	31.0	2.0, 29.0
2022	49.0	2.0, 38.0, 9.0

Legend:
- ■ Failure
- ■ New Falcon 9
- ■ Falcon Heavy
- ■ Falcon 1
- ■ Used Falcon 9
- ■ Planned
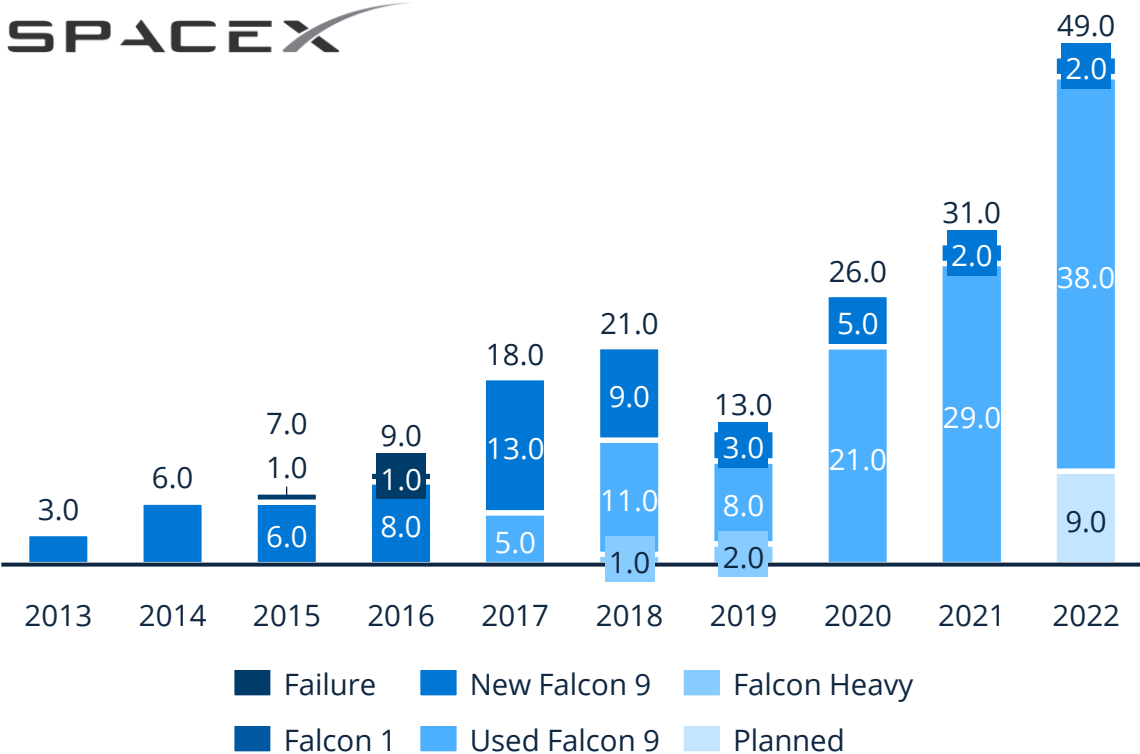
Global annual number of objects launched into space

Values on line chart: 72 (2005), 1,807 (2021)

X-axis: 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020, 2022
Y-axis: 500, 1,000, 1,500, 2,000

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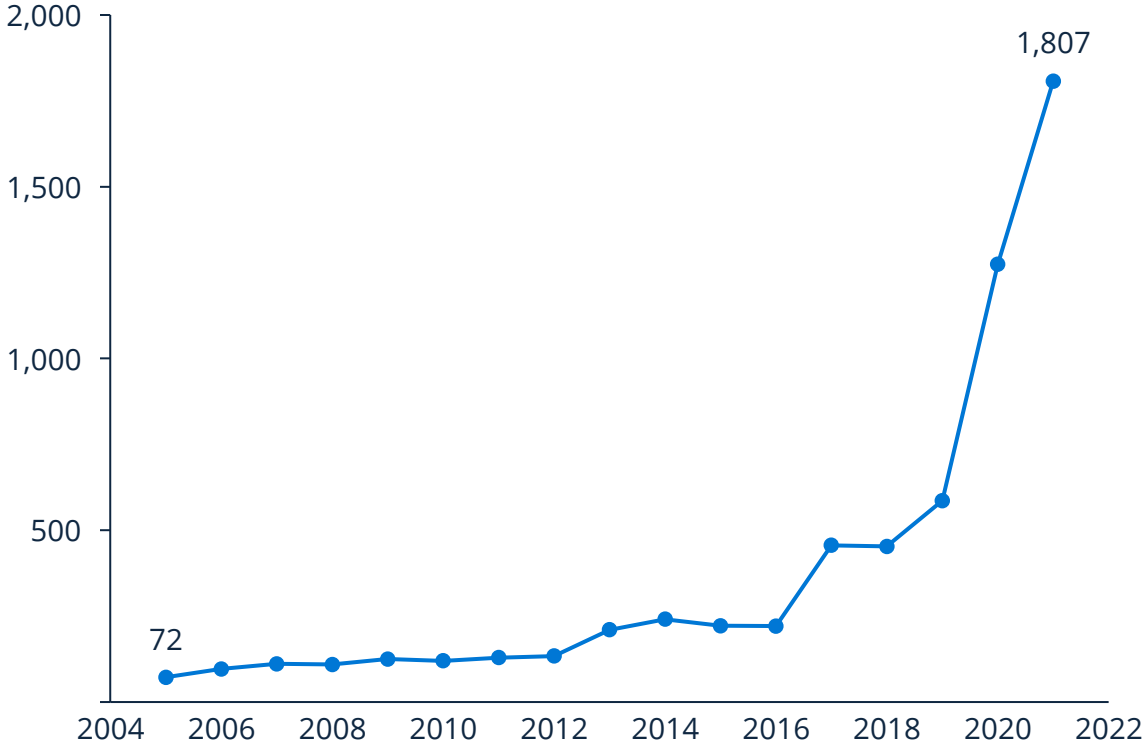
Since the privatization of the aerospace industry, several key players have made considerable headway in launching more efficient, cost-effective spacecrafts

SPACEX

SpaceX was the first aerospace corporation to build reusable launch vehicles. Its mission is to reduce the costs of space travel, in turn making space more accessible with the long-range goal of colonizing Mars.

