

Chapter 19

Investment Trends in Quantum Computing



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Abstract This chapter explores the ongoing substantial financial investments required for developing and commercializing quantum computing technology. Given the field's high uncertainty and long-term potential, investments are crucial for advancing breakthroughs in cryptography, materials science, and complex system simulations. The chapter examines the rise of quantum computing funding from the private equity and venture capital standpoints, highlighting key players like IBM and Google and emerging firms such as Rigetti and IonQ. It provides a detailed analysis of private funding trends, valuations, and geographic distribution, underscoring the sector's growth despite market volatility and regional concentration challenges. It also focuses on the discrepancies in funding allocation and performance among startups and the significant role of established companies like Microsoft, Google, and IBM in shaping the industry. Looking ahead, the chapter emphasizes the need for innovative financial models to assess investment returns, considering the nascent nature of quantum technology and the scarcity of financial data from private firms.

19.1 Introduction

Compared to most other emerging technologies, the massive infrastructure required for the development of quantum computing, along with its high uncertainty in efficiency and maturity horizon, requires heavy and long-term investments. These play a crucial role in determining the success of these initiatives. Quantum computing promises to revolutionize cryptography, materials science, and complex system simulations, driving competition among leading technology firms and research institutions. The increasing media coverage of the latest quantum computing achievements has also almost surely driven the most recent investments, reflecting

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the high stakes and potential rewards in this emerging field. For instance, IBM's significant budget for quantum research and Google's continued support of its quantum subsidiary, Google Quantum AI, are examples of the substantial funding fueling the quantum computing growth of quantum computing. Other notable companies include Rigetti Computing, IonQ, and D-Wave Systems, which have also attracted significant external funding from venture capital and private equity funds to advance their quantum technologies.^{1,2} The share of financing in the sector has increased sharply over the last five years, mirroring the rising interest and expectations from the public and private sectors. Conversely, identifying a clear trend in the private funding of quantum early-stage firms remains challenging due to the nascent nature of the technology and its high entry barriers. Post-money valuations in the quantum computing sector have also sharply risen, highlighting growing investor confidence.³ However, this increase is accompanied by significant time and cross-sectional volatility, likely due to uncertainties regarding the practical applications and timelines for quantum computing breakthroughs. This field's distribution of investment amounts shows significant outliers, underscoring the disparity between high-profile investments and the broader landscape. Furthermore, most investors and investees are based in the USA and China, indicating a regional concentration of resources and expertise. Despite the challenges, the substantial investments and increasing valuations suggest a robust growth trajectory. Continued investment is expected to drive further advancements, but stakeholders must remain aware of the associated risks and uncertainties inherent in pioneering such transformative technology. The following analyses tackle both public and private investments targeting private firms.

19.2 Outline of Investments

19.2.1 *Investment Trends*

Most of the following analyses use data from Crunchbase. Crunchbase is a database providing access to financial and managerial data on private companies. Its inception in 2007 was by TechCrunch, a US news service focusing on high-tech and startups. It is maintained by Crunchbase Inc. since 2015. This database is now adopted by academics (see, e.g., Besten [1]) and practitioners [1]. It is also used by international organizations such as the OECD (see, e.g., Dalle, Besten, and Menon; 2017) [2].

¹ **Venture capital:** capital investment in a project in which there is a substantial element of risk, typically startups.

² **Private equity:** capital investment in companies that are not publicly traded but typically larger than startups.

³ **Post-money valuations:** a company's value after new capital injections from venture capitalists or angel investors are added to its balance sheet.

Crunchbase collects data by combining crowd-sourcing, machine learning, tracking top news publications, in-house processing, and relying on third-party providers. Crunchbase reports private and public investments that target private firms and updates its data daily.

The top panel of Fig. 19.1 reports the yearly evolution of funding rounds from venture capital or private equity targeted firms in quantum computing. The first spike in average and total funding in 2017 also marks the beginning of a regime change in these investments. Between 2016 and 2022, the average funding went from a mere USD 10 million to over USD 40 million. In the meantime, the number of funding rounds increased, along with investee companies, and the total funding increased tenfold, close to USD 1.4 billion in the year 2021. More strikingly, the total funding for 2024 is already close to USD 1.5 billion only for the first half of the year.

The bottom panel depicts the evolution of valuations following the funding rounds, post-money valuations (hereafter, PMVs), when available.⁴ Before 2020, PMVs of quantum computing-related firms are virtually nonexistent. 2021 shows a first spike of available PMVs, following the massive funding rounds inflow (both in number and size). The interpretation regarding the first half of 2024 PMVs is the same as for funding rounds, with the notable exception that the median PMVs reached USD 100 million for the period, highlighting that not only valuations increase *per se* but also the analysts' willingness to report those of the sector.

