Chattanooga Quantum Collaborative

Hamilton County, Tennessee

Supported Agencies - Budget Year 2025

1015910 - CHATTANOOGA QUANTUM COLLABORATIVE		Prior Year Actuals					FY 2024 Budget			FY 2025 Budget			
	DESCRIPTION	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	Adopted	Amended	YTD Thru 3/31/2024	Requested	Cuts	Proposed	Change from PY Adopted
56003	APPROPRIATION	-	-	-	-	-	-	-	-	100,000		**100,000**	100,000
	Operating Expenditures Subtotal:	-	-	-	-	-	-	-	-	*100,000*		***100,000***	*100,000*
	1015910-CHATTANOOGA QUANTUM COLLABORATIVE Totals:	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	***100,000***		***100,000***	***100,000***

BUDGET REQUEST APPLICATION
FY 2024-2025

A. Cover Form

Organization Name: Chattanooga Quantum Collaborative

Organization Legal Name: Chattanooga Quantum Collaborative

Project Name(s): Chattanooga Quantum Collaborative

Federal Tax ID#: 93-3260008

Mailing Address: 1615 Williams Street Chattanooga, TN 37408

Hamilton County Address: 1615 Williams Street Chattanooga, TN 37408

Year Established: 2023

Years organization has operated in Hamilton County or served Hamilton County residents: 8 months

Organization's authorizing official contact: Charlie Brock

Organization's application contact person: Haden Gibbons

Fiscal year operating budget: $1.2 million

Current fiscal year start/end date: January 1, 2024 - December 31, 2024

First time applicant: YES

Requested county funds: 100,000

The above and following schedules embodying a request for an allocation from Hamilton County, Tennessee for the fiscal year ending June 30, 2025 (fiscal year 2025) were considered and approved by our Board of Directors on 03/26/2024. In the judgment of our Board, it represents the minimum needs of our organization for this fiscal year.

Charlie Brock

Signature of President or Board Chair

Signature of Executive Director

THIS ALLOCATION REQUEST IS DUE BY JANUARY 31,2024

B. Grant Application

STATEMENT OF NEED

1. What needs does your program address, and why is it important to the Hamilton County population?

Chattanooga Quantum Collaborative (CQC) leverages quantum assets and partnerships to benefit Hamilton County's people, communities, and businesses.

2. Provide data and statistics that support your organization's needs.

Quantum technology promises significant economic benefits, as noted by McKinsey in the attached document. Chattanooga and Hamilton County are uniquely positioned to leverage these advantages springboarding from the establishment of the nation's first commercially available quantum network, EPB Quantum Network powered by Quibtekk. Additionally, our efforts will prepare CQC to access federal funds, such as those from the NSF Innovation Engines.

OUTCOMES / OUTPUTS / INITIATIVES

3. How do you plan to utilize grant money awarded by Hamilton County?

The grant money awarded by Hamilton County will be utilized for programmatic development that focuses on learning, awareness, economic development and bolstering the region's capabilities and competitiveness in the emerging field of quantum technology.

4. What results are you committed to achieving during the grant period? What key performance measures will you use to evaluate and track those results? (750-word suggestion)

During the grant period, we are committed to achieving the following results:

Using expert resources, conduct regional study to inform a longer-term strategic plan including 3 year Objectives and Key Results (OKR's) and targeted federal and state funding opportunities.

Over 50 statewide stakeholders interviewed, including industry, academia, and government.

Establish cross-functional working groups for Economic and Workforce Development, having convened at least 3x and have a draft plan for FY 25 and established OKR's.

Mobilize community around World Quantum Day observation with 4,000 activities complete by 5/31/24.

Host Quantum Discovery Days as part of the CoMobility Summit, engaging over 300 attendees

B. Grant Application

STATEMENT OF NEED

1. What needs does your program address, and why is it important to the Hamilton County population?

Chattanooga Quantum Collaborative (CQC) leverages quantum assets and partnerships to benefit Hamilton County's people, communities, and businesses.

It is estimated that quantum computing will generate $1.3 trillion, benefiting key industries such as energy, advanced manufacturing, financial services/insurance, and logistics, with 90% of the advantages accruing to early adopters.

Signature of President or Board Chair

5. What entities do you collaborate with which could also benefit from monies awarded by Hamilton County?

UTC
Hamilton County School System
Chattanooga State
Company Lab

6. What is your organization's long-term vision, as it relates to your philanthropy and operations?

To be a region where the advancement and adoption of quantum technology provides a safer, healthier, and more prosperous world.

C. Evaluation and Sustainability

7. If you utilize any evidence-based programs, please indicate which state and/or federal websites list the program and the rating given.

We do not currently use any evidence based programs.

8. Describe how your organization plans to sustain services financially if Hamilton County funds do not extend past the awarded fiscal year

We are actively seeking funding from multiple sources, including city, county, state, federal, industry partners, and foundations.

D. Budget, Supporting Financial Documents and Attachments

Submit each of the following and complete the schedules that follow. If a document is not attached to your submission, please select N/A in the appropriate dropdown box:

- Your most recent audit (and previous two audits for organizations with a budget of $750,000 or more)

  N/A

- The organization's current operating budget - Schedule I

  Document Attached

- A Form 990 from the previous three (3) years

  N/A

- IRS Letter of Determination

  Document Attached

- Current Certificate of Good Standing with the State of Tennessee

  N/A

- Demographic information for clients served - Schedule II

  N/A

- Board & Staff Information - Schedule III

  Document Attached

- Grants, Contracts, MOU Table - Schedule IV

  Document Attached

- Strategic Plan

  N/A

- Letters of Support

  N/A

PROGRAM BUDGET SUPPORT REVENUE

Schedule I

NAME OF AGENCY BUDGET BY SERVICES FOR	FY 2024 Approved Budget	FY 2025 Proposed Budget	REVENUES Support/ Revenues	EXPENSES/EXPENDITURES PROGRAM SERVICES Program 1	Program 2	Program 3	Total Prog. Servs.	SUPPORT SERVICES Mgmt & General	Fund Raising	Total Supp. Serv.
SUPPORT/REVENUE FOR CURRENT OPERATIONS:										
Contributions	675,000	900,000	900,000							
Net Proceeds Special Events		0								
Designations		0								
United Way		0								
Fees/Grants from Governmental Agencies	300,000	200,000	200,000							
Membership Dues		0								
Program Income		0								
Sales to Public		0								
Investment Income		0								
Transfers to Operating Budget		0								
Income from Previous Year		0								
Miscellaneous		0								
*Support Requested from Hamilton County		100,000	100,000							
TOTAL SUPPORT/REVENUES	975,000	1,200,000	1,200,000							
EXPENDITURES FOR CURRENT OPERATIONS:										
Salaries Only (No Benefits)	286,920	452,000		452,000			452,000			0
Employee Health & Retirement Benefits	57,029	124,960		124,960			124,960			0
Employment Taxes, etc.		0					0			0
Professional Fees/Contract Service Payments	430,225	315,000		315,000			315,000			0
Supplies	5,000	30,000		30,000			30,000			0
Telephone		0					0			0
Postage and Shipping		0					0			0
Occupancy	8,050	0					0			0
Equipment Rental and Maintenance		0			0		0			0
Outside printing, art work, etc.		0					0			0
Local Transportation		0					0			0
Conferences, Conventions, etc.	27,250	51,000		51,000			51,000			0
Special Assistance to Individuals		0					0			0
Organization Dues		0					0			0
Awards and Grants	79,500	150,000		150,000			150,000			0
Fund Raising/Self-Support Activities	21,250	50,000		50,000			50,000			0
Insurance		0					0			0
Miscellaneous	4,500	15,000		15,000			15,000			0
Depreciation		0					0			0
National Dues/Support Payments		0					0			0
Equipment Purchases		0					0			0
TOTAL EXPENSES/EXPENDITURES	919,724	1,187,960		1,187,960	0	0	1,187,960	0	0	0
REVENUES OVER (UNDER) EXPENDITURES	60,276	12,040								

Program Beneficiary Statistics

(This should reflect total program count. Copy as needed for each program.)

Chattanooga Quantum Collaborative

(Name of Program)

Program Beneficiary Characteristics Clients/Patients/Recipients/Other		Fiscal 2024 Budget	Fiscal 2024 Projected	Fiscal 2025 Proposed Budget
1. Unduplicated Count of Program Beneficiaries	TOTAL	0	0	0
a. Total Continuing from Previous Fiscal Year				
b. Total New for the Year				
c. Total Terminated During the Year				
2. Age Group	TOTAL	0	0	0
a. Infants-Under 5				
b. Between 5 and 12				
c. Between 13 and 17				
d. Between 18 and 29				
e. Between 30 and 64				
f. 65 and over				
g. Not Known				
3. Gender	TOTAL	0	0	0
a. Male				
b. Female				
c. Not Known/Other				
4. Ethnic Background	TOTAL	0	0	0
a. White				
b. Black				
c. Hispanic				
d. Oriental				
e. Other - Ethnic Minority				
f. Not Known				
5. Income Level	TOTAL	0	0	0
a. Below 4,999				
b. 5,000-7,499				
c. 7,500-9,999				
d. 10,000-14,999				
e. 15,000-19,999				
f. 20,000-29,999				
g. 30,000 and Over				
h. Not Known				
6. Location of Residence	TOTAL	0	0	0
a. Hamilton County				
b. Outside of Hamilton County				
c. Not Known				

HAMILTON COUNTY, TENNESSEE
FISCAL YEAR 2025

Agency Name: Chattanooga Quantum Collaborative

1. Are the dollars Hamilton County appropriates to your agency designated for the benefit of a specific geographical segment of the community? NO

2. If the answer to question number 1 above is yes, please explain.

3. Please estimate the percentage of your services provided to the geographic area listed below:

Unincorporated County	0.0%
City of Chattanooga	0.0%
City of East Ridge	0.0%
City of Signal Mountain	0.0%
City of Red Bank	0.0%
City of Soddy Daisy	0.0%
City of Lakesite	0.0%
City of Walden	0.0%
City of Collegedale	0.0%
City of Ridgeside	0.0%
City of Lookout Mountain	0.0%
All areas outside of Hamilton County	0.0%
Total	0.0%

Schedule of Positions, Salaries & Wages

Confidential (for Hamilton County internal use only)

Chattanooga Quantum Collaborative

(Name of Agency)

ALL FINANCIAL INFORMATION ROUNDED TO NEAREST DOLLAR

Board of Directors Title and/or Position	Name(s) Last Name, Initial	Part Time	#Years Emp	Emp. Covered by Retirement (a)	Current FY			Requested		
					# Weeks Employed	Annual Salary	Budgeted Salary	# Weeks Employed	Annual Salary	Budgeted Salary
Chairman	Sen. Bob Corker	--		NO						
Board Member	David Wade	--		NO						
Board Member	Mayor Tim Kelly	--		NO						
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* If a position is changed from a part-time to a full-time position, show each as a separate position unit.
List positions in order of responsibility and include all staff and employees of agency in this schedule.
Non-professional employees performing similar services may be reported as a group.
(a.) Check if person is covered by retirement benefits.

Schedule of Positions, Salaries & Wages

Confidential (for Hamilton County internal use only)

Chattanooga Quantum Collaborative

(Name of Agency)

ALL FINANCIAL INFORMATION ROUNDED TO NEAREST DOLLAR

Organization Staff Members Title and/or Position	Name(s) Last Name, Initial	Part Time	#Years Emp	Emp. Covered by Retirement (a)	Current FY			Requested		
					# Weeks Employed	Annual Salary	Budgeted Salary	# Weeks Employed	Annual Salary	Budgeted Salary
CEO	Charlie Brock	NO		--	32	$210,000	$210,000			
Loaned Executive	Marie Webb	--		--						
Loaned Executive	Danna Bailey	--		--						
Managing Coordinator	Haden Gibbons	YES		--	2	18,200	18,200			
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* If a position is changed from a part-time to a full-time position, show each as a separate position unit.
List positions in order of responsibility and include all staff and employees of agency in this schedule.
Non-professional employees performing similar services may be reported as a group.
(a.) Check if person is covered by retirement benefits.

AGENCY: Chattanooga Quantum Collaborative

AWARDS AND GRANTS FROM GOVERNMENTAL AGENCIES CITY/COUNTY/STATE/FEDERAL

	PROGRAM/PROJECT TITLE	NAME OF SOURCE	FOR HOW LONG?	LAST YEAR	THIS YEAR	NEXT YEAR
1	CQC Membership	City of Chattanooga	1 year		100,000	100,000
2	CQC Membership	EPB	2 year		100,000	100,000
3	CQC Membership	TVA	1 year		50,000	
4	CQC Membership	ORNL	1 year		50,000	
5	CQC Membership	UTC	3 year		50,000	50,000
6	CQC Membership	Chatt State	1 year		5,000	
7	CQC Membership	Chattanooga Chamber	1 year		2,500	
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
	Total Fees From Governmental Agencies			0	357,500	250,000

ALL FINANCIAL INFORMATION ROUNDED TO NEAREST DOLLAR

Department of the Treasury
Internal Revenue Service
Tax Exempt and Government Entities
P.O. Box 2508
Cincinnati, OH 45201

Date:
01/29/2024
Employer ID number:
93-3260008
Person to contact:
Name: Customer Service
ID number: 31954
Telephone: 877-829-5500
Accounting period ending:
December 31
Public charity status:
170(b)(1)(A)(vi)
Form 990 / 990-EZ / 990-N required:
Yes
Effective date of exemption:
August 9, 2023
Contribution deductibility:
Yes
Addendum applies:
No
DLN:
26053424006154

CHATTANOOGA QUANTUM COLLABORATIVE
C/O CHARLIE BROCK
1615 WILLIAMS STREET
CHATTANOOGA, TN 37408

Dear Applicant:

We're pleased to tell you we determined you're exempt from federal income tax under Internal Revenue Code (IRC) Section 501(c)(3). Donors can deduct contributions they make to you under IRC Section 170. You're also qualified to receive tax deductible bequests, devises, transfers or gifts under Section 2055, 2106, or 2522. This letter could help resolve questions on your exempt status. Please keep it for your records.

Organizations exempt under IRC Section 501(c)(3) are further classified as either public charities or private foundations. We determined you're a public charity under the IRC Section listed at the top of this letter.

If we indicated at the top of this letter that you're required to file Form 990/990-EZ/990-N, our records show you're required to file an annual information return (Form 990 or Form 990-EZ) or electronic notice (Form 990-N, the e-Postcard). If you don't file a required return or notice for three consecutive years, your exempt status will be automatically revoked.

If we indicated at the top of this letter that an addendum applies, the enclosed addendum is an integral part of this letter.

For important information about your responsibilities as a tax-exempt organization, go to www.irs.gov/charities. Enter "4221-PC" in the search bar to view Publication 4221-PC, Compliance Guide for 501(c)(3) Public Charities, which describes your recordkeeping, reporting, and disclosure requirements.

We sent a copy of this letter to your representative as indicated in your power of attorney.

Sincerely,

Stephen A. Martin

Stephen A. Martin
Director, Exempt Organizations
Rulings and Agreements

McKinsey & Company

Quantum Technology Monitor

April 2023

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What can you find in this report?