However, the majority of turnover is generated by commercial satellite launches, with Starlink posed to become a multi-billion-dollar enterprise.

Key Facts

- Employees: ca. 12,000

- Total Number of Launches: 185

- Revenue: US$1.6 billion (2021)

- Valuation: US$127 billion (2022)

BLUE ORIGIN

Blue Origin has ambitions to create a future in which millions of people live and work in space, potentially even moving industries that the company deems environmentally damaging into space.

Blue Origin's reusable rockets are suitable for manned missions and cargo transport alike. Blue Origin is already conducting spaceflights for private persons.

Key Facts

- Employees: ca. 6,000

- Total Number of Launches: 23

- Revenue: >US$100 million (2022)

- Funding: US$167.4 million[1]

GALACTIC

Virgin Galactic mainly focuses on space tourism and connects potential civilian astronauts with the luxury of space travel, as opposed to commercial applications like satellite communications.

Unlike SpaceX and Blue Origin, Virgin Galactic employs winged spacecraft in lieu of vertical, ground-launch rockets. Spaceflights will become available in 2023.

Key Facts

- Employees: 803 (Dec. 2021)

- Total Number of Spaceflights: 4

- Revenue: US$3.3 million (2021)

- Market Capitalization: US$1.23 billion (Oct. 2022)

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In congested urban areas, going underground could also help to unclog traffic

Underground Tunneling

Dense urban areas commonly face the problem of congestion in traffic, yet there is little space to add additional lanes. Instead of building multilevel streets, the idea of building elaborate tunnel systems to solve this problem is gaining traction.

This concept is somewhat related to but nonetheless distinct from subway systems. An underground tunnel system was commissioned in Las Vegas, and proposals in Fort Lauderdale and other cities have been submitted.

Hyperloop

Hyperloops are a nascent technology in which pods carrying passengers or freight are sent through a partially evacuated tube by means of magnetic propulsion, allowing for speeds of over 1000 km/h.

Several global routes have been proposed from the U.S. East Coast to India, but the technology is still in development and largely hypothetical.

Pros
- Reduces road congestion
- More elaborate structures possible

Cons
- Construction is costly
- Favors private transport over mass transportation

Pros
- Reduces road congestion
- Faster (under)ground travel

Cons
- High development costs
- Technical hurdles

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While recent advances in tunnel boring could be described as underwhelming, first tests with hyperloop technology have shown promising results

Tunnel construction key players

Hyperloop key players

The Boring Company was founded with the ambition of building faster tunnel boring machines by vertical integration and technical innovation. The company has already built tunnels in Las Vegas and Hawthorne, CA.

Founded in 2014 by an associate of Elon Musk, the company has since entered a strategic partnership with Virgin Group, leading to restructuring and rebranding. The company had its first hyperloop human trial in 2021 but has since decided to abandon passenger transport in favor of freight transport.

Bechtel is the largest construction company in the US and a world leader in tunnel construction. It was involved in the construction of the Channel Tunnel connecting the UK and France.

This French-Canadian startup plans to build a transport network system and corresponding passenger pods based on hyperloop technology connecting major cities in Canada, starting with Calgary and Edmonton.

A German world leader in tunnel construction and the manufacture of tunnel boring machines. According to their own statements, they had a market share of over 70% of the €1.5 billion market for tunnel boring machines in 2014.

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The City of Tomorrow: It revolves around efficiency and modern technology

The smart city refers to a technology-based approach, which aims to increase life quality for citizens, government interactions, and sustainable development. As many cities grow in the coming years, area efficiency is a core challenge many countries face as housing becomes more expensive and free spaces become scarce. Digital solutions, such as smart control of traffic zones, promise to assist in solving these problems. As an example, mobility-on-demand services can free up space by reducing parking lots and targeted transportation. Additionally, e-governance promises a digital transformation of public administration processes that improve and/or eliminate cumbersome procedures.

Rapid urbanization and its repercussions are leading to a demand for new smart-city solutions

Global megacity populations in thousands in 2022

City	Population
Tokyo-Yokohama, Japan	37,732
Jakarta, Indonesia	33,756
Delhi, India	32,226
Guangzhou-Foshan, China	26,940
Mumbai, India	24,972
Manila, Philippines	24,922
Shanghai, China	24,073
São Paula, Brazil	23,086
Seoul-Incheon, South Korea	23,016
Mexico City, Mexico	21,804
New York City, United States	21,509
Cairo, Egypt	20,296
Dhaka, Bangladesh	18,627
Beijing, China	18,522
Kolkata, India	18,502
Bangkok, Thailand	18,007
Shenzhen, China	17,619
Moscow, Russia	17,332
Buenos Aires, Argentina	16,710
Lagos, Nigeria	16,637

Global smart city initiatives and spending distribution in 2020

- Others 10%
- Japan 6%
- Asia Pacific excl. Japan 12%
- United States 26%
- Western Europe 25%
- China 22%

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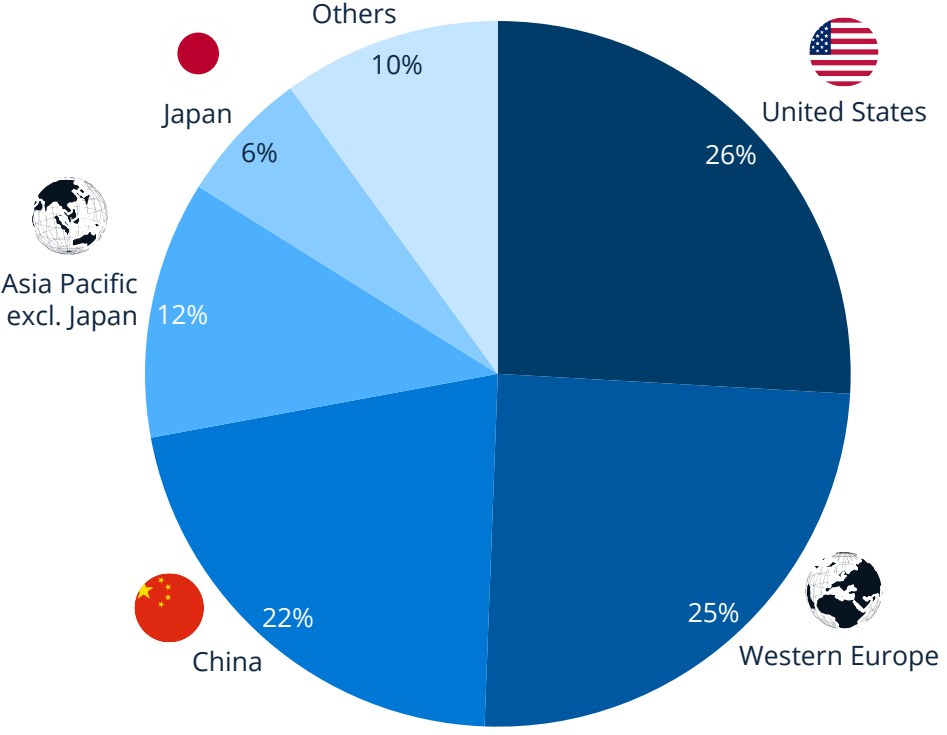
A multitude of smart-city solutions can ensure the sustainable transition of a territory and also contribute to improving the quality of life of its citizens