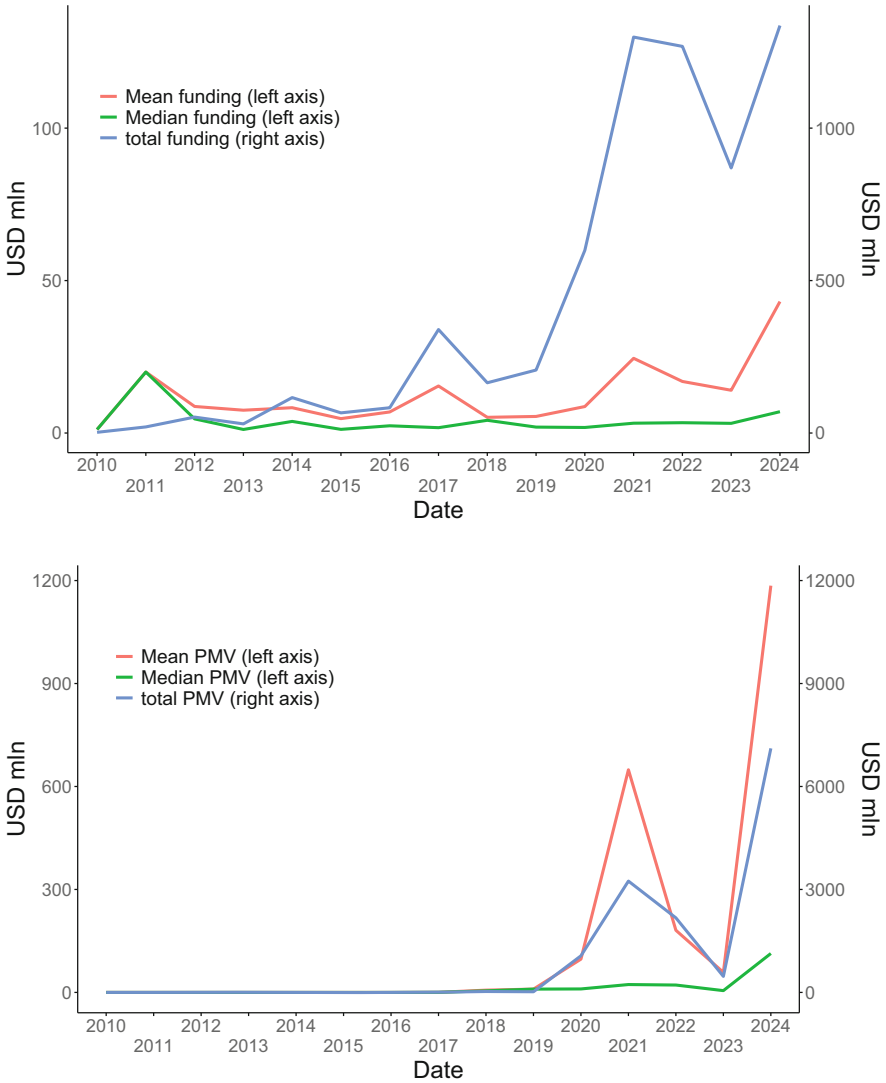
Figure 19.2 depicts the distribution of the natural logarithm of funding amounts for all funding rounds targeting quantum computing firms.⁵ The distribution mode and median are slightly above and below USD 3 million, respectively.

19.2.2 Geographic Location

Figure 19.3 reports the share of funding amount (left panel) and PMVs (right panel) for all countries that represent more than 4% of the total. Unsurprisingly, 48% of the total funding targets US quantum computing firms, and more than half of the recorded PMVs are accounted for in the USA. Canadian firms are second in terms of raised amount (12%); they only account for 6% of PMVs. In contrast, while Great Britain firms have raised only 10% of the total quantum computing funding, this translates into 32% of the PMVs. However, at this stage and for private firms, the data scope is too narrow to infer their relative performance. Finally, Chinese