Continuously evolving overview of the **global quantum technology (QT) player and investment space,** updated annually, including quantum computing (QC), quantum communications (QComms), and quantum sensing (QS); see page 3 for definitions of these areas

Dynamic overview of the **maturity of the QT ecosystem and the use of QT in the broader industry context,** based on the current application of the technology and patents

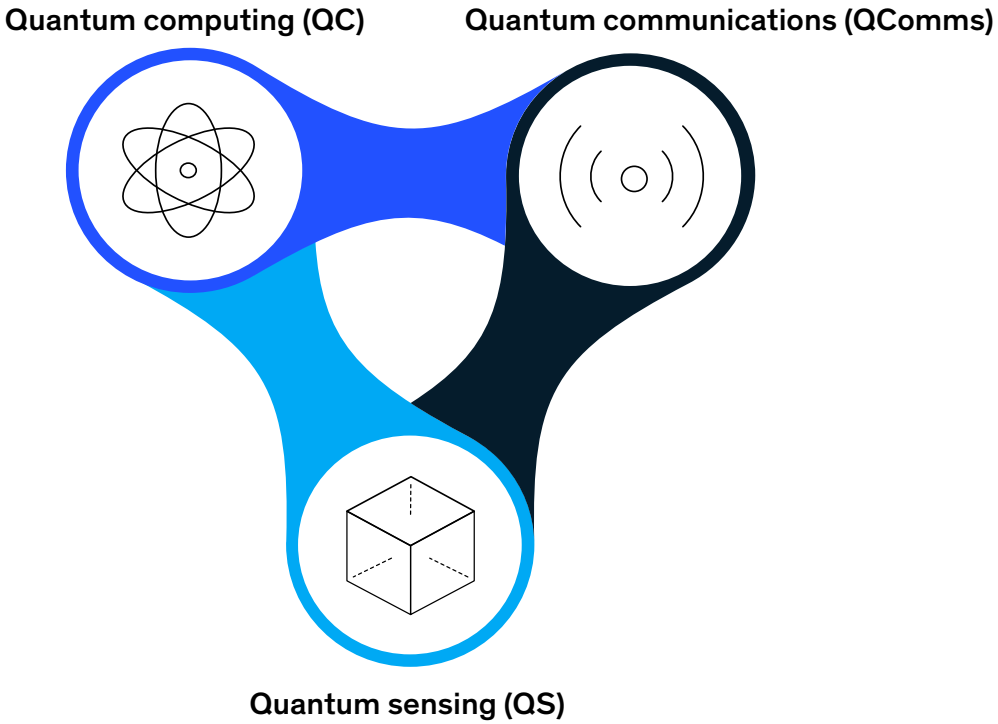
Definitive and exhaustive list of the start-up, investment, and economic activities in the QT realm

New additions to the Monitor

- Improved investment insights (pp 7–17)
- Enhanced perspective on quantum technology (QT) in China and Japan (pp 16–17)
- Deep dive on the quantum software ecosystem (pp 26–27)
- Refreshed use-case value matrix of quantum computing (QC) by industry (p 30)
- Deep dive on the quantum sensing (QS) ecosystem (pp 40–43)

Note: The Quantum Technology Monitor is based on research from numerous data sources (including but not limited to CapitalIQ, Crunchbase, PitchBook, Quantum Computing Report, expert interviews, and McKinsey analysis); minor data deviations may exist due to updates of the respective databases.

Definitions: Quantum technology encompasses three subfields: computing, communications, and sensing.



- **Quantum computing (QC)** is a new technology for computation, which leverages the laws of quantum mechanics to provide exponential performance improvement for some applications and to potentially enable completely new territories of computing. Some of the early quantum hardware products are special-purpose quantum computers, also called quantum simulators.
- **Quantum communications (QComms)** is the secure transfer of quantum information across space.[1] It could ensure security of communications, enabled by quantum cryptography, even in the face of unlimited (quantum) computing power.[2]
- **Quantum sensing (QS)** is the new generation of sensors built from quantum systems. It could provide measurements of various quantities (eg, gravity, time, electromagnetism) that are orders of magnitude more sensitive than classical sensors.

[1]Quantum information is information stored in qubits. Qubits are the unit of information for QC and are an extension of the classical bit (the unit of information for classical computing).
[2]Quantum cryptography draws on the exchange of a secret key to encrypt messages based on the quantum mechanical phenomenon of entanglement. Unlike any classical cryptographic protocol, it is in principle not possible to "eavesdrop" on messages exchanged with quantum cryptography. However, early implementations have been shown to have some weaknesses.

Source: Expert interviews

The quantum technology ecosystem in 2023

Summary of Quantum Technology Monitor findings

Quantum computing

$9B–$93B

estimated market size by 2040

$5.4B invested as of Dec 2022

223 start-ups as of Dec 2022

$106B

potential quantum technology market size by 2040[1]

350

start-ups in the ecosystem[2]

$34B total government investment announced

Quantum communications

$1B–$7B

estimated market size by 2040

$1.0B invested as of Dec 2022

72 start-ups as of Dec 2022

Quantum sensing

$1B–$6B

estimated market size by 2040

$0.4B invested as of Dec 2022

23 start-ups as of Dec 2022

Potential economic value from quantum computing

$620B–$1,270B

across four industries by 2035: chemicals, life sciences, finance, and automotive[3]

Quantum-capable talent

50

QT master's degree programs

180

universities with QT research groups

Scientific progress

1,589

QT-related patents granted in 2022

44,155

QT-related publications in 2022

[1] The potential 2040 market size is a sum of the upper ranges across quantum computing, quantum communications, and quantum sensing.
[2] Total includes 32 companies that do two or more quantum technologies simultaneously.
[3] Economic value is defined as the additional revenue and saved costs that the application of quantum computing can unlock. These four industries are the most likely to realize this value earlier than other industries; therefore, they are examined in more depth.

Executive summary

Investment and ecosystem

- Total annual QT start-up investment hit a new high ($2.35 billion), though growth was only 1% YoY
- About two-thirds, or 68 percent, of all QT start-up investments since 2001 occurred in 2021 and 2022
- With 350 start-ups in the QT ecosystem, the rate of start-up creation slowed and has not kept pace with investments, indicating that investments are going into established start-ups rather than toward new ideas; information that Series A and B start-ups have attracted particular attention in 2022 supports that statement
- 2022 was a year of big deals: four of the ten biggest QT investment deals since 2001 were closed in 2022: SandboxAQ ($500 million), Rigetti ($345 million in a SPAC deal), D-Wave ($300 million in a SPAC deal), and Origin Quantum ($149 million)
- Public investments continue: the United States, the European Union, and Canada committed an additional $1.8 billion, $1.2 billion, and $0.1 billion, respectively

Research and technology progress

- The 2022 Nobel Prize in Physics was awarded to quantum-entanglement pioneers Alain Aspect, John Clauser, and Anton Zeilinger
- IBM unveiled the Osprey (433 qubits) and updated its road map to develop a 4,000+ qubit processor in 2025
- Xanadu demonstrated quantum advantage for GBS[1] using its photonic quantum computer
- Patent issuance and publishing dropped in 2022, potentially indicating that the easiest challenges have already been addressed; 1,589 QT-related patents were granted in 2022, 61 percent less than in 2021, and 44,155 QT-related papers were published in 2022, 5 percent less than 2021

Potential economic value

- Our updated analysis for 2023 shows that the four industries likely to see the earliest economic impact from quantum computing—automotive, chemicals, financial services, and life sciences—stand to potentially gain up to $1.3 trillion in value by 2035.
- The update of the value potential comes from a reassessment of the potential economic value of QC use cases in the financial services industry, which has grown to between $394 billion and $700 billion. Corporate banking, risk, and cybersecurity offer the most valuable use cases.

Quantum talent

- The talent gap for QT jobs narrowed, yet remains wide; approximately one in two jobs remained vacant in 2022, compared to one in three in 2021
- The number of universities offering official master's degrees in QT nearly doubled in 2022, from 29 to 50

[1] Gaussian boson sampling: a probability-distribution-sampling problem; quantum advantage has previously been demonstrated for this problem by Google and researchers from the Chinese Academy of Sciences.

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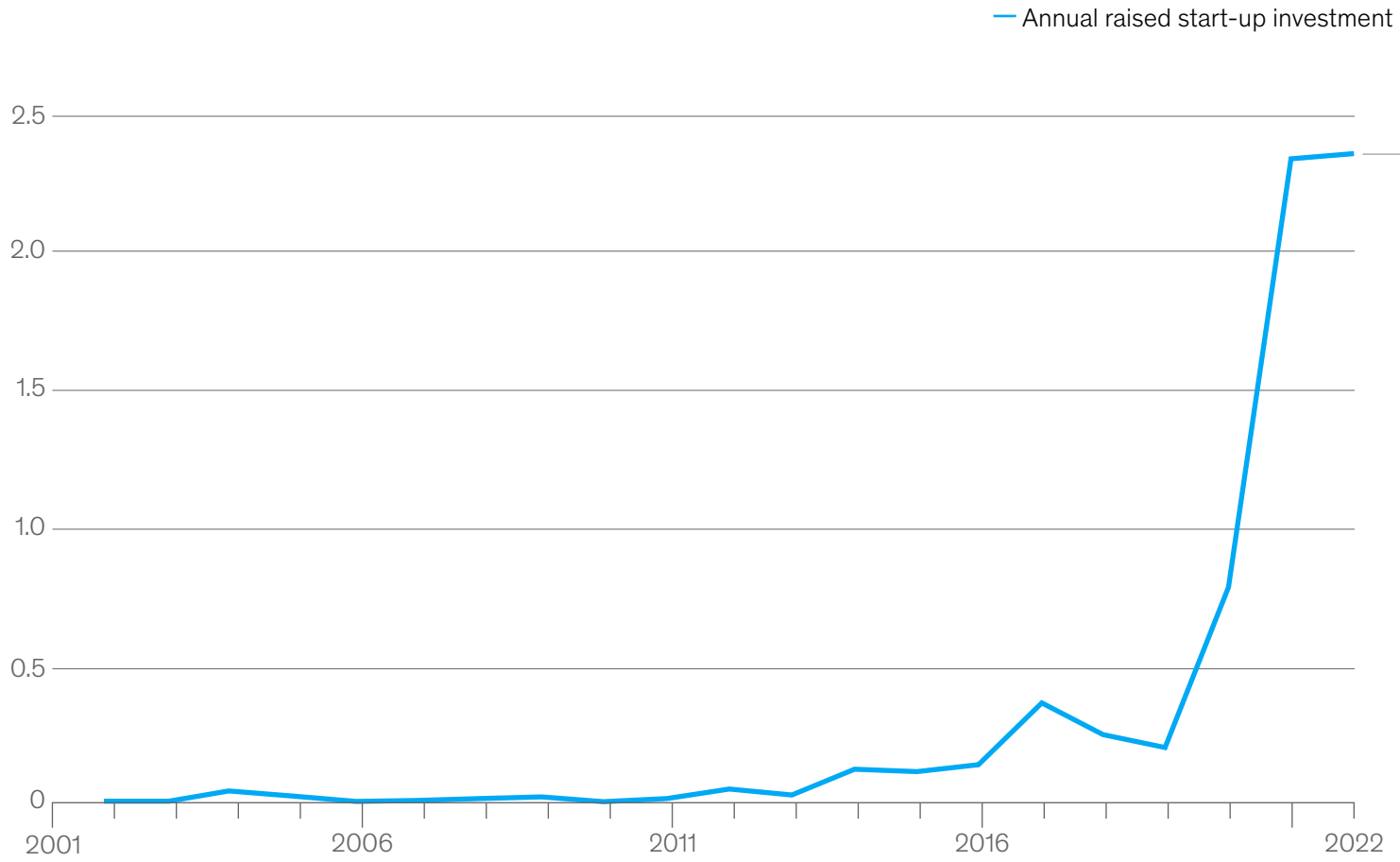
Quantum technology investment landscape

Total annual QT start-up investment hit the highest level of all-time, though it grew only 1 percent year over year.

Volume of raised investment in the indicated year,[1] $ billion



$2.35B

75%

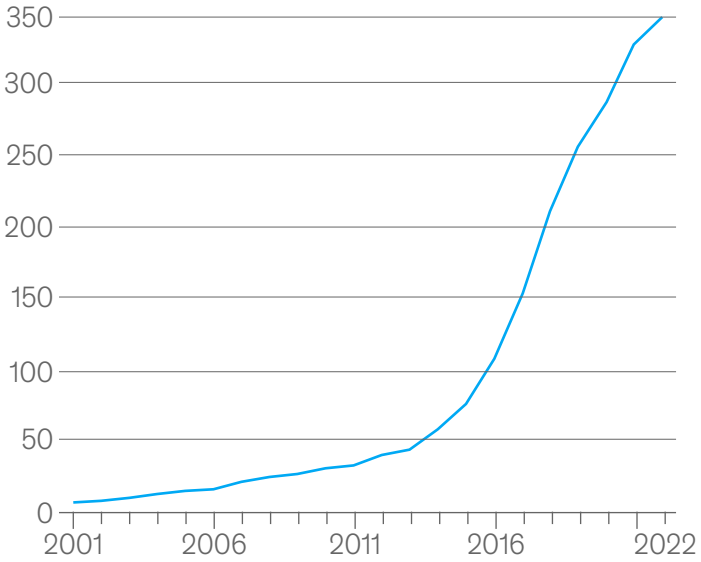
of investment goes toward quantum computing players

[1]Based on public investment data recorded in PitchBook; actual investment is likely higher.

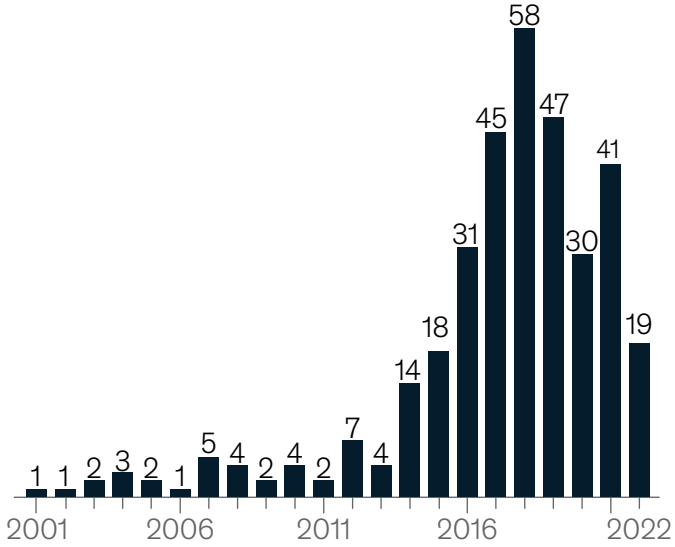
Source: PitchBook

Despite record investment, the rate of QT start-up creation slowed in 2022.

Cumulative number of QT start-ups founded



Number of QT start-ups founded per year



Potential hypotheses on the causes of the slowdown:

- **Lack of talent:** Most experienced specialists (generally academics with research focus in QT) already work in a start-up
- **Few working use cases:** Application start-up creation is limited because working use cases are very limited or not sufficiently developed for commercial implementation (eg, in QS)
- **Investor trends:** Investors prefer to invest in scale-ups and later-stage start-ups, limiting capital for a company that is just starting

80%

of start-ups founded in past 3 years are in QC space

Source: Crunchbase; PitchBook

The year featured comparatively big deals, with four new entrants into the top ten.

Top 10 venture capital/private equity investments in QT start-ups of all time, by deal size (descending)

New entrants | Quantum computing | Quantum communications | Quantum sensing

Company	Country	Tech	Segment	Deal size, $ million	Deal year
SandboxAQ	United States	Quantum sensing, Quantum communications, Quantum computing	Application software	500	2022
PsiQuantum	United States	Quantum computing	Hardware manufacturing	450	2021
IonQ	United States	Quantum computing	Hardware manufacturing	350	2021
Rigetti Computing	United States	Quantum computing	Hardware manufacturing	345	2022
Arqit	United Kingdom	Quantum communications	Hardware manufacturing	345	2021
IonQ	United States	Quantum computing	Hardware manufacturing	300	2021
Quantinuum	United Kingdom	Quantum computing	Vertically integrated[1]	300	2021
D-Wave Systems	Canada	Quantum computing	Hardware manufacturing	300	2022
PsiQuantum	United States	Quantum computing	Hardware manufacturing	230	2020
Origin Quantum	China	Quantum computing	Hardware manufacturing	149	2022

[1]Quantinuum crosses all segments, from hardware to services and software, as it was created in a merger between Honeywell Quantum Solutions (hardware manufacturer) and Cambridge Quantum Computing (systems and application software).