Smart Mobility
- Local accessibility
- ICT Infrastructure
- Sustainable, innovative, and safe transport systems

Smart City Dimensions

Smart Environment
- Attractivity of natural resources
- Environmental protection
- Sustainable resource management

Smart Governance
- Participation in decision-making
- Public and social services
- Transparent governance

Smart People
- Level of qualification
- Social and ethnic plurality
- Cosmopolitanism / Open-mindedness

Smart Economy
- Entrepreneurship
- Productivity
- Ability to transform

Smart Living
- Cultural facilities
- Housing quality
- Touristic attractivity

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Smart cities are evolving around the globe with Singapore at the top

Global technology spending on smart city initiatives in billion US$

+19%(1)

Year	Value
2018	81.0
2019	104.3
2020	124.0
2022	158.0
2023	189.5
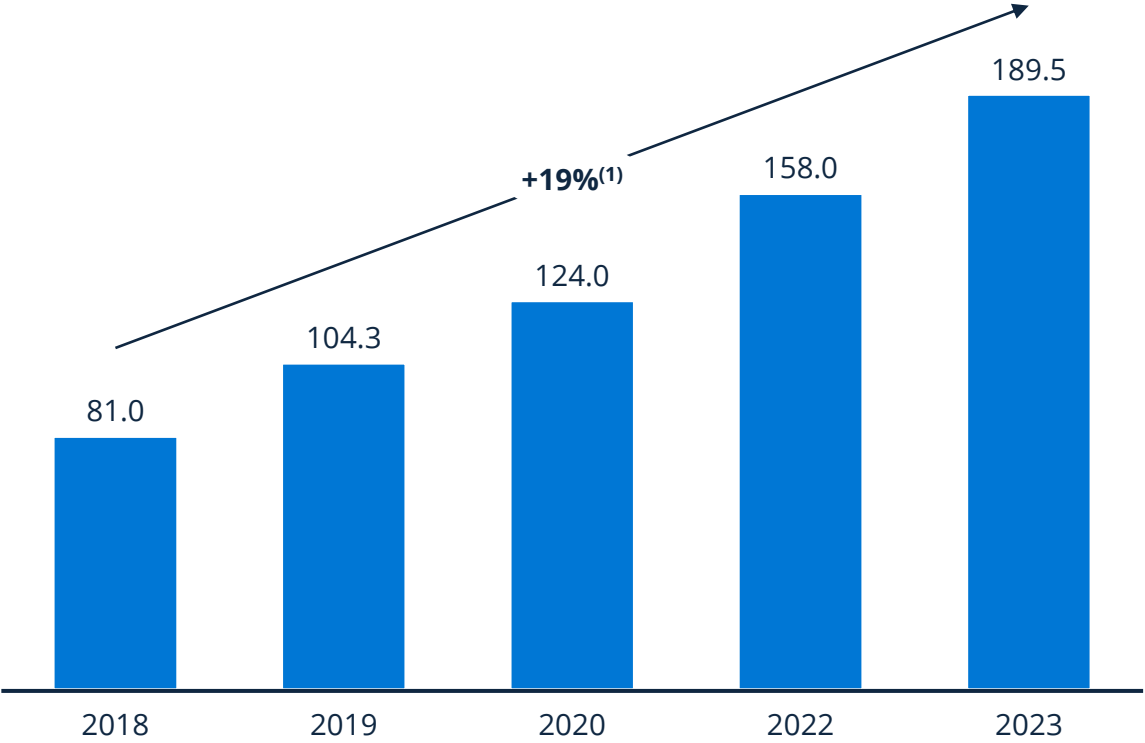
Smart City Ranking 2021

#	City	Smart City Rating	Country
1	Singapore	AAA	
2	Zurich	AA	
3	Oslo	AA	
4	Taipei City	A	
5	Lausanne	A	
6	Helsinki	A	
7	Copenhagen	A	
8	Geneva	A	
9	Auckland	A	
10	Bilbao	BBB	

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Smart city market revenue is forecast to double from 2020 to 2025 and reflects the increasing importance of smart cities