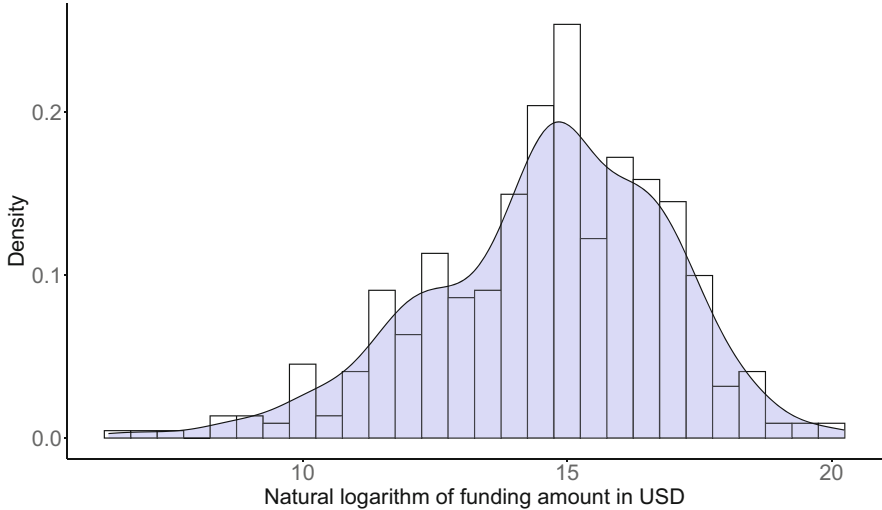
⁴ Unlike the public market, where the valuation is continuously observable through the market capitalization, valuations of private firms are scarce and often done after a significant funding round by dedicated analysts. This generates a selection bias toward large firms; however, this is the single metric publicly available regarding their financial performance.

⁵ Since the funding round sizes distribution is heavily right-skewed, it is standard to use this transformation in financial analysis. For ease of interpretation, USD 1, 10, and 100 million correspond to logarithm values of 13.8, 16.1, and 18.4.



Funding amount and post-money valuations statistics of quantum computing-related firms

Fig. 19.1 The top panel depicts the yearly evolution of mean and median funding and total funding directed toward private quantum computing-related firms. The bottom panel depicts the yearly evolution of post-money valuations (when available) made on private and public quantum computing firms. Public firms’ post-money valuations are considered once and correspond to the market capitalization available over their IPOs. Quantum computing firms are identified by selecting firms tagged with *Quantum Computing* in the Crunchbase sector classification. The data is from Crunchbase [3], and the period is Q1-2010–Q3-2024



Natural logarithm funding distribution targeting quantum computing-related firms

Fig. 19.2 Distribution of natural logarithm funding amount in private firms tagged with *quantum computing*. The data is from Crunchbase [3], and the period is Q1-2010–Q3-2024

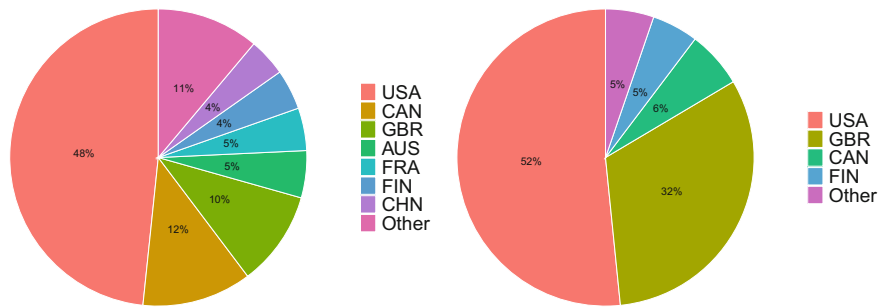
firms only account for 4% of the total funding and are not even reported in terms of PMVs. Three aspects may explain these counterintuitive results. First, Crunchbase has a representative bias toward the USA and, more generally, the Western world.⁶ Second, China is more opaque and probably even more in such a strategic field. Third, it is likely that the popular view of the tremendous Chinese investments in quantum computing is mainly done through public investments and/or in national institutions.

19.3 Discretionary Evidence

19.3.1 Start-ups and Unicorns

Table 19.1 reports the total amount invested in the top 20 firms entirely dedicated to quantum computing. PsiQuantum vastly dominates the ranking in total funding, with nearly USD 1.3 billion raised since its inception. Yet, the latest valuation

⁶ This bias is persistent across databases, and despite recent improvements, mitigating remains a challenge (see, e.g. Te et al. [4]).



Funding amount by geographic location

Fig. 19.3 The left (right) panel reports the share of funding amount (post-money valuations) in private firms tagged with *quantum computing* by their most important locations. The data is from Crunchbase [3], and the period is Q1-2010–Q3-2024

available only implies a multiple⁷ below 2.5. IonQ ranks second with USD 432 million for a 3.6 multiple. Interestingly, this low multiple is attained while the firm is now listed. Quantinuum, Exohood Labs, and Cambridge Quantum Computing have the highest multiple, with 16.31, 13.50, and 6.18, respectively. Some firms display large skewness in funding and considerable discrepancies in valuations and multiple. This might support the views of uncertainties attached to the sector as well as significant variations in each firm’s specific quantum computing activities.