Source: Crunchbase; PitchBook

Seven out of ten deals in 2022 were valued at more than $100 million.

Top 10 venture capital/private equity investments in QT start-ups in 2022, by deal size (descending)

Quantum computing · Quantum communications · Quantum sensing

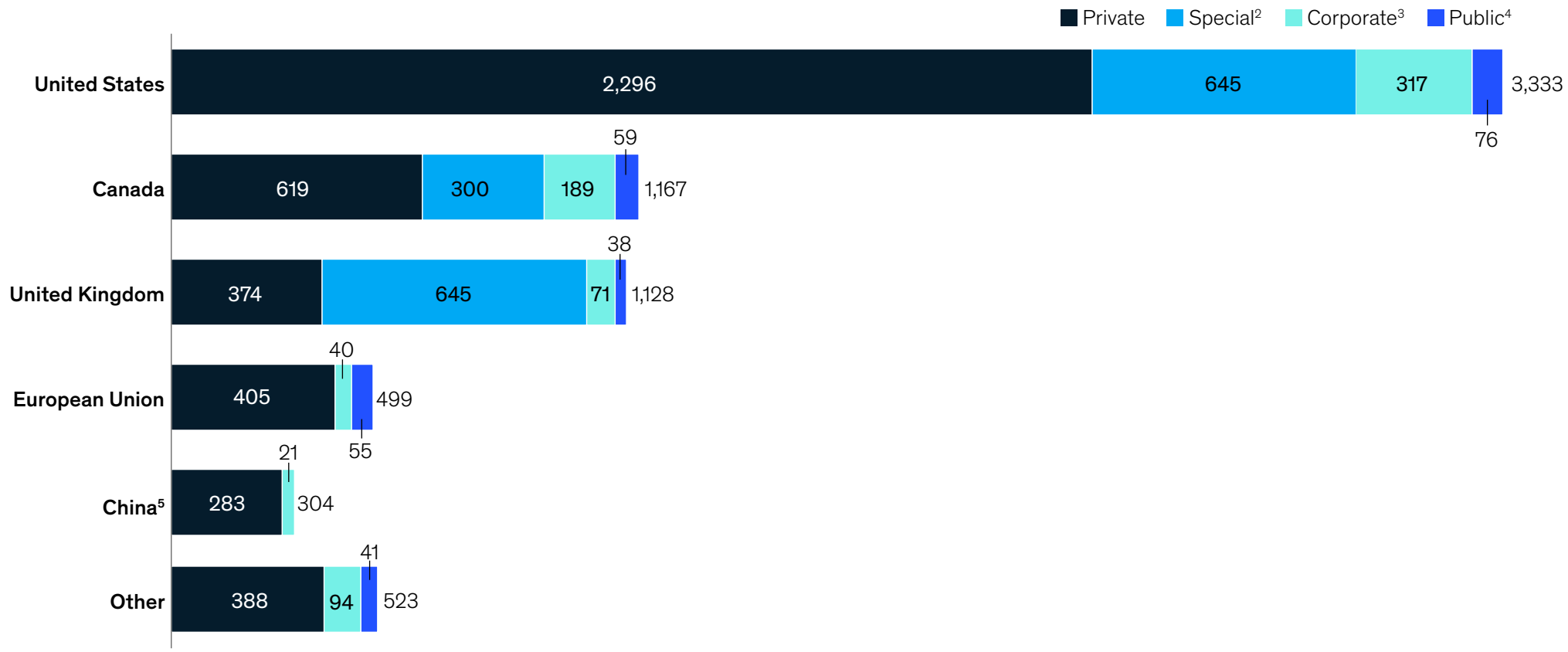
Company	Country	Tech	Segment	Deal size, $ million	Deal year
SandboxAQ	United States	Quantum sensing, Quantum communications, Quantum computing	Application software	500	2022
Rigetti Computing	United States	Quantum computing	Hardware manufacturing	345	2022
D-Wave Systems	Canada	Quantum computing	Hardware manufacturing	300	2022
Origin Quantum	China	Quantum computing	Hardware manufacturing	149	2022
ColdQuanta (now Infleqtion)	United States	Quantum sensing, Quantum computing	Vertically integrated[1]	133	2022
IQM	Finland	Quantum computing	Hardware manufacturing	132	2022
Xanadu	Canada	Quantum computing	Hardware manufacturing	100	2022
Terra Quantum	Switzerland	Quantum sensing, Quantum communications, Quantum computing	Application software, QNO,[2] services	75	2022
Atom Computing	United States	Quantum computing	Hardware manufacturing	59	2022
Classiq	Israel	Quantum computing	Systems software	49	2022

[1] With the acquisition of Super.tech in 2022, the company also has a robust software offering.
[2] QNO = quantum network operator.

Source: Crunchbase; PitchBook

The majority of investments are in US companies, driven primarily by private investors.

Total investment in QT start-ups by location and primary investor type, 2001–22, $ million[1]

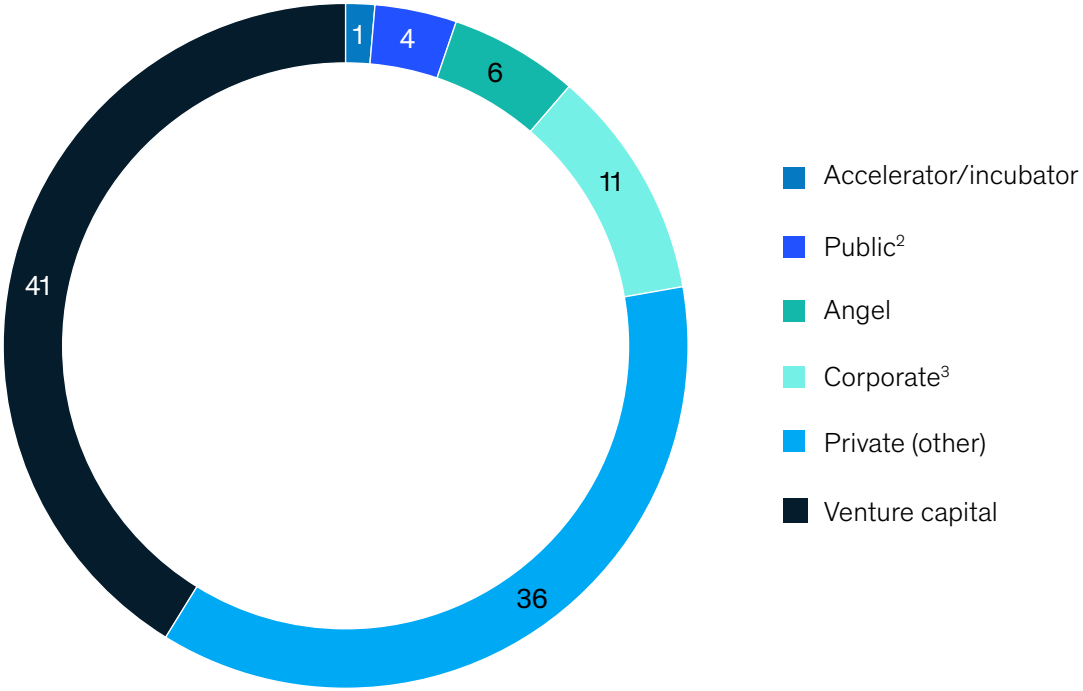


[1] Based on PitchBook data. Actual investment volume in QTs is likely higher. Figures may not sum to totals, because of rounding.
[2] Includes SPACs (eg, Rigetti Computing) and other special deal types (eg, Honeywell's investment of $300 million in Quantinuum).
[3] Includes investments from corporations and corporate venture capital in external start-ups; excludes corporate investments in internal QT programs.
[4] Includes investments by governments, sovereign wealth funds, and universities.
[5] Data availability on start-up investment in China is limited. The overview includes all publicly available data on China. While actual investment is likely higher, we think that at this stage most investment awarded by China is to research institutions; other estimates place total private investments closer to $615 million.

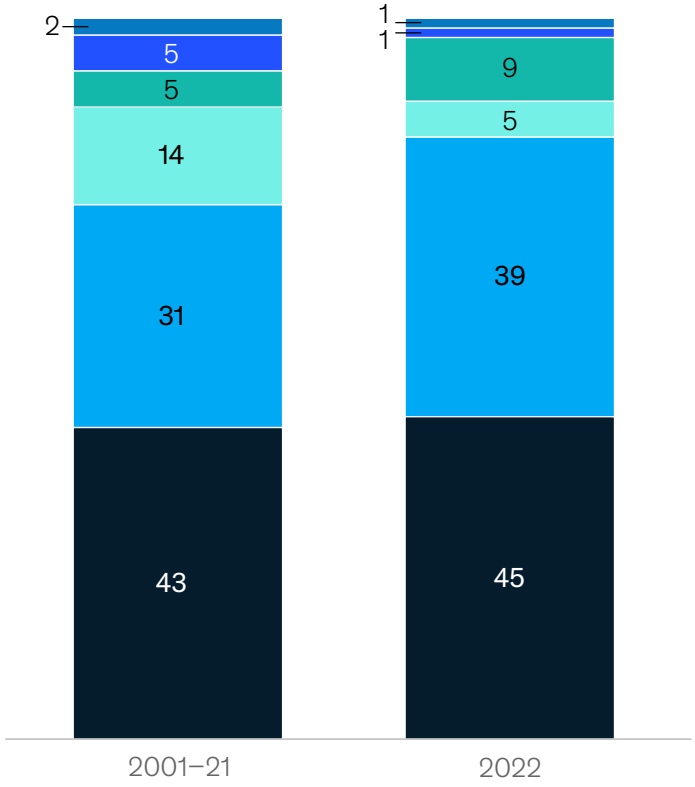
Source: ICV Thinktank; IT橘子(IT Orange); PitchBook

Venture capital and other private funding make up nearly 80 percent of QT inflows; venture capital, private, and angel investments grew in 2022.

Split of QT investments, by investor type, 2001–22, % of total investment value[1]



Change in QT investments, by investor type, 2001–21 vs 2022, % of total investment value

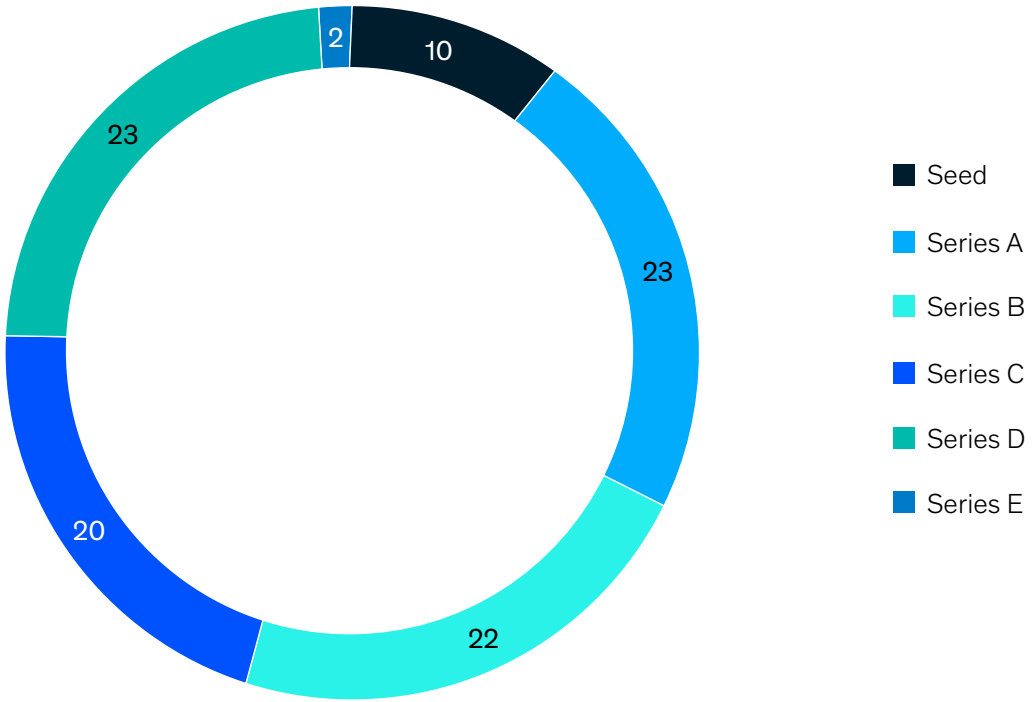


[1] Figures may not sum to 100%, because of rounding.
[2] Includes governments, sovereign wealth funds, and universities.
[3] Includes corporations, corporate venture capital, venture-capital-backed companies, and private-equity-backed companies investing in an external start-up; does not include corporations investing in internal QT programs.

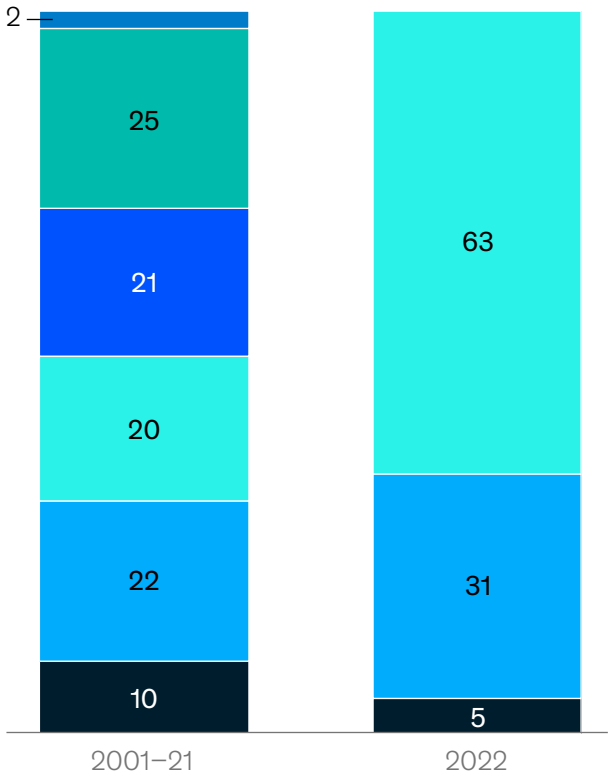
Source: PitchBook

Most investment went to early-stage start-ups in 2022.