Worldwide projected revenue of the smart city market by segment in billion US$
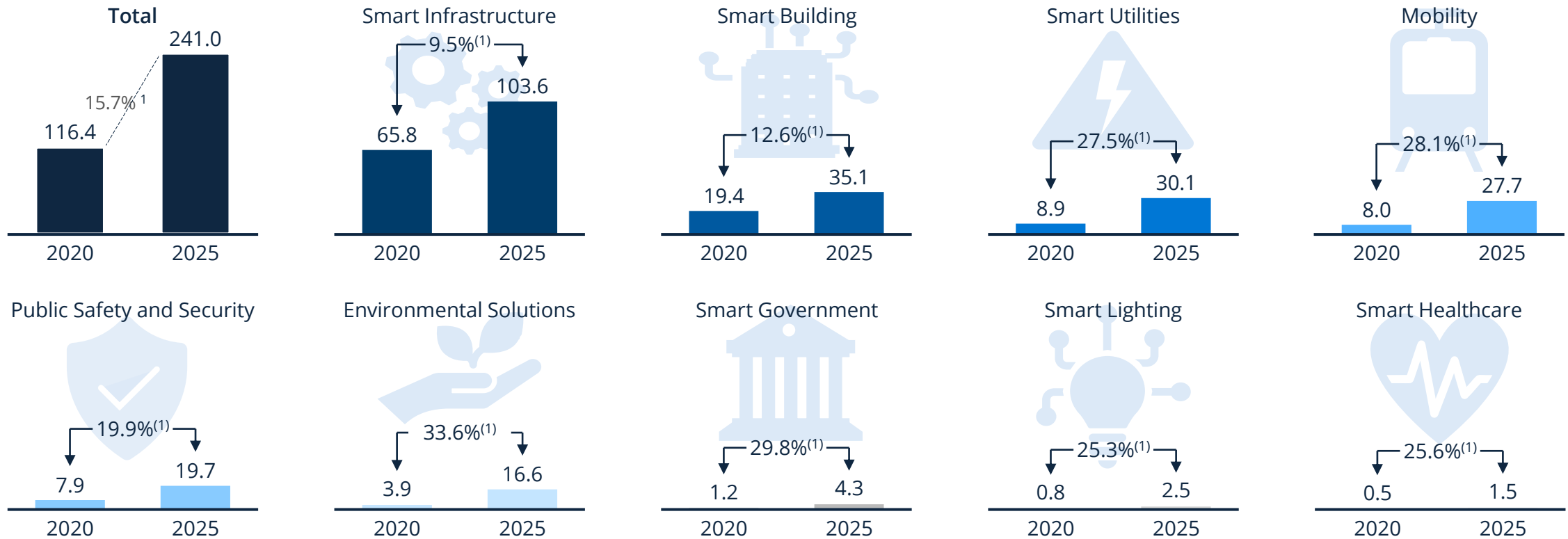
Total
116.4 (2020)
241.0 (2025)
15.7% [1]

Smart Infrastructure
9.5% [1]
65.8 (2020)
103.6 (2025)

Smart Building
12.6% [1]
19.4 (2020)
35.1 (2025)

Smart Utilities
27.5% [1]
8.9 (2020)
30.1 (2025)

Mobility
28.1% [1]
8.0 (2020)
27.7 (2025)

Public Safety and Security
19.9% [1]
7.9 (2020)
19.7 (2025)

Environmental Solutions
33.6% [1]
3.9 (2020)
16.6 (2025)

Smart Government
29.8% [1]
1.2 (2020)
4.3 (2025)

Smart Lighting
25.3% [1]
0.8 (2020)
2.5 (2025)

Smart Healthcare
25.6% [1]
0.5 (2020)
1.5 (2025)

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Our products

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The digital future of
90+ markets in over 150 locations

The Digital Market Outlook presents up-to-date figures on markets of the digital economy. The comparable key figures are based on extensive analyses of relevant indicators from the areas of society, economy, and technology.

- Eight digital verticals: eCommerce, Smart Home, Digital Media, eServices, FinTech, Digital Advertising, Digital Health, and App
- Covering the period 2017 to 2026

Go to Outlook

Find out more on:
statista.com/outlook/digital-markets

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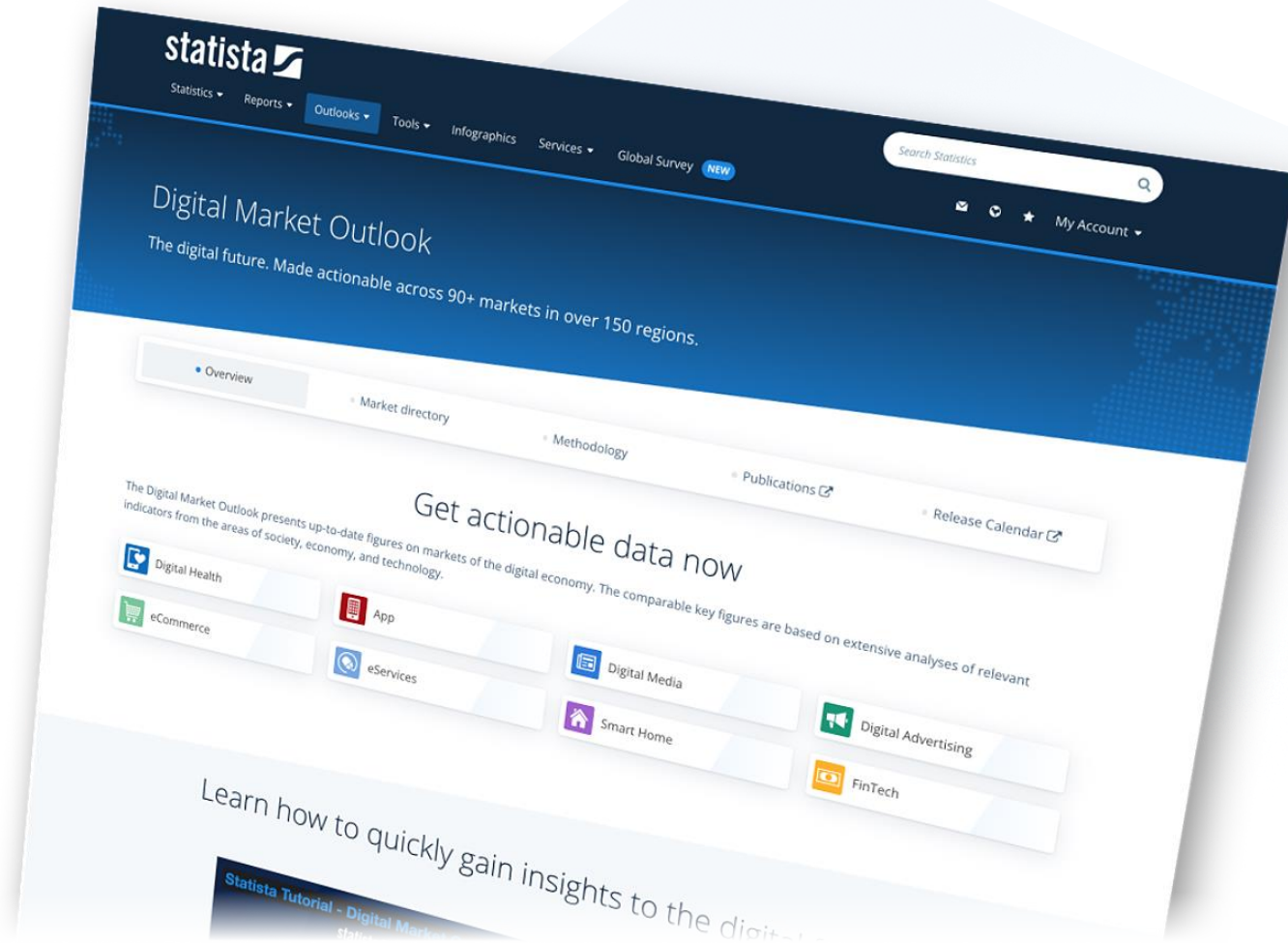
Figures and insights about the **advertising and media** world

The Advertising & Media Outlook provides forecasts and detailed market information regarding two interlinked topics relevant to decision-makers in almost every industry. It is designed to help you understand these markets on a global scale.