Split of venture capital investments, by deal type, 2001–22, % of total investment value



Split of investments, by deal type, 2001–21 vs 2022, % of total investment value[1]

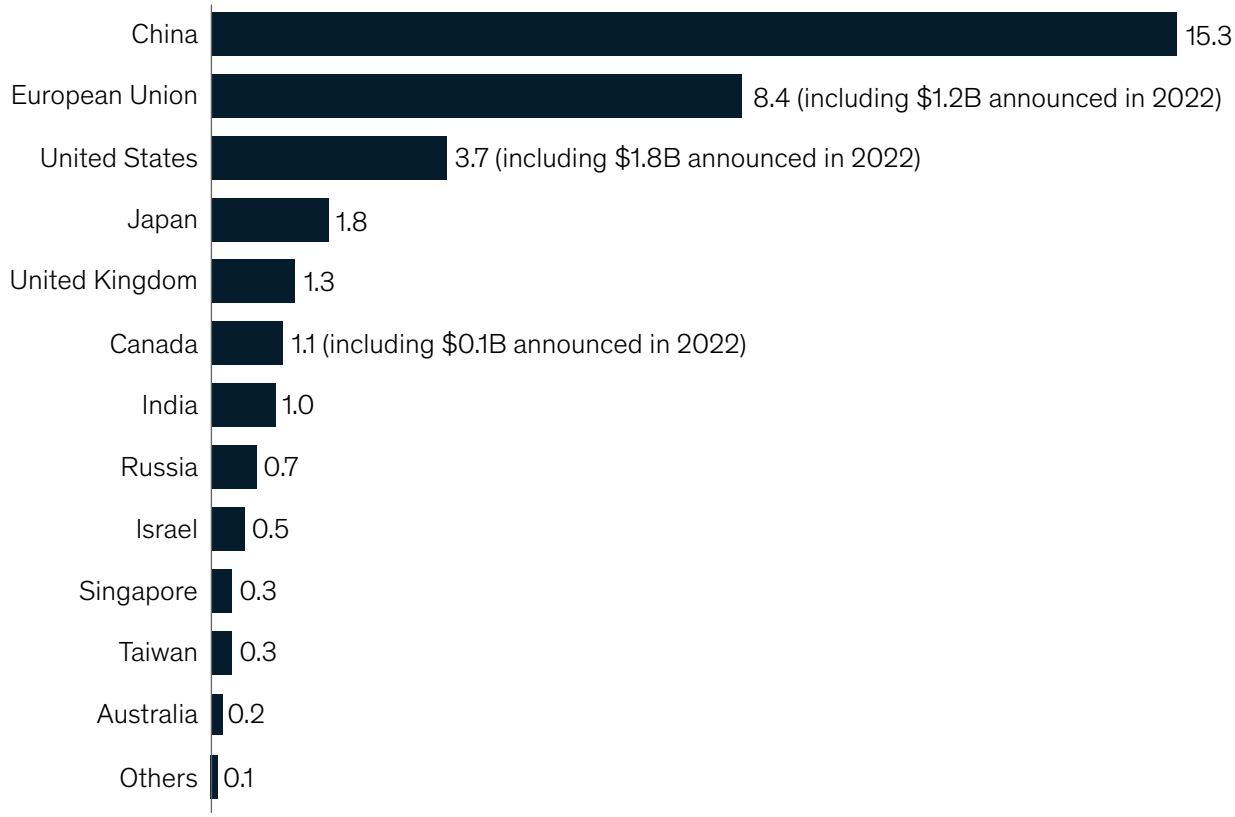


[1] Figures may not sum to 100%, because of rounding.

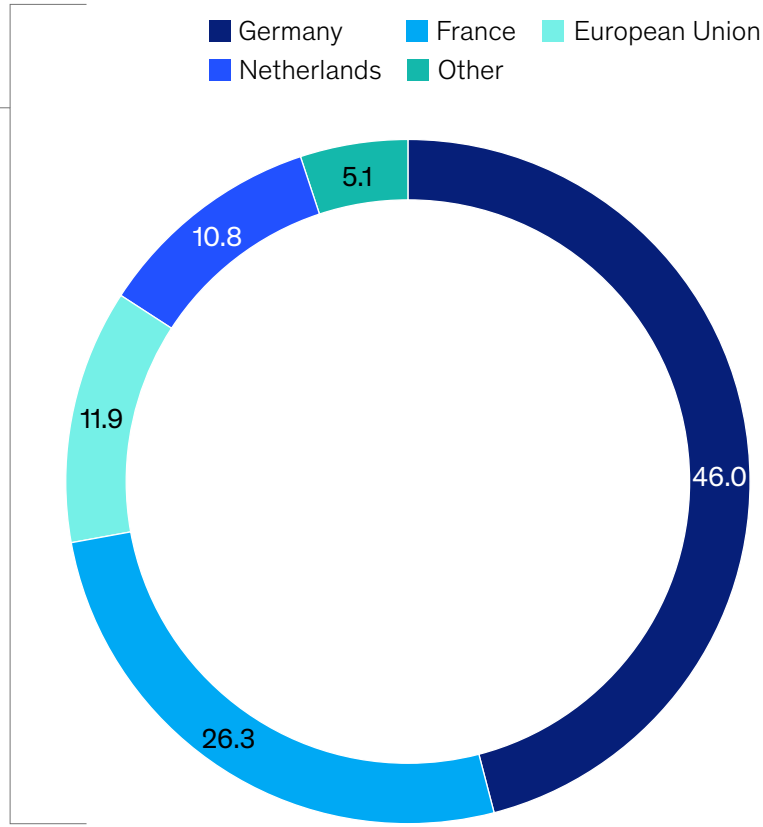
Source: PitchBook

The United States and European Union announced additional public funding for QT in 2022; however, China has announced the most public investment to date.

Announced governmental investment,[1] $ billion



EU public investment sources, %



[1] Total historic announced investment; timelines for investment of investment vary per country.

Source: Johnny Kung and Muriam Fancy, *A quantum revolution: Report on global policies for quantum technology*, CIFAR, April 2021 ; press search

In China, government investment is helping drive quantum technology research and education.

~$15 billion
for QT as part of China's 14th five-year plan (2021–25)[1]

~52%
of all QT-related patents have been granted to Chinese researchers

33
companies active in QT

~$479 million
of private investments into Chinese QT start-ups

12
dedicated QT research institutions

News

- **2019:** China announced an education modernization plan that assumes 4 percent of GDP spend on education and differentiates quantum technology as one of four main areas of focus
- **2021:** Quantum information science was announced as a new major in the catalog of undergraduate majors in general colleges and universities
- **2021:** University of Science and Technology of China (USTC) was authorized to award doctorates in quantum science and technology, making it the country's first doctoral program in QT
- **2021:** In January, Chinese scientists set up an integrated quantum network that combines 700 fiber and two ground-to-satellite links and realized quantum key distribution between more than 150 users over a combined distance of 4,600 kilometers
- **2022:** A Chinese team announced it cracked 48-bit RSA using a 10-qubit quantum computer-based hybrid system, and could potentially do the same for 2048-bits
- **2023:** China has become the third country (besides the United States and Canada) with the ability to deliver a quantum computer for commercial use, which was developed by a Chinese enterprise

[1]Other sources put this figure at closer to ~$25 billion, but we based our estimate only on data produced with transparent methodology. China's five-year plans detail the country's economic development goals.

Source: IT橘子(ITOrange)

In Japan, private investment in QT remains low, though public investment is stimulating quantum efforts.

~$1.8 billion
of public investment

~14%
of all QT-related patents have been granted to Japanese researchers

17
companies active in QT

~$58 million
of private investment into Japanese QT start-ups

7
dedicated QT research institutions

News

- **2018:** Japan's Ministry of Education initiated MEXT Q-LEAP, a Quantum Leap Flagship Program with the goal of advancing QT across four areas: QC, QS, next-gen lasers, and quantum human resources
- **2019:** Japan started the Moonshot Project, with the goal of creating a fault-tolerant universal quantum computer by 2050
- **2021:** The Integrated Innovation Strategy Promotion Council, formulated by the Japanese government, proposed the creation of a Quantum Technology International Collaboration Hub at the Okinawa Institute of Science and Technology (OIST)
- **2022:** The government of Japan formulated the Vision of Quantum Future Society, with goals of ten million quantum users by 2030, subsidizing quantum technology start-ups, and establishing ecosystem-supporting public-private collaborations
- **2022:** Fujitsu and RIKEN Research Institute planned to jointly offer quantum computers to enterprise clients starting in April 2023

Source: IT橘子(ITOrange)

Quantum computing

The United States and Canada still have the most vibrant QC start-up communities.

Number of QC start-ups, by country, 2022

+ change since 2021

		Start-ups	Incumbent companies	Public/government organizations	Academic groups
Top 7	United States	72 +12	9	18	67 +3
	Canada	28 +2	0	2	9
	United Kingdom	22 +3	1	2	14
	Japan	14 +1	1	0	7
	France	11 +3	1	3	9
	Germany	11 +4	2	1	7
	China[1]	9 +1	2	12	11
Rest of world		84 +10	1	19	55 +1
Total		**248 +36**	**17**	**57**	**180 +4**

[1] There is limited transparency on commercial activity in China and to a lesser extent for Japan. We think Chinese activity in QTs is primarily through government-funded research institutions.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

QC start-ups continue to emerge across the globe, with the European Union and Canada launching the most.

Number of QC start-ups, by country, 2022

+ change since 2021

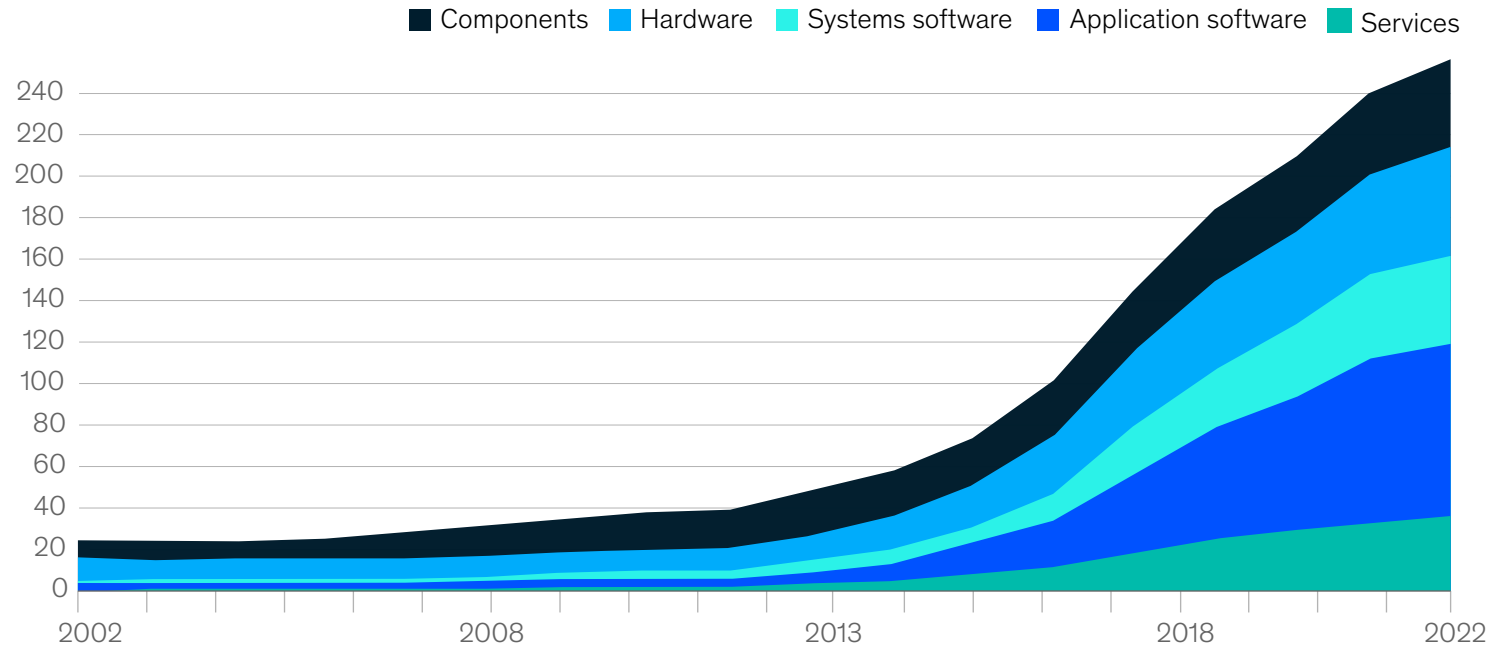
Country	2022	Country	2022	Country	2022
United States	72 +12	Switzerland	5	Bulgaria	1
Canada	28 +2	Sweden	3 +1	Liechtenstein	1
United Kingdom	22 +3	Denmark	3 +1	Philippines	1
Japan	14 +1	Colombia	2	Norway	1
Germany	12 +4	Poland	2	Portugal	1
France	11 +3	Singapore	2	Romania	1
China[1]	9 +1	Austria	2	Russia	1
Australia	8 +1	United Arab Emirates	2	Taiwan	1
Spain	8 +1	Italy	2 +1	Turkey	1
Netherlands	7 +1	Czech Republic	1	Uruguay	1
Finland	6	Estonia	1	Ireland	1
India	6 +1	Greece	1	South Korea	1 +1
Israel	6 +2	Hong Kong	1	**Total**	**248 +36**

[1] There is limited transparency on commercial activity in China and to a lesser extent for Japan. We think Chinese activity in QT is primarily through government-funded research institutions.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Across the globe, the rate of publicly announced QC start-up creation has slowed over the past four years.

Number of QC start-ups founded (cumulative)



Number of QC companies founded in each year

2018	2019	2020	2021	2022
3	5	2	3	3
8	7	2	4	5
11	4	7	6	2
16	16	10	17	4
6	7	5	4	3
Total: 44	**39** (–11%)	**26** (–33%)	**34** (+31%)	**17** (–50%)

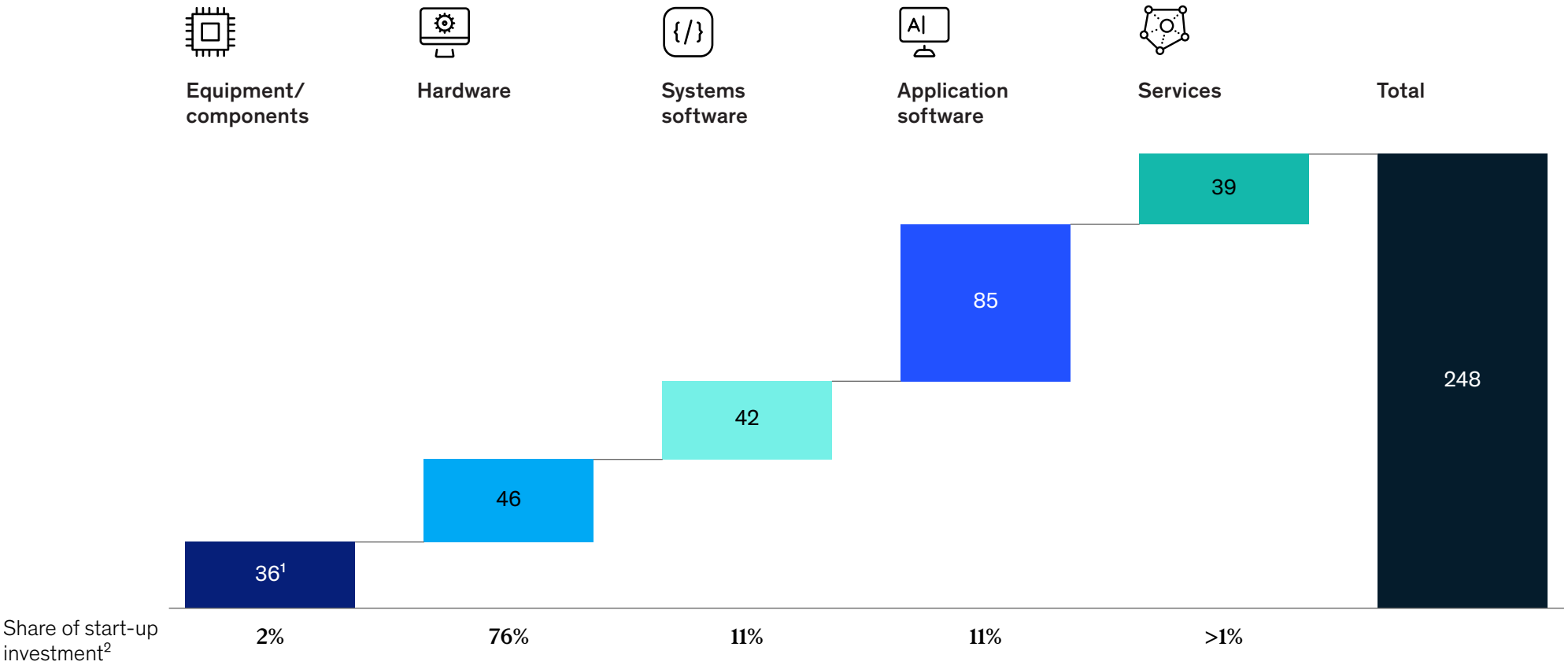
Potential hypotheses on the causes of the slowdown:

- **Lack of talent:** Most experienced specialists (generally academics whose research focus is QC) already work in a start-up.
- **Few working use cases:** Application start-up creation is hindered by limited working use cases and existing hardware patents.
- **Investor trends:** Investors prefer to invest in scale-ups and later-stage start-ups, limiting capital available for new companies.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Among QC value-chain start-ups, hardware manufacturers continue to see the most investment.