- All relevant advertising and media topics
- Market insights, forecasts, and key performance indicators
- 150+ countries and territories as well as 37 regions

Go to Outlook

Find out more on:
statista.com/outlook/advertising-media

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Everything you need to know about **consumer goods**
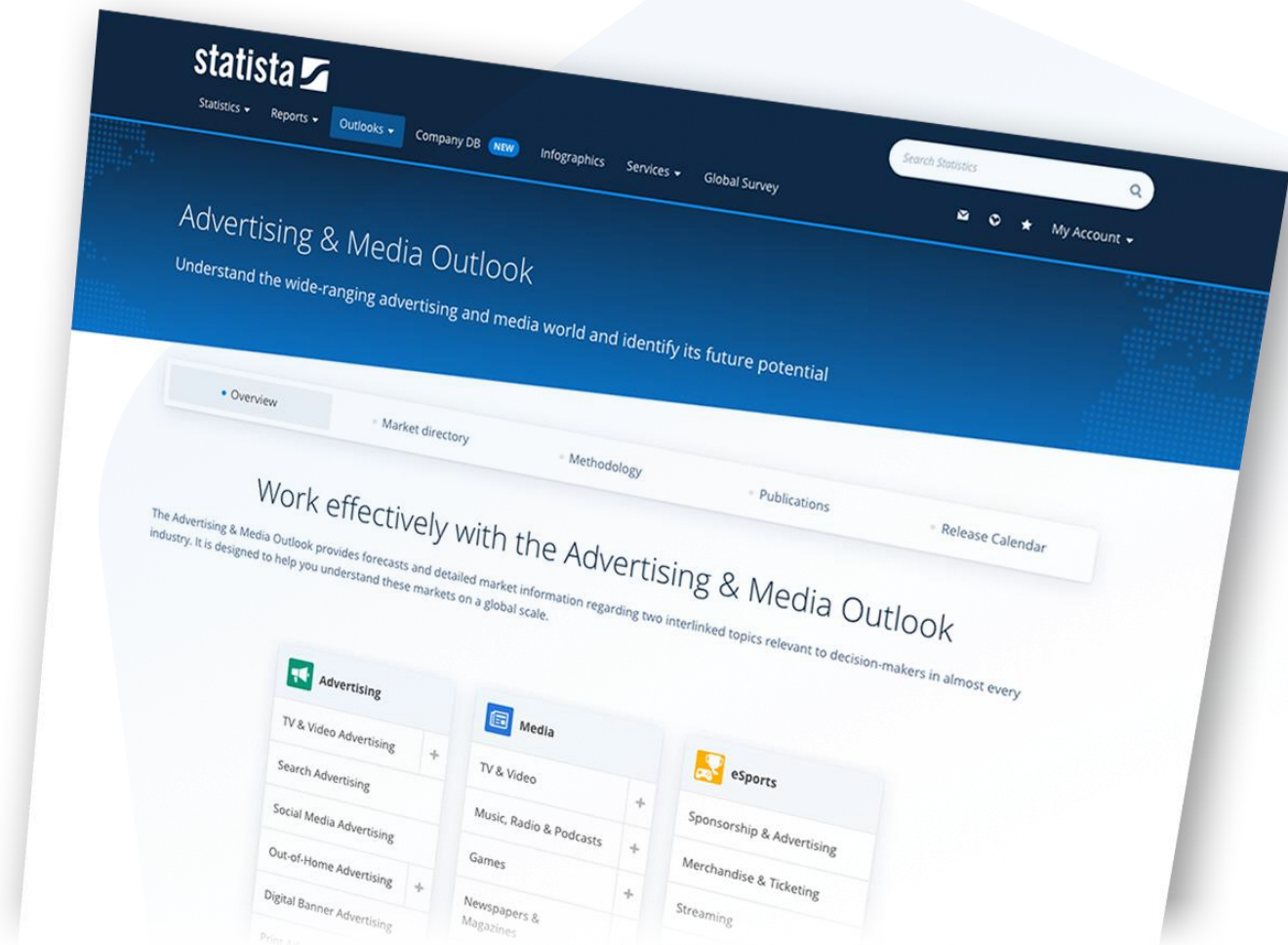
The Consumer Market Outlook presents the key performance indicators – sales, revenues, and prices – of the most important consumer markets worldwide. Our market calculations made by our in-house analysts are based on data from validated sources.

- Revenues, volumes , prices, COVID-19 impact, and forecasts
- More than 250 product categories in 150+ countries and territories as well as 37 regions
- Covering the period 2012 to 2026