Number of QC start-ups, by value-chain segment



[1] There are more than 100 total suppliers; however, only 36 are start-ups specific to quantum computing.
[2] Based on public investments in start-ups recorded on PitchBook and announced in the press; includes announced deals for 2022; excludes investments in internal QT departments or projects by incumbents; actual investment is likely higher. Figures do not sum to 100%, because of rounding.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

The QC equipment and components segment of the value chain is the most mature, with room for specialized players.

MATURE MARKET

Equipment/components

DEVELOPING MARKETS

Hardware

Systems software

Application software

Services

- The components segment is the only segment of the QC value chain that is generating significant revenue through sales to universities, research institutes, and technology companies.
- Players range from specialized QC players to general technology manufacturers (eg, electronics), scattered across a range of technologies.
- Product maturity varies per component, yet nearly all components still require customization by quantum players.
- Technology improvement is needed across component types to enable scaling to fault-tolerant QC. This leaves room for specialized players to enter the market.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

QC hardware is dominated by big tech players and a few scale-ups.

MATURE MARKET

DEVELOPING MARKETS

Equipment/components

Hardware

Systems software

Application software

Services

There are currently five major hardware being developed: photonic networks, superconducting circuits, spin qubits, neutral atoms, and trapped ions.[1]

— Due to the complexity of the technology, the hardware segment has high risk and long development times. As a result, players require significant capital and highly specialized knowledge. The hardware segment today is dominated by technology giants, most of which entered the market a decade ago and focus on superconducting qubits.

— In the past three years, start-up companies in ion traps, neutral atoms, and photonic qubits have raised significant investment and are scaling up, eg, IonQ, PASQAL, PsiQuantum, etc.

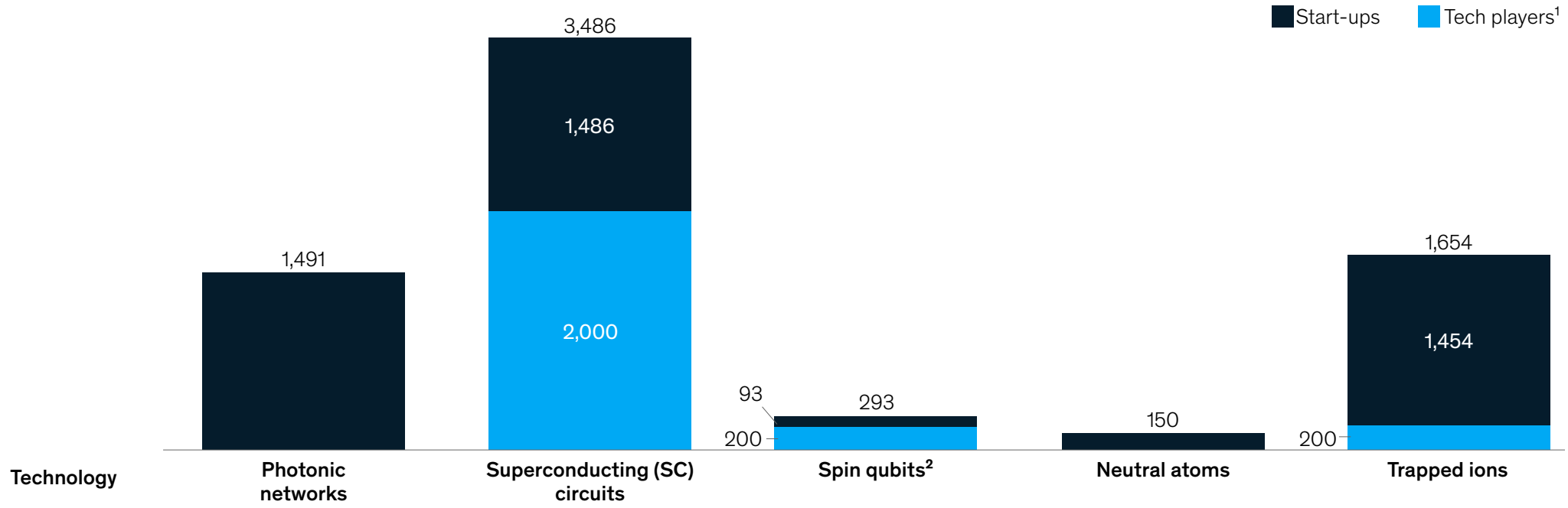
— Based on public announcements, superconducting qubits are the most developed, yet some experts believe photonic qubits are technologically ahead.

[1] Additional technologies in the exploratory phase are likely to join these five, including, for example, Majorana fermions.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

In hardware, tech incumbents invest most in superconducting circuits, while start-ups invest more in ions and photonic networks.

Investment, $ million



[1]Assumptions: $500 million per major player (Google, IBM, Alibaba, AWS), $200 million per medium player (Honeywell before merger with CQC into Quantinuum, Intel).
[2]We examine electron spins in silicon quantum dots, as other spin qubits are generally not considered for applications in quantum computing, eg, NV centers in diamond are unlikely to be a good qubit for computing; however, they can serve as quantum sensors.

Source: Crunchbase; Capital IQ; Pitchbook; Quantum Computing report; expert interviews

The systems software market is split between full-stack and dedicated software players; most products are in the prototype phase.

MATURE MARKET | DEVELOPING MARKETS

Equipment/components | Hardware | **Systems software** | Application software | Services

- Systems software players offer logical programming languages for quantum computers as well as compilers and error-correction software. Some systems software players offer dedicated control software for quantum hardware.
- The systems software market is divided between leading full-stack players, who offer programming languages for their own hardware, and dedicated software players offering hardware-agnostic solutions.
- Leading systems software solutions are available in prototype form, mostly open source. Existing solutions are suitable for the small-scale quantum hardware available today and require further development to support large-scale, fault-tolerant quantum computers.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

The application software segment is not yet fully mature and is far from saturated.

MATURE MARKET

DEVELOPING MARKETS

Equipment/components

Hardware

Systems software

Application software

Services

- The application software market has emerged in the past few years. Key players are hardware and systems software players offering full-stack solutions. They operate across all industries, or focus on finance, pharmaceuticals, and chemicals. Off-the-shelf products do not yet exist; most business models are still based on exploratory research projects in collaboration with industry.
- The development of end-to-end quantum solutions for business problems still takes years; due to the wide range of potential quantum applications in various industries, the application software market is far from saturated.
- Some players in this segment have chosen to focus on developing quantum-inspired algorithms—algorithms that are run on classical hardware but incorporate principles and ideas from quantum computing. These algorithms have shown great promise and could be an avenue to realize value without a fault-tolerant computer.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

The services segment is split between consulting, education, and cloud services.

MATURE MARKET

DEVELOPING MARKETS

Equipment/components

Hardware

Systems software

Application software

Services

— The cloud services market is in an early stage of development. Players offer public access and premium computing time on existing hardware for education and experimentation. Cloud players are split between upward integrating hardware players and dedicated cloud players offering access to third-party hardware. Significant growth of this segment is expected once quantum hardware matures.

— Consulting services and joint research projects are a key source of income for hardware and software players. In addition, there are few dedicated consulting players as well as players offering QC education and media.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Quantum computing

Industry adoption

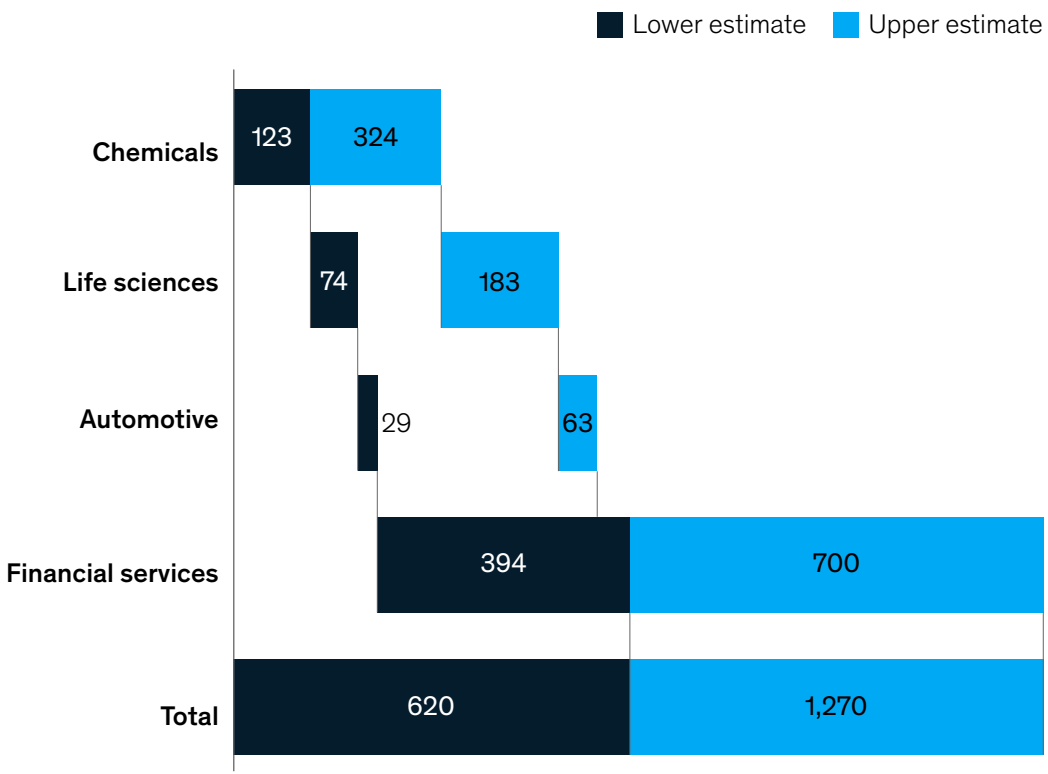
The estimated value at stake for QC in the four industries most likely to see impact first has now reached nearly $1.3 trillion.

Economic value + Incremental ++ Significant +++ Disruptive

Industry	Key segment for QC	2025–30	2030–35
Global energy and materials	Oil and gas	+	++
	Sustainable energy	+	+++
	Chemicals	++	+++
Life sciences	Pharmaceuticals	++	+++
Advanced industries	Automotive	++	++
	Aerospace and defense	+	++
	Advanced electronics	+	++
	Semiconductors	+	++
Finance	Financial services	++	+++
Telecom, media, and technology	Telecom	+	++
	Media	+	+
Travel, transport, and logistics	Logistics	+	++
Insurance	Insurance	+	+

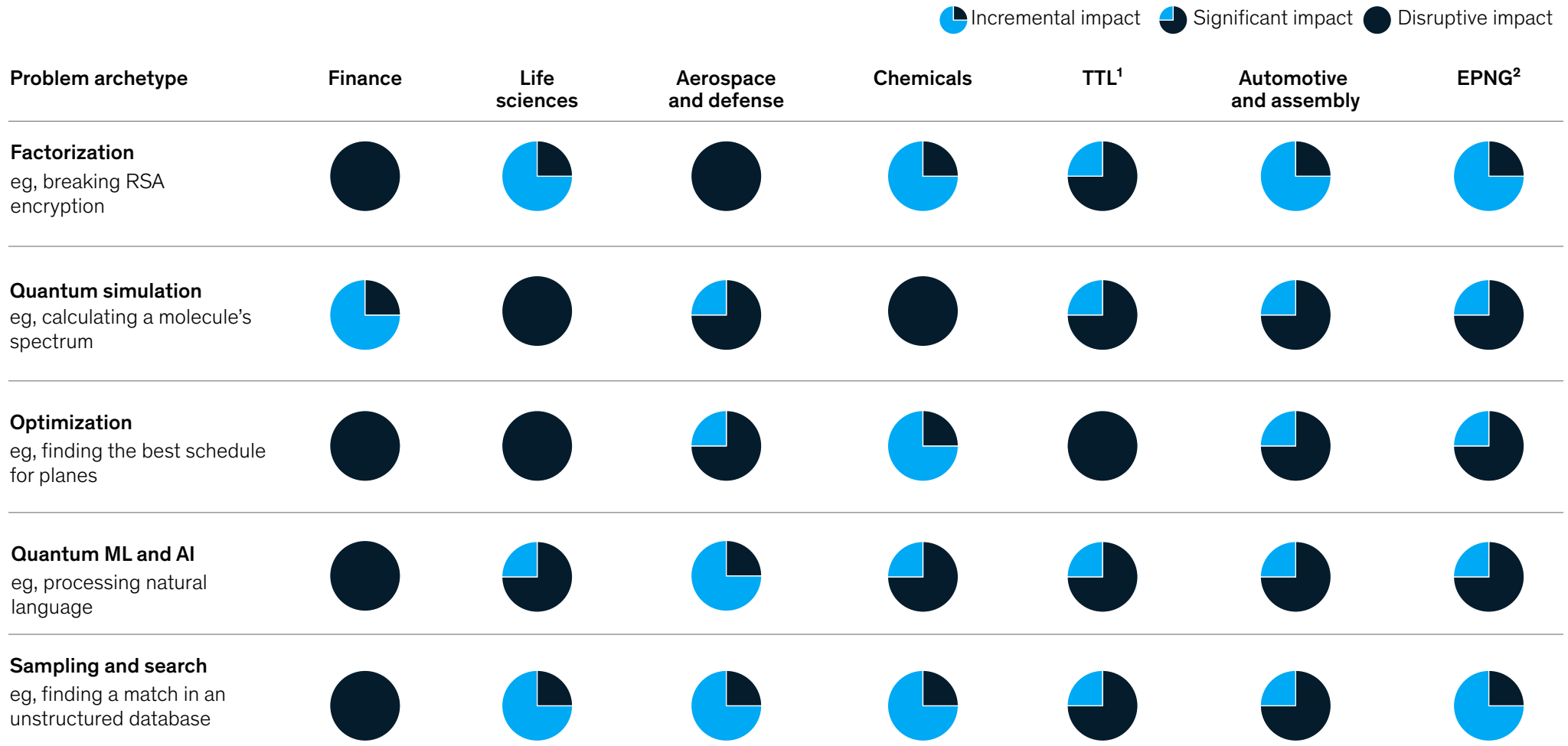
Four industries expected to see first impact

Value at stake with incremental impact of QC by 2035, $ billion



Source: "Quantum computing use cases are getting real—what you need to know," McKinsey, December 14, 2021; expert interviews

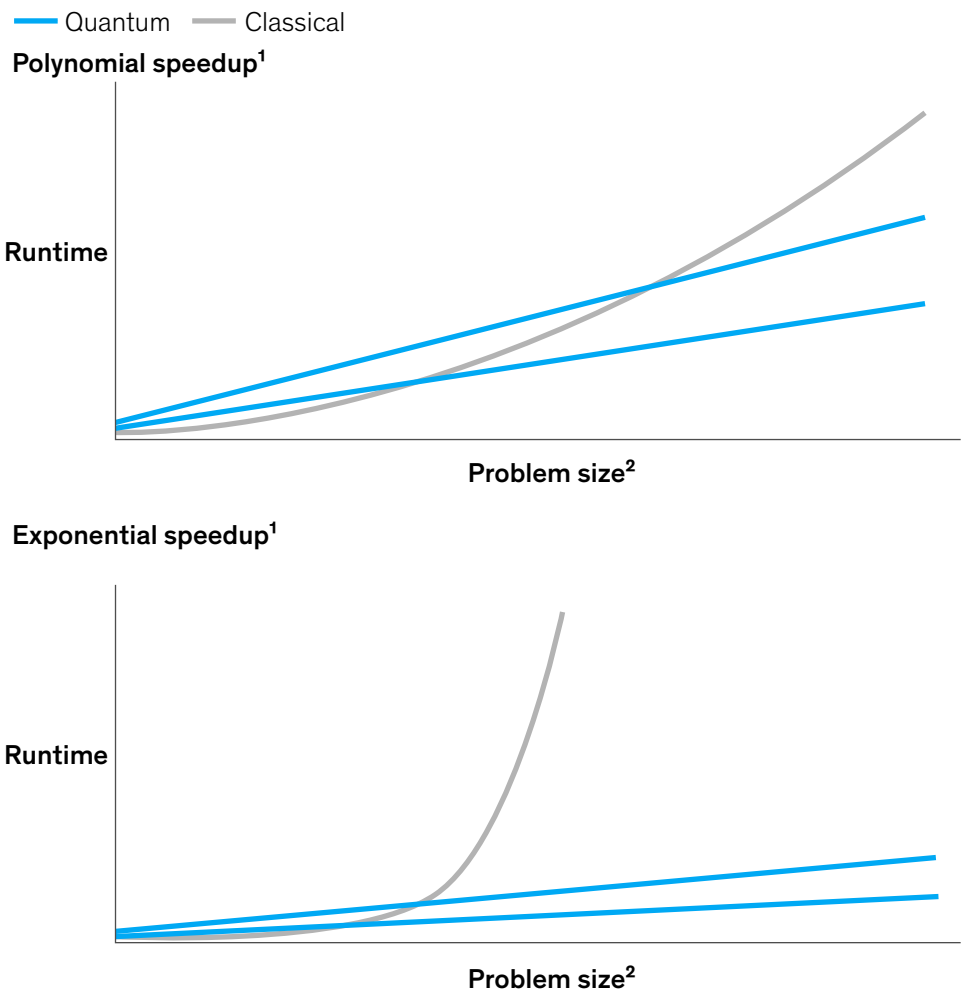
The use cases most likely to have the highest value over the long term are in the finance and life sciences sectors.



[1] Travel, transport, and logistics.
[2] Electric power and natural gas.

Source: Expert interviews

Economic value is unlocked through speedup, which depends on algorithm complexity, execution time, and problem size.



Algorithm complexity

The different natures of classical and quantum algorithms lead to inherent computation advantages in different problems. For certain problems, quantum algorithms can be polynomially or exponentially less complex than the classical algorithm.

Execution time

The total computation time is highly dependent on the different hardware (eg, gate speed, readout cleaning) and architecture (eg, data loading) used in high-performance computing (HPC) and QC; therefore it is different from algorithm complexity.

Problem size

The practicality of the quantum algorithm is also dependent on the problem size. If a problem is too small, then the speedup is not significant enough to be adopted; if a problem is too big, even with the speedup, it can still be too big to solve practically.

[1] Two quantum algorithms are considered with slightly different speedups for illustrative purposes. "Speedup" is how much faster quantum computing solves a problem as compared to classical computing.
[2] Problem in consideration is generic and imaginary for illustrative purposes.

Source: Expert interviews

Before a fault-tolerant quantum computer is available, QC will likely provide speedup for three of the four types of problems for which it has demonstrated advantage.

Simulation problems

Compared to classical computations, QC is expected to enable precise simulation molecules (eg, electronic structure or molecular dynamics).

Optimization problems

Optimization algorithms aim to minimize the cost function based on multiple parameters. Classical algorithms are advantageous in sectioning the bigger problems into digestible smaller problems which quantum algorithms can calculate faster.

Hybrid ML/AI problems

Quantum algorithms can reduce the training time for ML/AI models, especially in the most computationally intensive layers by providing at least polynomial speed up in learning certain data classes.

Cryptography problems

Quantum algorithms can pose danger to services including online/mobile communication and bank transfer by breaking current classical encryption protocols. Quantum technology can provide new encryption protocols with enhanced security.

In the near term, leveraging a hybrid operating system to distribute a complex problem between HPC and QC can bring a bigger computational advantage than either system alone

Source: Partnership for Advanced Computing in Europe, National Renewable Energy Laboratory

Hybrid or heuristic alternations offer options for exploring the full potential of NISQ and early fault-tolerant devices.

We cannot fully capture value today…

Fault-tolerant (FT) algorithms cannot be performed on noisy intermediate-scale quantum (NISQ) or early FT devices at scale to demonstrate quantum advantages, due to hardware limits, such as circuit volume, execution time, and noise level

…but hybrid or heuristic algorithms could harness some value

	Description	Pros	Cons
Heuristics algorithms	Use digital simulation such as variational quantum algorithms (VQA) or analogue simulation including annealing to replace FT subroutine such as quantum phase estimation (QPE) on NISQ devices	Protect the quantum-ness of the algorithm to potentially realize advantage Explore and leverage the structure of different hardware technologies to prepare for FT	Speedup of heuristic algorithms is not clear and problem dependent Dependent on NISQ development Digital simulation relies heavily on two-qubit gate, which is limited by coherence time on NISQ devices
Hybrid algorithms	Using classical computers to simulate quantum processes based on the system (Hamiltonian) to replace FT routine such as QPE on NISQ devices, such as maximum-likelihood quantum amplitude estimation (MLQAE)	Clarity on speedup compared with heuristic algorithms Less dependent on quantum hardware	Less clear/lack of general classical approach to replace FT algorithms; early stage and problem dependent

Source: Jean-Charles Cabelguen,"Why analog neutral atoms quantum computing is the most promising direction for early quantum advantage," Pasqal, July 6, 2022; Adam Callison and Dan E. Browne, "Improved maximum-likelihood quantum amplitude estimation," arXiv, September 7, 2022

NISQ-era experimentation helps advance development of FTQC hardware; algorithmic learning is less transferable.

	Noisy intermediate-scale quantum (NISQ)	Fault-tolerant quantum computation (FTQC)
Description	NISQ refers to roughly 50 to a few hundred qubit quantum computers able to perform tasks surpassing classical computers but noise in the quantum gates limits the size of the circuits on which algorithms can be executed with reliability. Industrial advantage expected at 200–1,000 qubits.	FTQC refers to universal general-purpose quantum computers with physical error rates below a certain threshold, so algorithms run accurately and execute scale efficiently in the presence of faults during the computation.
Characteristics of algorithms	• Lack of performance guarantees, slower • Robust to error • Short circuit depth • Often use heuristic and classical computation required as aid	• Low error tolerance • Higher accuracy • Extensive quantum volume required • Short execution time required
Algorithms	VQE, QAOA, variational QML	Shor's, Grover's, quantum counting, QITE, QPE

The future is FTQC: the development of fault-tolerant hardware is aided by certain NISQ-era innovations; algorithmic learning carries over less easily due to fundamental differences in applicable algorithms and compilers between the two forms of QC.

Quantum communications

QComms start-ups continue to be created, though at a rate slower than QC start-ups.

Number of QComms start-ups by country

+ change since 2021

Country	2022	
United States	20	+1
China[1]	16	
United Kingdom	14	
Canada	9	+1
France	4	
Germany	3	
Netherlands	3	
Switzerland	3	
Singapore	3	
Spain	3	+1
Japan	2	
Poland	2	

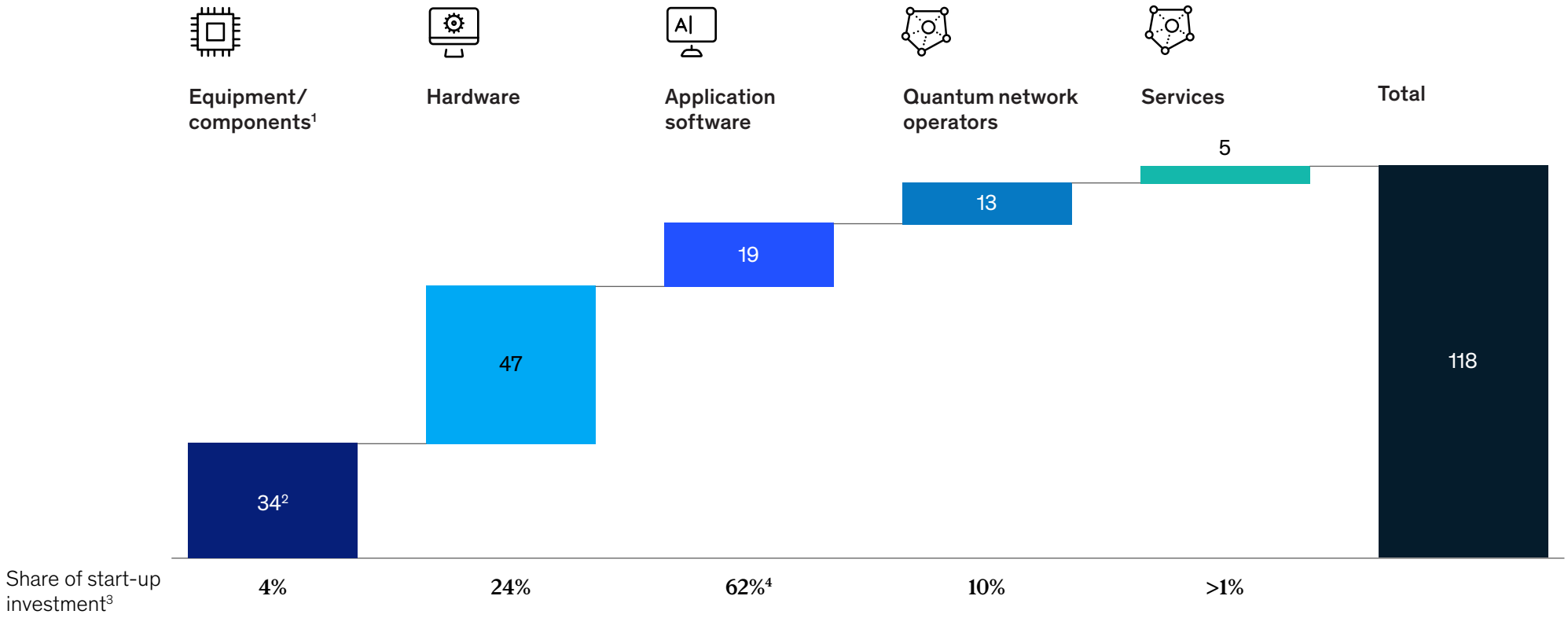
Country	2022	
Australia	2	
India	2	
Russia	2	+1
Colombia	1	
Finland	1	
Israel	1	
Bulgaria	1	
South Korea	1	
Scotland	1	
Liechtenstein	1	+1
Total	**95**	**+5**

[1] There is limited transparency on commercial activity in China and to a lesser extent for Japan. We think Chinese activity in QTs is primarily through government-funded research institutions.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

QComms application software start-ups garner the most investment but make up only 16 percent of players.

Number of QComms players by value-chain segment[1]



[1]Includes start-ups and incumbents that develop or offer QT products; see methodology pages for details.
[2]There are more than 100 total suppliers; however, only 34 are start-ups specific to quantum communications.
[3]Based on public investments in start-ups recorded on PitchBook and announced in the press; excludes investments in internal QT departments or projects by incumbents. Actual investment is likely higher. Figures do not sum to 100%, because of rounding.
[4]Application software investment is driven by large deal ($400 million) for Arqit (United Kingdom) to develop quantum satellite communication.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Equipment and components are the mature aspects of the QComms value chain.

Overview of QComms players

MATURE MARKET

Equipment/components

The equipment/components segment is split between general component suppliers and specialized QComms players.

DEVELOPING MARKETS

Hardware

Big global players have entered the hardware segment of the QComms market, yet medium-sized start-ups are technologically more advanced. Partnerships are formed to bridge the gap.

Systems software

The application software market is relatively immature. Various start-ups are scaling up.

Application software

Various telecommunications providers have started to invest in quantum communications; these are likely to fulfill the role of quantum network operators in the future.

Services

Few consulting services players of low maturity have entered the market; their focus is primarily on security, or QT in general.

The **core parts** of the quantum communications ecosystem **(hardware and software)** do not have commercial products yet. Revenue is generated mainly through component players, consulting services, and joint research projects.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Quantum sensing

Two new players have emerged in the QS ecosystem.

Number of QS start-ups by country

+ change since 2021

Country	2022	
United States	14	+1
Switzerland	5	
Germany	5	+1
France	4	
United Kingdom	4	
China[1]	3	
Netherlands	2	
Denmark	2	
Australia	1	
Canada	1	
Finland	1	
Japan	1	

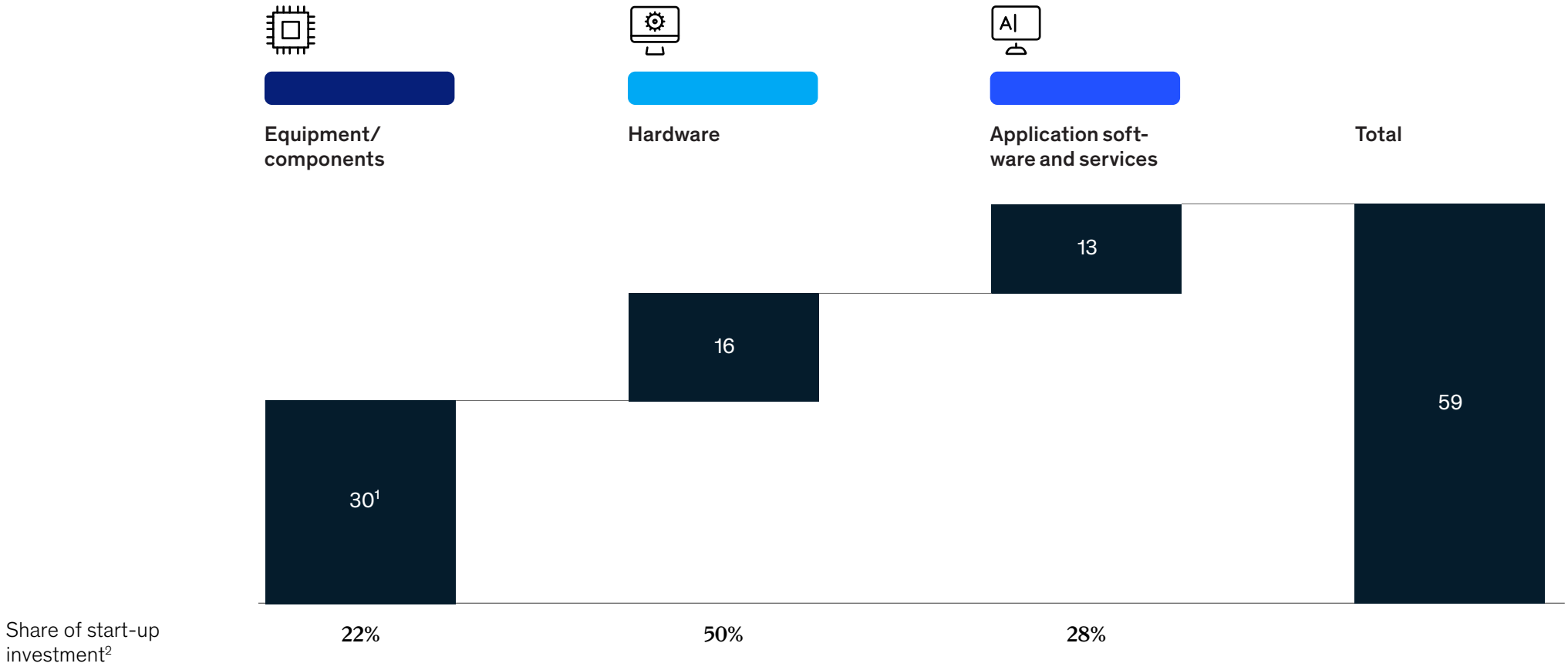
Country	2022	
Singapore	1	
Sweden	1	
Turkey	1	
Total	**46**	**+2**

[1] There is limited transparency on commercial activity in China and to a lesser extent for Japan. We think Chinese activity in QTs is primarily through government-funded research institutions.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

In QS, half of the players are in components; however, more investment has flowed to hardware manufacturers.