Go to Outlook

Find out more on:
statista.com/outlook/consumer-markets

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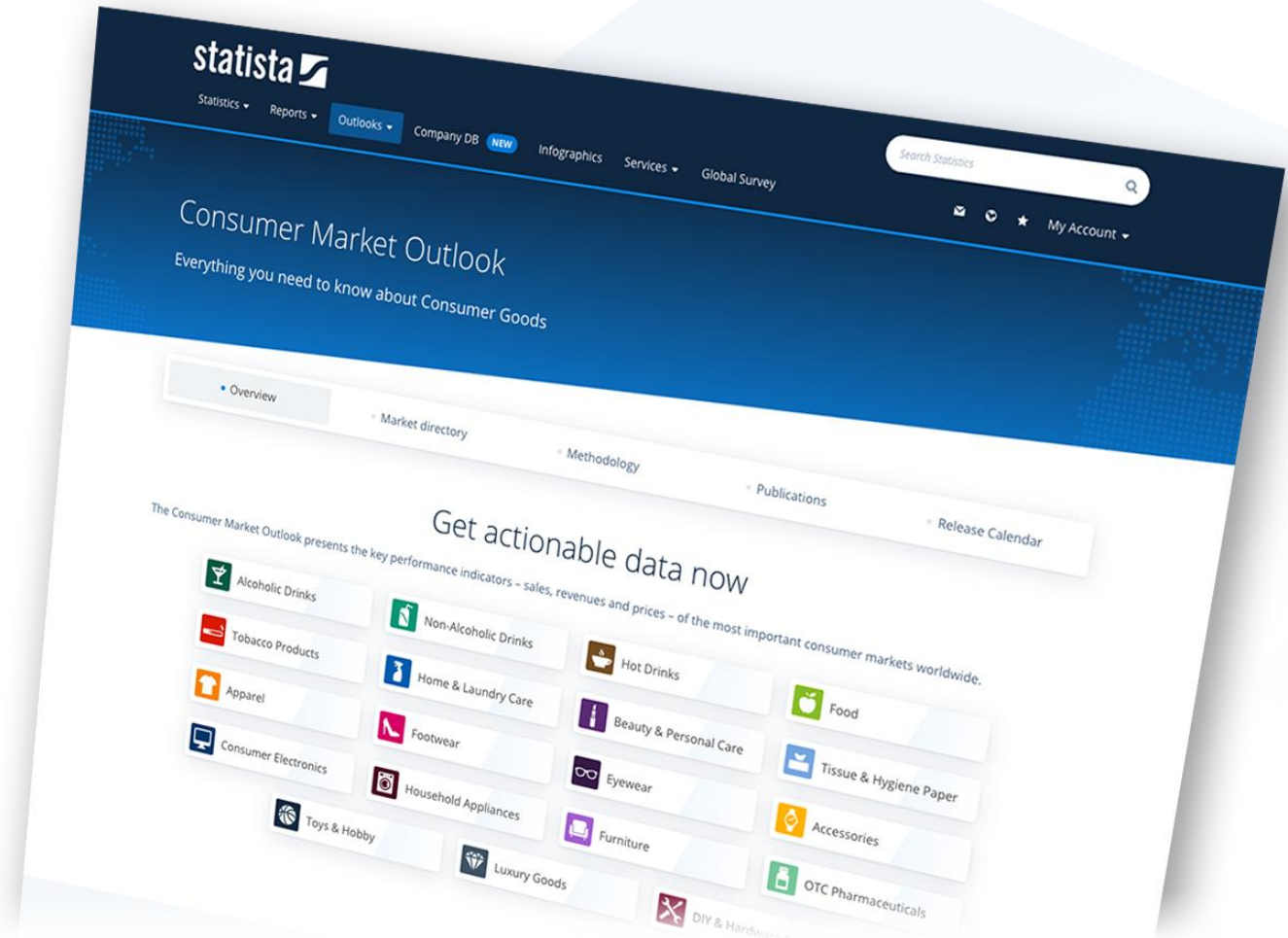
Insights into the world's most important **technology markets**

The Technology Market Outlook is an intuitive tool with valid and comparable information that can be processed immediately about different technology markets.

- 150+ countries and territories as well as 37 regions
- 55+ of the most relevant technology markets
- The most important KPIs
- Market developments and forecasts up to 2026

Go to Outlook

Find out more on:
statista.com/outlook/technology-outlook

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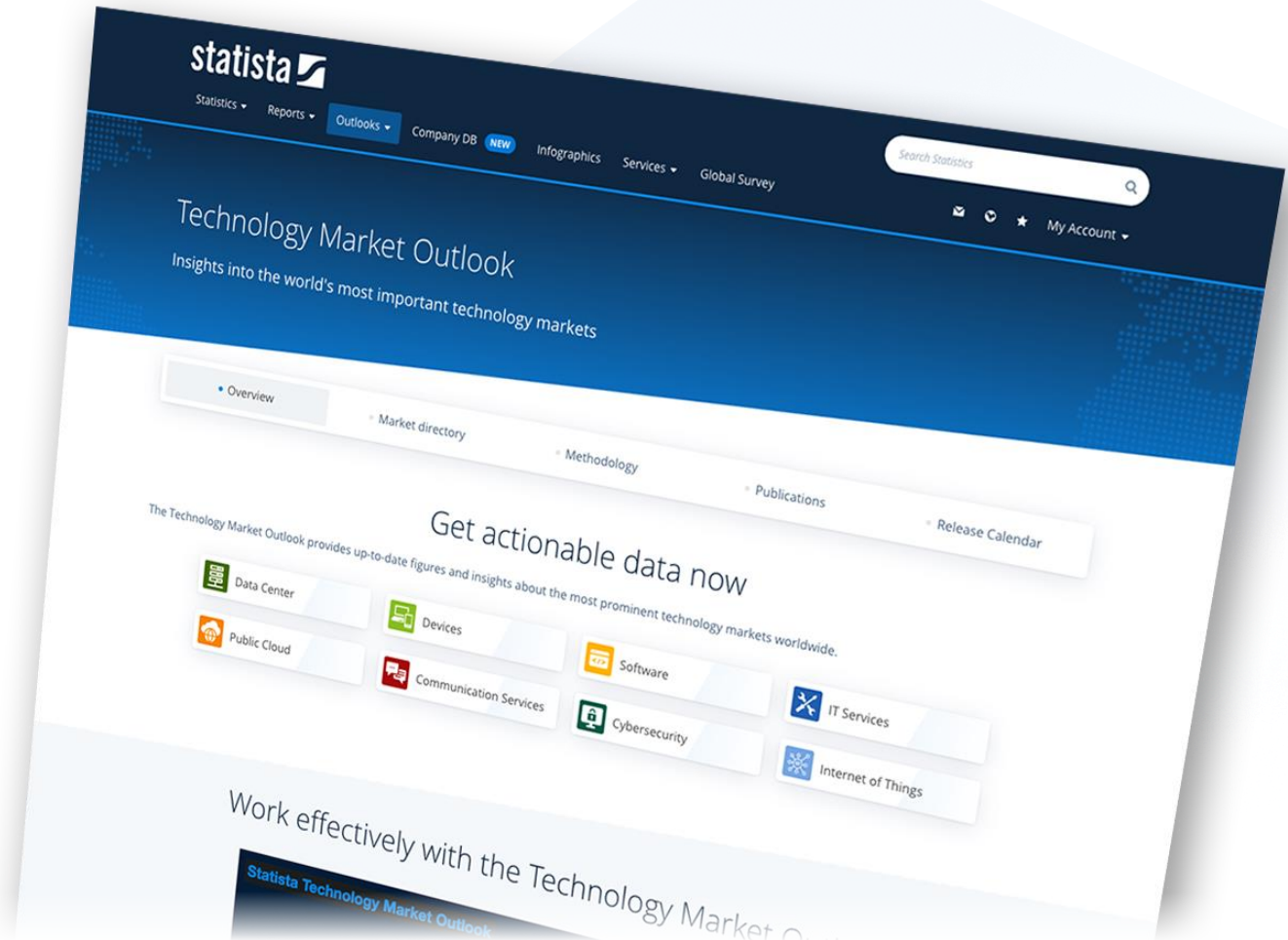
Everything you need to know about the **future of mobility**

The Mobility Market Outlook combines key mobility topics and provides relevant figures and forecasts about the automotive market and mobility services on a global scale. We analyze, measure, and predict market behavior and share the results with you.