Number of QS players by value-chain segment



[1] There are more than 100 total suppliers; however, only 30 are start-ups specific to quantum sensing.
[2] Based on public investments in start-ups recorded on PitchBook and announced in the press. excludes investments in internal QT departments or projects by incumbents; actual investment is likely higher.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Equipment and components are the most mature aspect of the QS value chain.

MATURE MARKET

Equipment/components

The components segment of the QS market is most mature; manufacturers sell commercial products, but push-button solutions do not yet exist.

DEVELOPING MARKETS

Hardware

Hardware products are mostly at the level of prototypes. They require optimization in price, size, and weight to become competitive beyond niche markets. Large incumbents are partnering with smaller players to drive industrialization in QS.

Application software and services

The application software and services segment has few players; it is expected to grow as hardware matures.

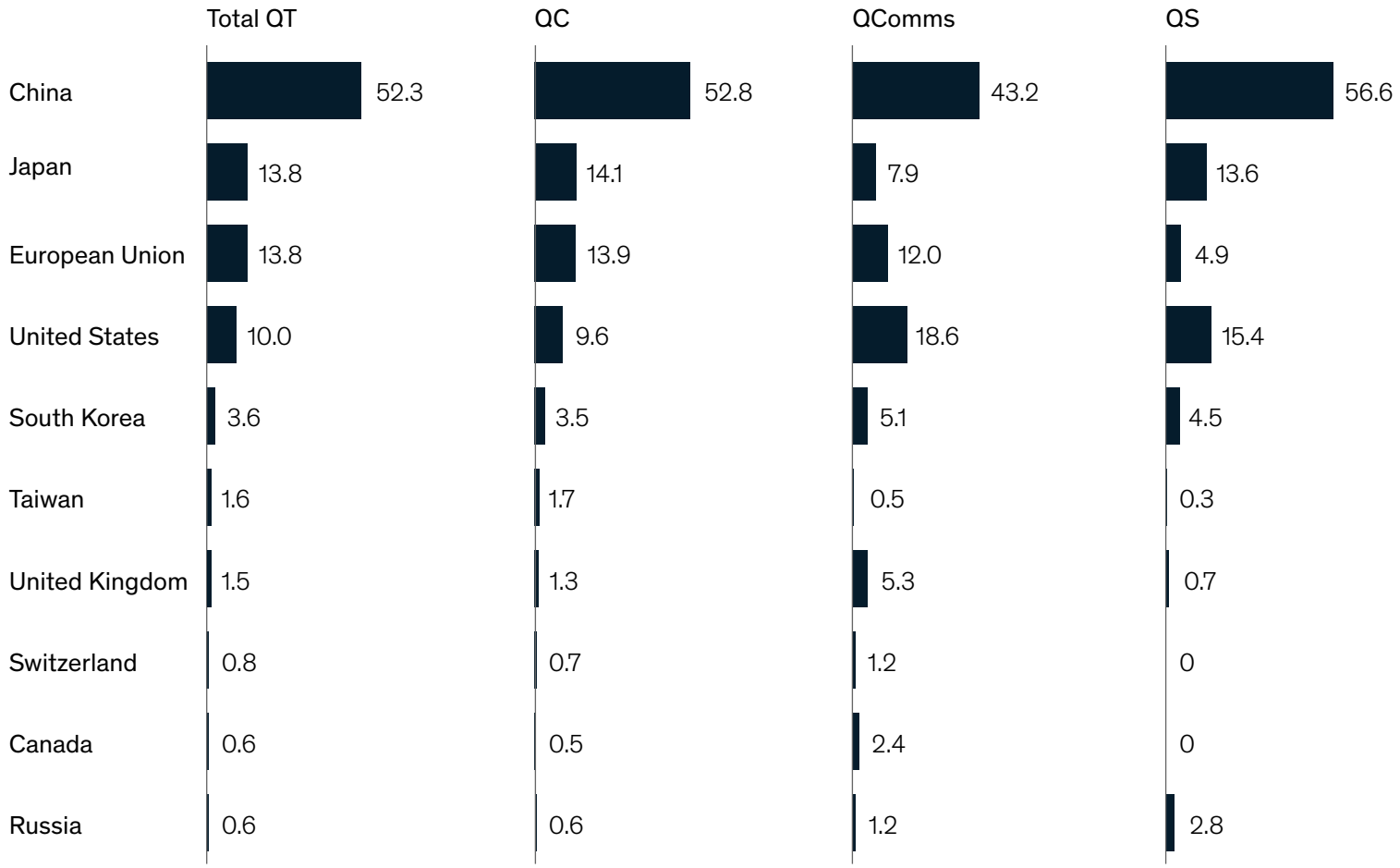
The **core parts** of the quantum sensing ecosystem **(hardware and software)** do not have commercial products yet. Revenue is generated mainly through component players, consulting services, and joint research projects.

Source: CapitalIQ; Crunchbase; PitchBook; Quantum Computing Report; expert interviews

Global technology progress

Over half of QT patents have been granted to Chinese companies.

Share of quantum patents by company's HQ country, 2000–22,[1] %



Takeaways:

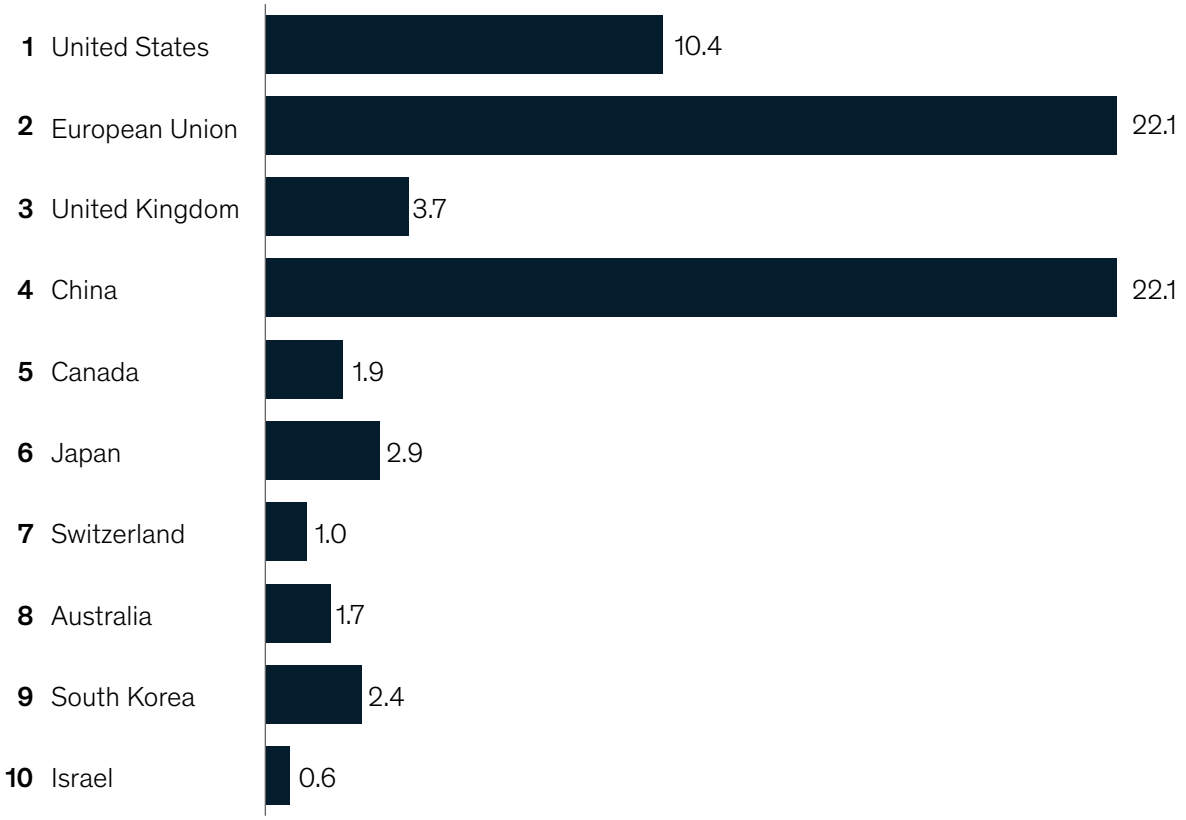
- China has increased its share of patents in recent years, across all technologies; Chinese government policies are a strong factor.
- Japan has been among the top 3 in QT patent development since the early 2000s, indicating a high degree of QT industry adoption and government influence.

[1]Only 50% of headquarters for patent applications are disclosed. Figures may not sum to 100%, because of rounding.

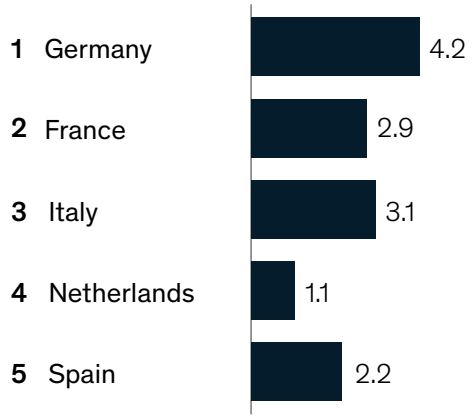
Source: Innography; expert interviews

While the European Union and China publish the most on QT, US publications are considered the most impactful, as measured by the h-index.

Top 10 countries worldwide 2021, sorted by h-index rank
Share of articles and country's h-index in quantum-relevant publications,[1] 2021, %



Top 5 EU countries, sorted by h-index rank
Share of articles and h-index, 2021, %



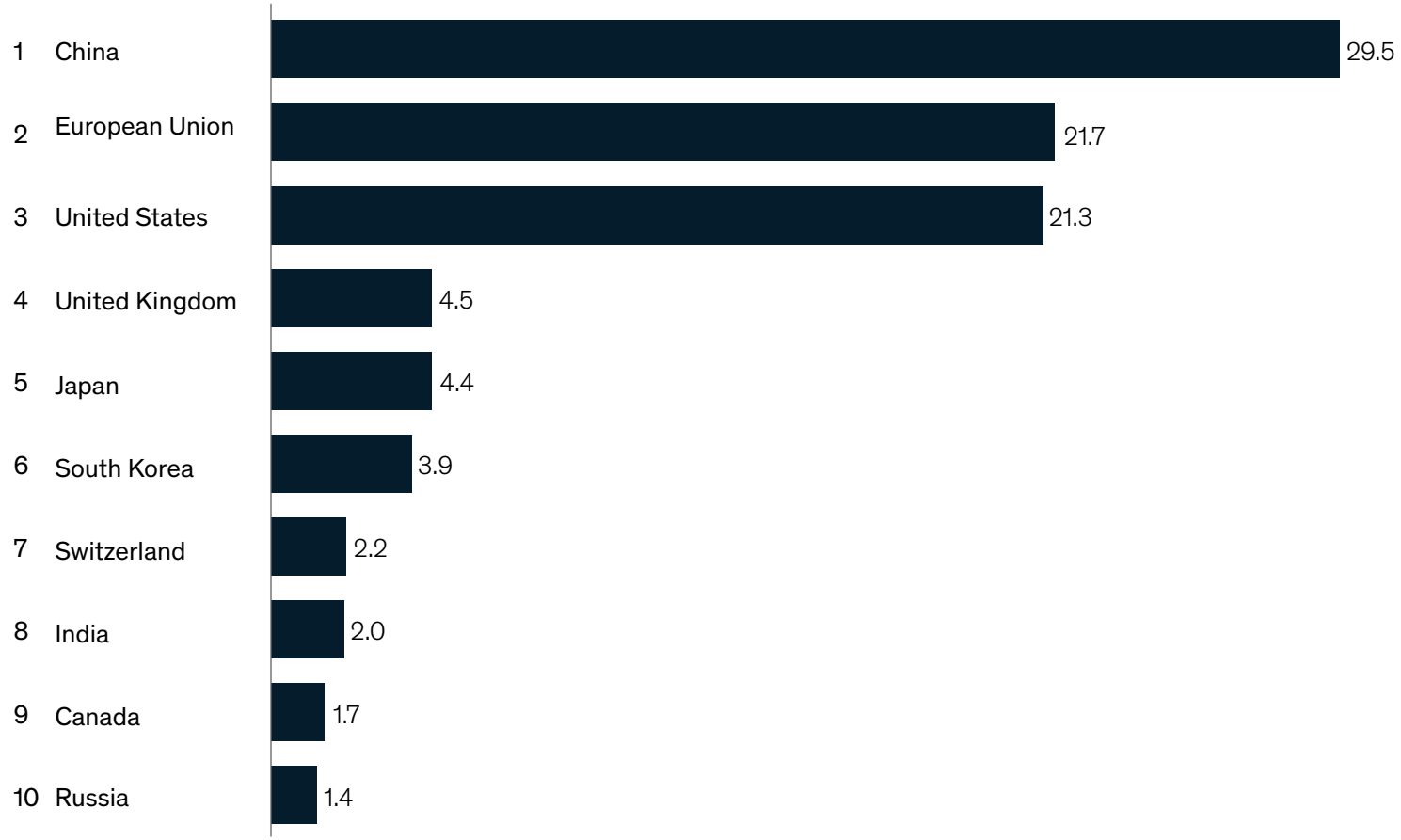
[1] The h-index is the number of articles (h) in a country that have been cited at least h times; quantum-relevant publications = publications in computer science, mathematics, and physics.

Source: SCImago Journal & Country Rank

Scientists from Chinese research institutions contribute most often to quantum-relevant publications.

Top 10 countries worldwide 2022, by share in scientific publications

Share of authors from country's research institutions contributing to quantum-relevant publications,[1] %

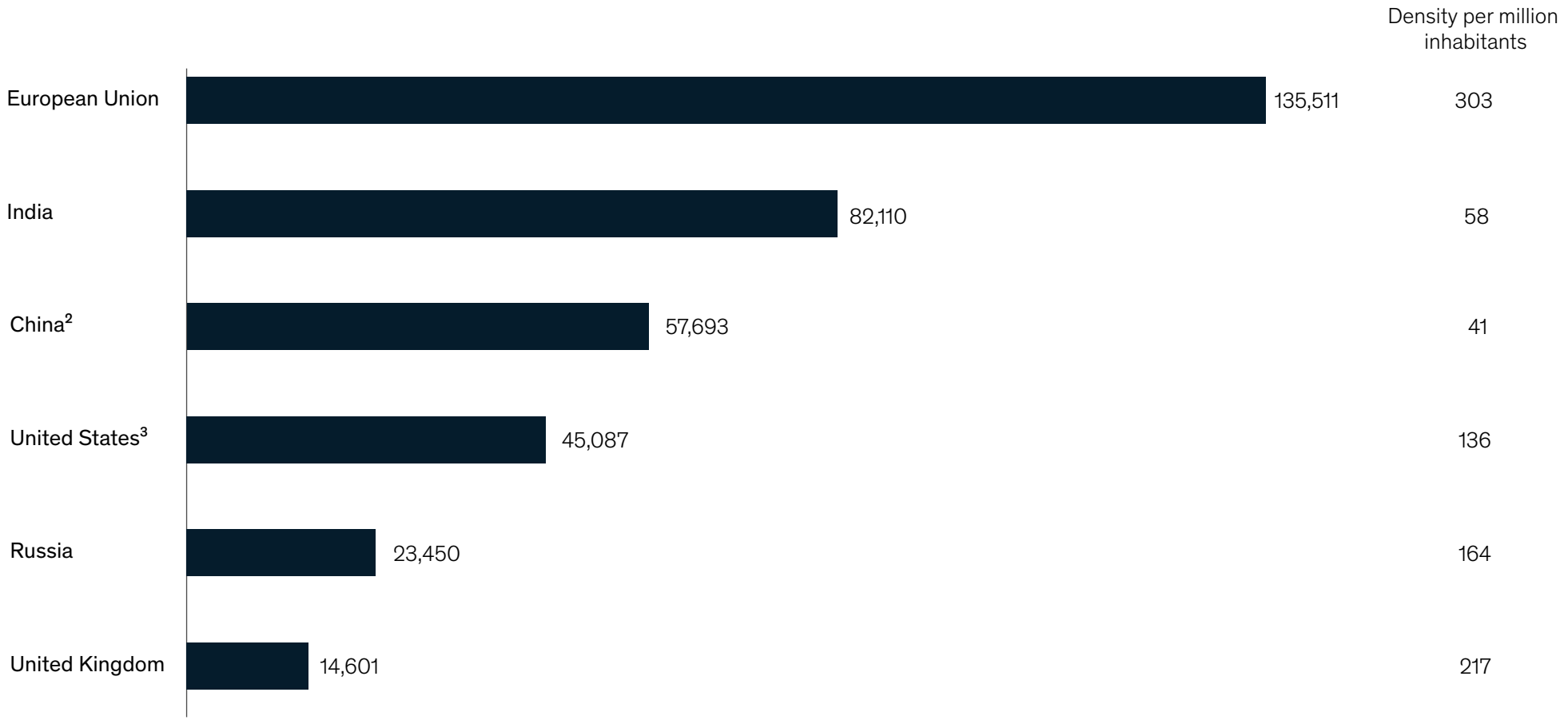


[1] Includes publications from October 1, 2021, to September 30, 2022. Quantum-relevant publications defined as publications in physical sciences.