- Mobility-related market insights, forecasts, and indicators
- Passenger cars in 12 car classes, 140+ makes, and 150+ countries and territories as well as 37 regions
- Insights into electric mobility and motorcycles
- 9 markets about shared mobility and in-depth data on tourism

Go to Outlook

Find out more on:
statista.com/outlook/mobility-markets
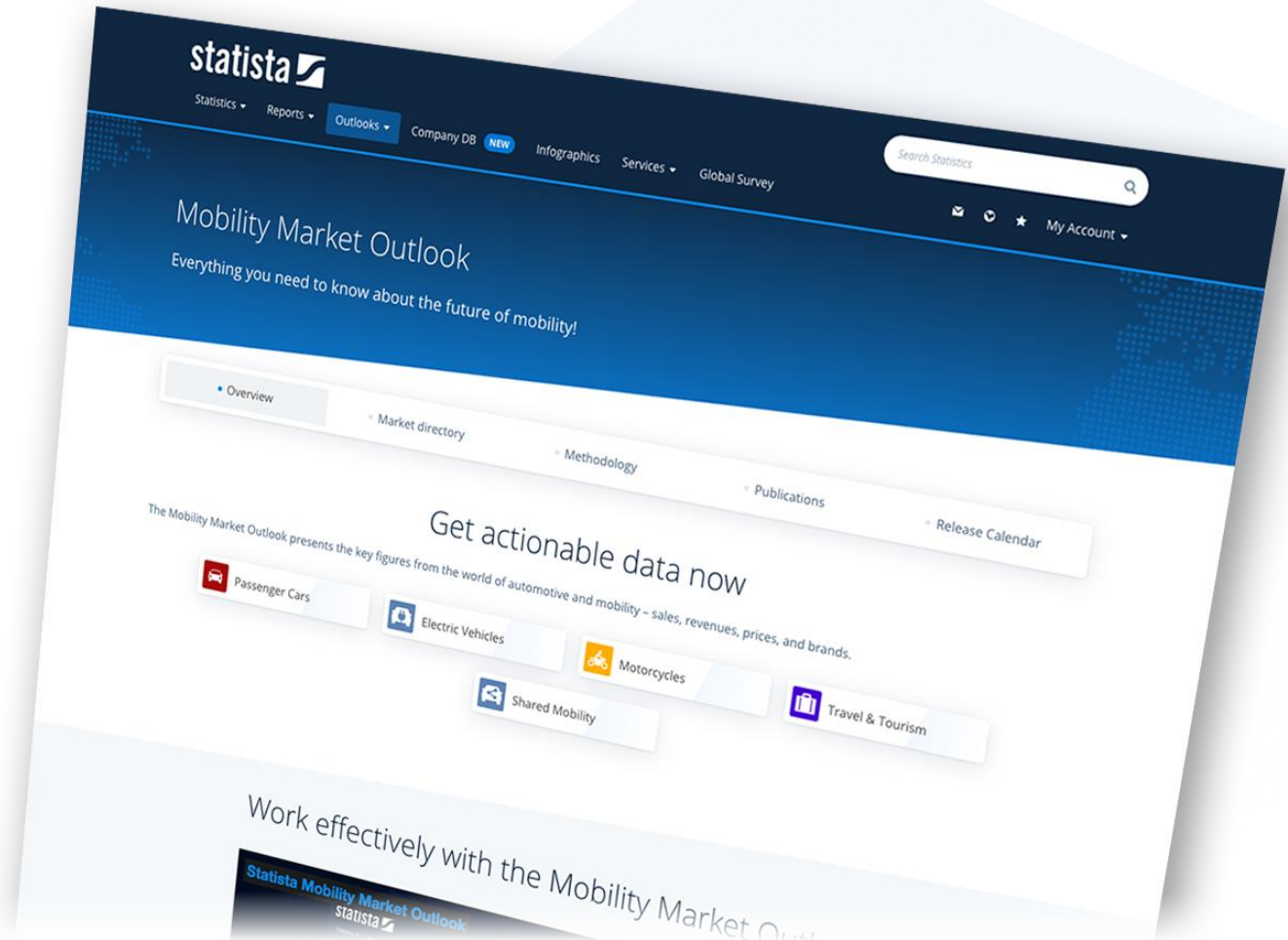
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Understand what drives consumers

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- Cross-tabulation
- Customized target groups
- Trend and country comparisons
- Export in Excel (CSV) or PowerPoint format

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1,700,000+
interviews

56
countries & territories

3.4bn.+
represented consumers

14,500+
international brands

50+
topics & industries

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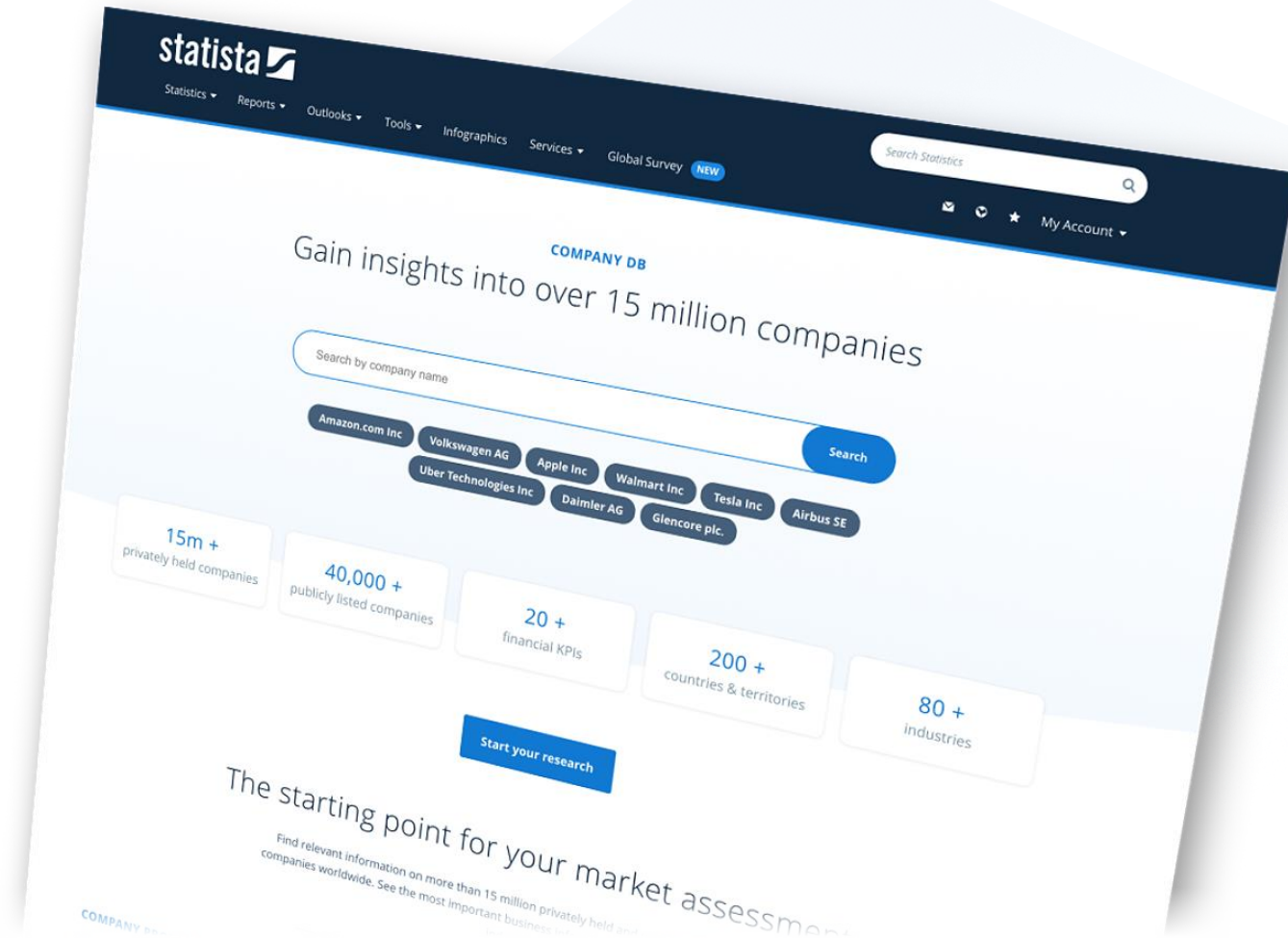
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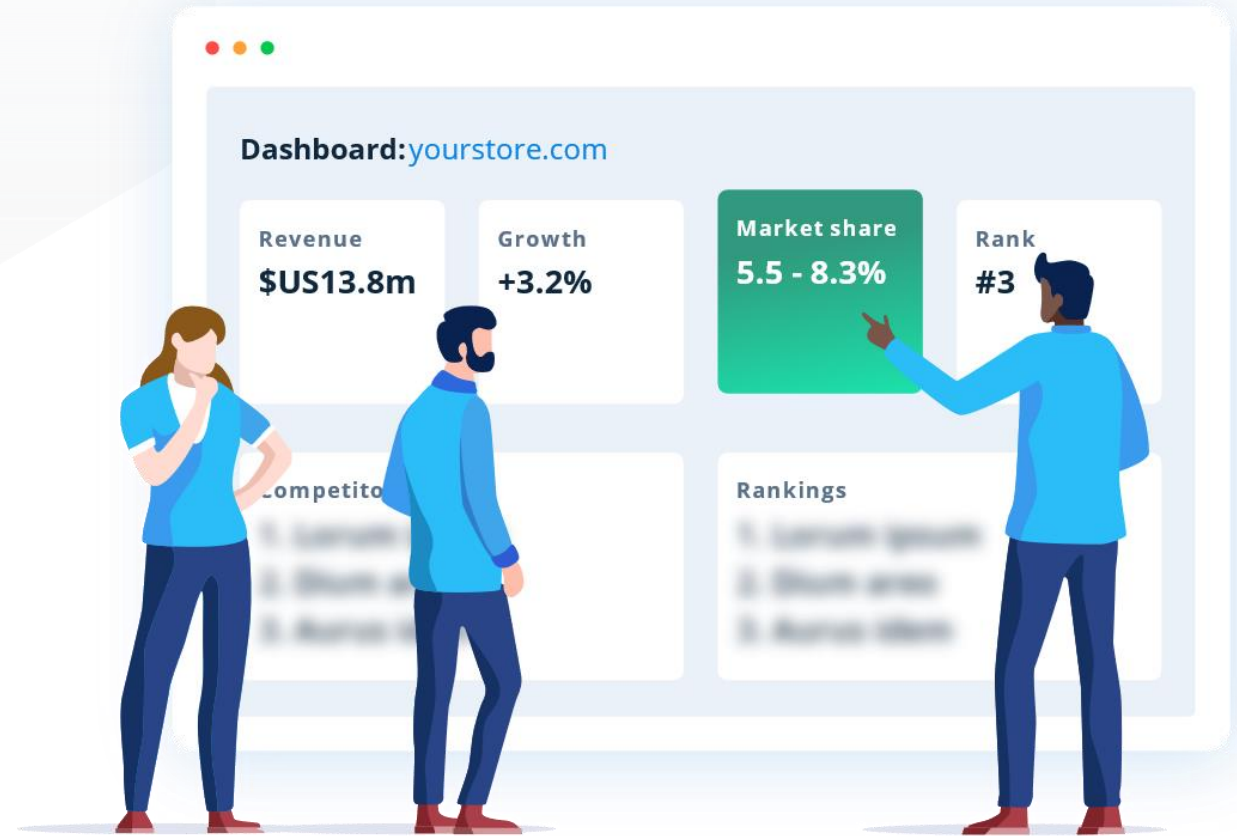
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