Source: Nature Index

The European Union has the highest number and concentration of QT talent.

Absolute number of graduates in QT-relevant fields,[1] 2020

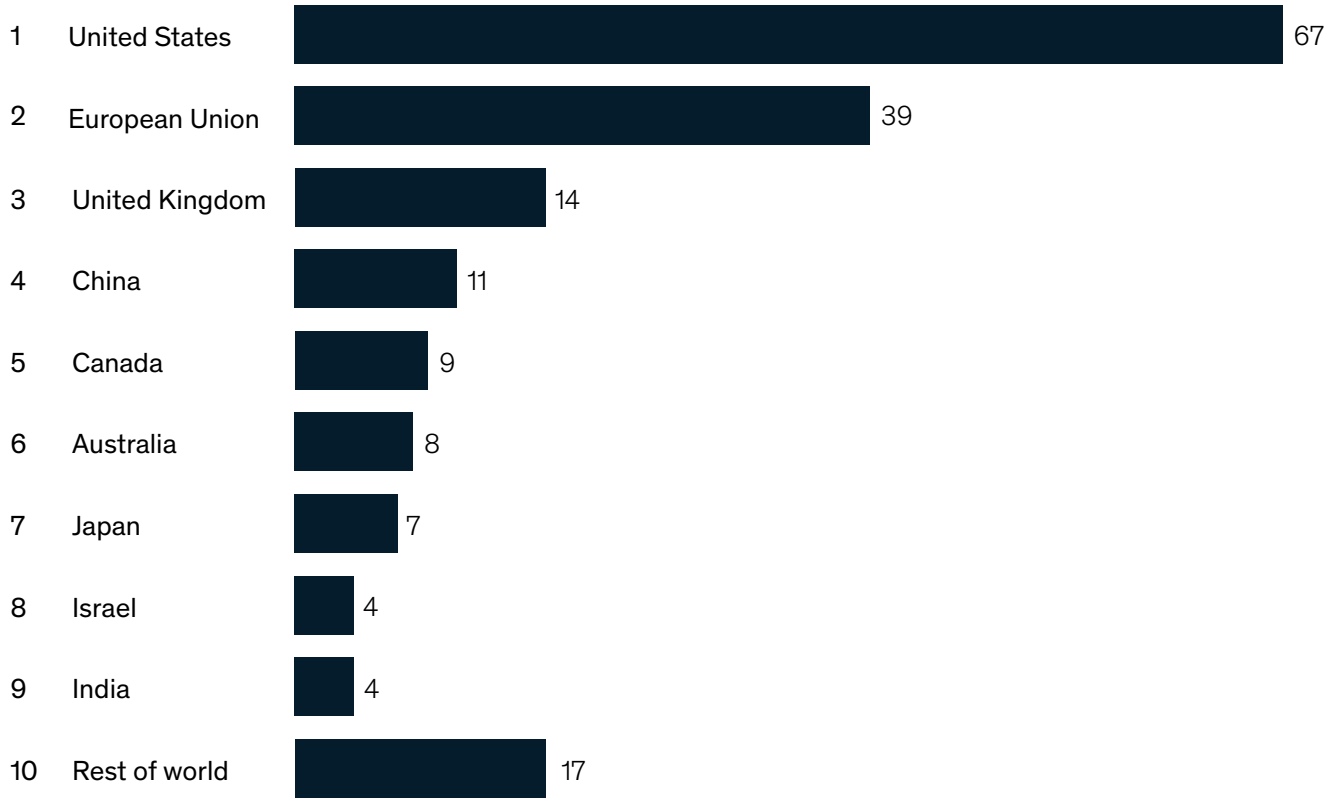


[1] Graduates of master's level or equivalent in 2019 in biochemistry, chemistry, electronics and chemical engineering, information and communications technology, mathematics and statistics, and physics.
[2] High-level estimates.
[3] The actual talent pool for the United States may be larger, as bachelor's programs are longer and master's programs are less common.

Source: National government websites; OECD

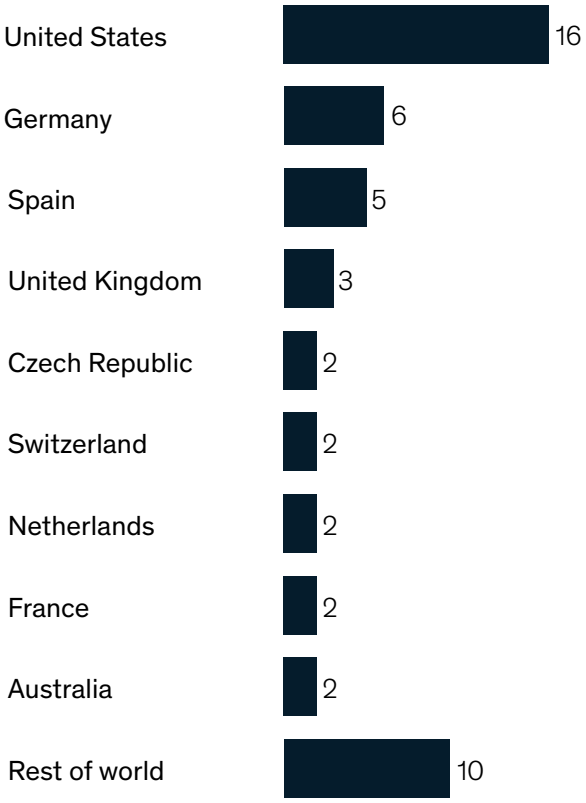
The number of universities offering QT master's degrees has increased to 50, a 74 percent increase since 2021.

Top countries for universities with QT research programs, 2022, number of universities per country



Total: 180

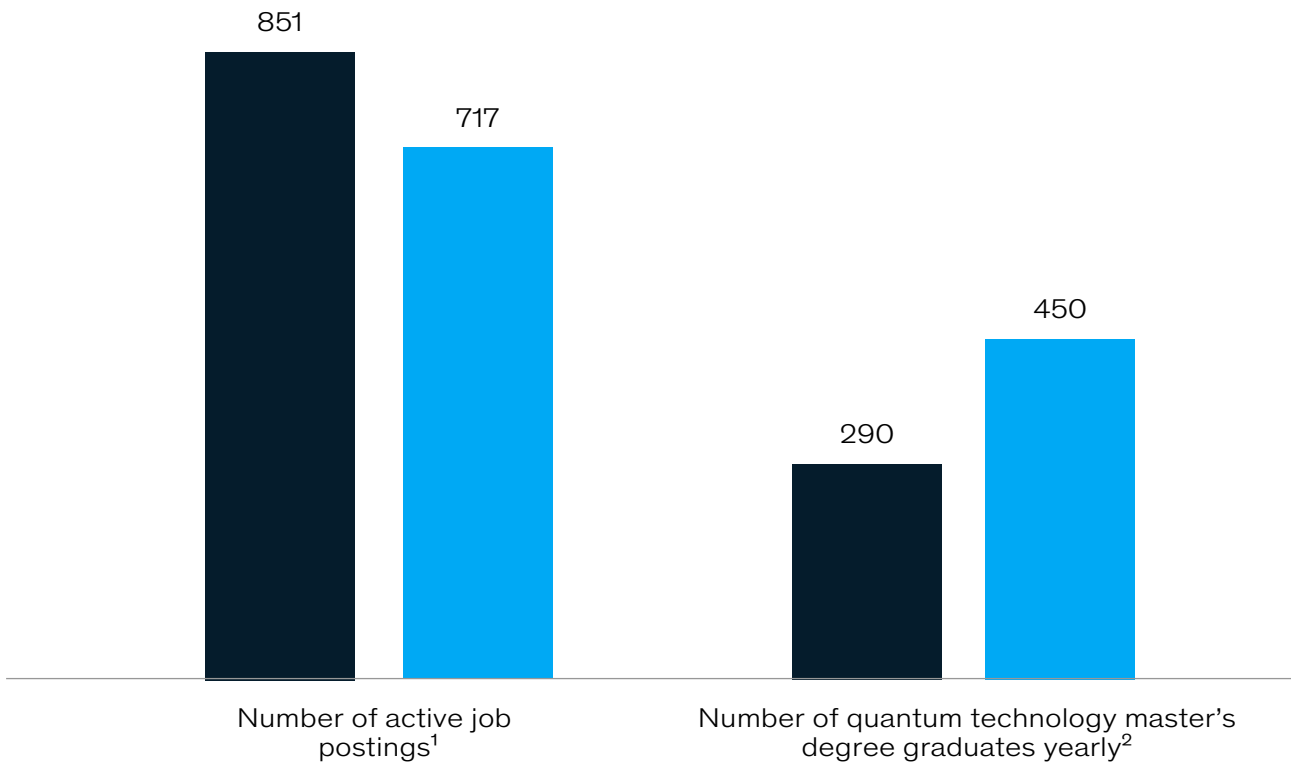
Universities offering QT master's degrees, 2022, number of universities per country



Total: 50

Source: QURECA; press search

While the QT talent gap has narrowed, there is still a shortage; upskilling graduates in QT-relevant jobs can help.



~350,000

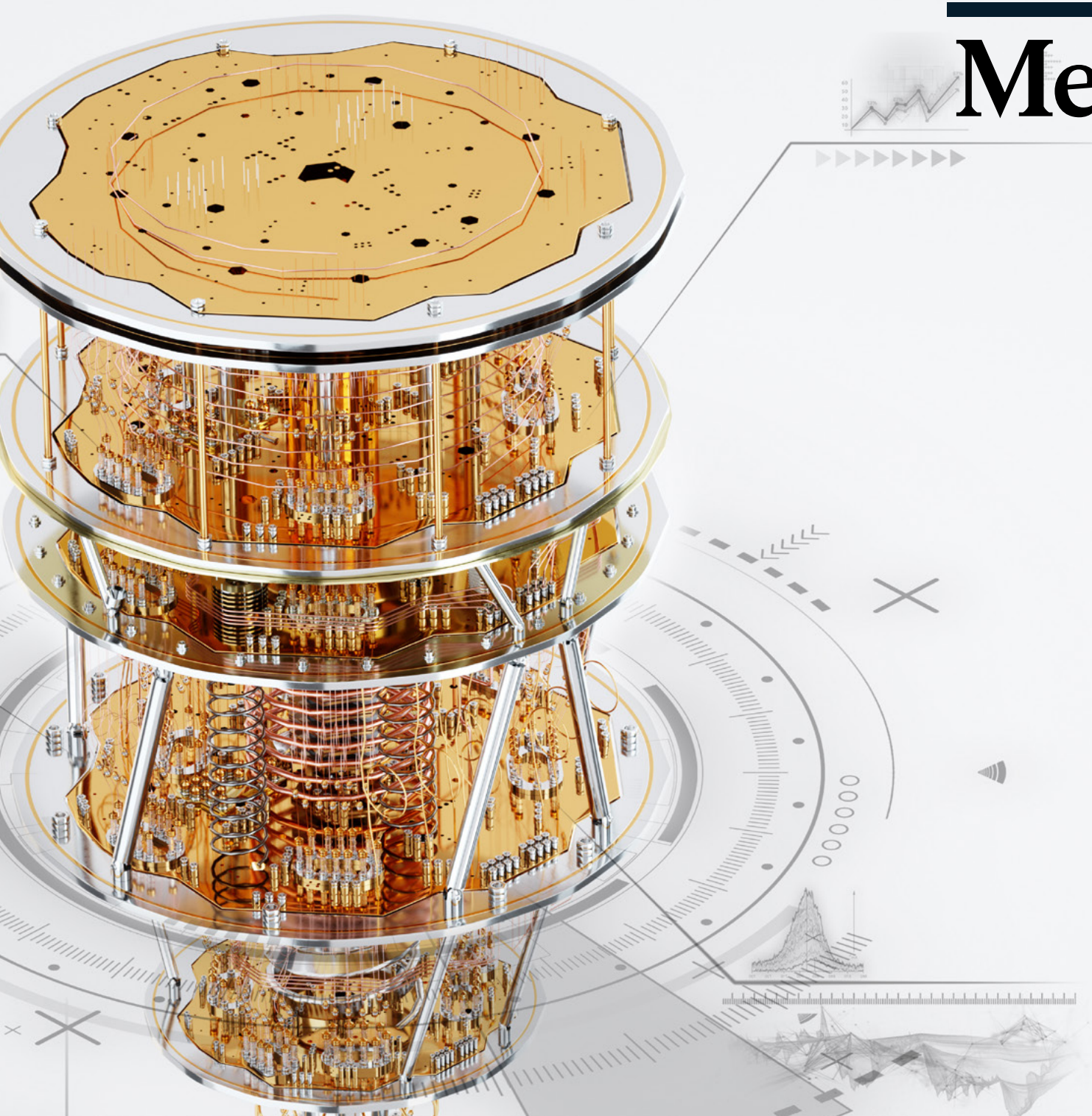
graduates per year in quantum technology–relevant fields[3]

Takeaways:

- The number of job postings outstrips qualified talent by as much as three to one.
- Job openings increased nearly 19% year over year and the number of master's-level graduates increased by 55%.
- As a result, the talent gap narrowed in 2022.
- However, there are still fewer QT-skilled job-ready graduates than positions open for them.
- Upskilling programs could potentially help narrow the talent gap, given the numbers of graduates with QT-relevant knowledge in adjacent fields.

[1] For 2021, number of active job postings as of December 2021, and for 2022, monthly average number of active job postings.
[2] Estimate based on the number of universities with such programs and how many students graduate per year.
[3] Graduates of master's level or equivalent in biochemistry, chemistry, electronics and chemical engineering, information and communications technology, mathematics and statistics, and physics.

Source: OECD; Quantum Computing Report; QURECA



Methodology

Methodology

Quantum technology player landscape, investments, and market sizing

— To obtain the QT player landscape, we considered the following:

- Start-ups: founded in the past 25 years, with estimated revenues below $200 million
- Incumbent companies: companies with revenues above $200 million
- Components manufacturers are considered if they develop components specifically for QT; general technology components suppliers are excluded
- Hardware manufacturers are considered if they have already demonstrated the creation of a quantum computer or have announced efforts in this direction
- Telecommunications companies are considered if they invest in QComms to become a quantum network operator
- Relevant general technology components suppliers are included in the ecosystem but not in the overall count of QT players; the same holds for quantum media companies and quantum education providers

— Investments in start-ups have been extracted from PitchBook and analyzed by McKinsey

— Market sizes have been calculated across three scenarios (low, base, high) that consider different hypotheses for the spread of use of QC, QComms, and QS, as well as the speed at which technological challenges are resolved

Acknowledgments

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