19.3.2 Public and Established Companies

It is hard to quantify the internal investments and R&D budget dedicated to quantum research and applications within established firms. However, the recent breakthroughs they have announced and their facilities support the view of a large amount. Moreover, most of these firms are already in the technology or IT sector and, thus, must be intrinsically innovative. Table 19.2 reports the list of the top listed companies in this field and their activities in the quantum computing sector. It highlights the significant dominance of tech giants like Microsoft, Nvidia, and Google, whose market caps far exceed those of other firms. Quantum computing research is being driven by diverse industries, including cloud computing (Microsoft, Google, Amazon), hardware (Intel, Nvidia), and specialized applications (Volkswagen, Toshiba). The table also underscores the role of companies with smaller market

⁷ Multiple: In the context of venture capital, this term refers to the return multiple, indicating how much money an investor will make compared to their initial investment.

Table 19.1 This table reports financial performance metrics for quantum computing firms. “Total funding” (in USD million) is the total amount raised by the company over Q1-2010–Q3-2024 in their private stage. “Latest valuation” (in USD million) indicates either the post-money valuation if the company is still private (when available) or the current market capitalization (as of August 14, 2024) if the company had an IPO or a SPAC and is now listed. A listed firm is indicated with the superscript *. “Multiple” indicates the ratio between the two former values. Source: Crunchbase [3]

Company	Total funding (USD million)	Latest valuation (USD million)	Multiple
PsiQuantum	1,280.17	3,150	2.46
IonQ	432.00	1551*	3.59
Quantinuum	325.00	5,300	16.31
Rigetti Computing	298.45	164*	0.55
Xanadu	268.32	1,000	3.73
D-Wave Systems	267.99	208*	0.78
IQM Quantum Computers	249.12	900	3.61
Infleqtion	195.68	67	0.34
Origin Quantum	152.71	—	—
Oxford Quantum Circuits	146.46	—	—
PASQAL	142.08	—	—
Silicon Quantum Computing	133.40	—	—
Exohood Labs	112.00	1,512	13.50
Photonic	99.34	—	—
InVisage Technologies	98.00	—	—
Quantum Machines	93.00	—	—
Terra Quantum	90.00	53	0.59
Zapata Computing	82.06	16*	0.20
Quandela	73.08	—	—
Cambridge Quantum Computing	72.80	450	6.18

capitalizations, such as FormFactor, which focuses on niche areas like cryostat production. This diversity illustrates the broad applicability and interdisciplinary nature of quantum computing. The inclusion of market capitalization figures adds financial context to each company’s engagement in the field, offering insights into the scale of their operations and influence in this rapidly evolving industry.

19.4 Future Work with Financial Methods

Given the novelty of the technology, the long-term horizon of the investments, and the secretive nature of the technology, either from private firms with no financial performance disclosure or from listed firms with budget tied to their overall R&D, it is hard to infer anything about the financial returns of this sector. In particular, the

Table 19.2 This table ranks the top listed firms active in the quantum computing sector by their market capitalization and describes their research activity. The market capitalization is recorded as of August 14, 2024. Source: Crunchbase [3]. **Top listed firms active in quantum computing**

Company	Research description	Market cap. (USD billion)
Microsoft	Azure cloud services and research—research in quantum computing	3,094
Nvidia	GPU and AI technology branches include quantum computing research	2,875
Google	Google Quantum AI—research in quantum computing	1,975
Amazon	Quantum computing services in AWS—research in quantum computing	1,783
Samsung	Electronics and semiconductor branches include quantum computing research	378
Alibaba	Quantum computing services are available through its cloud platform	189
IBM	Technology and research in quantum computing	177
Toshiba	Technology and research in quantum computing and cryptography	167
AT&T	Telecommunications branches include research in quantum networking	140
Honeywell	Quantum computing is part of its aerospace business	128
Siemens	Quantum computing research for industrial applications	114
Hitachi	Technology and research initiatives in quantum computing	107
Intel	Quantum computing hardware development and research	86
Volkswagen	Automotive research includes quantum computing for optimization purposes	44
Fujitsu	IT and computing branches include quantum computing research	31
Baidu	AI and technology research divisions include quantum computing research	29
Hewlett Packard	Technology and research initiatives in quantum computing	23
Tencent	Technology and research initiatives in quantum computing	22
FormFactor	Cryostat design and production for quantum computers	4

market lacks maturity for adjusted returns and systematic risk analyses. Instead, once enough successful exits, IPOs in particular, of these firms are observable, and one could use dedicated financial models to estimate these parameters. Such methods include [5, 6] to estimate the financial performance of such investments at the sector level [5, 6]. In particular, the latter research uses an ML algorithm to infer all valuations that are often missing in private equity datasets and are even more pronounced in the restricted quantum computing field based on correlated features. It also uses returns computed from investment rounds to exits, accounting for capital

dilution, thereby estimating the financial performance with a maximum likelihood function that leverages information from all observable firms at once.

19.5 Recommendations

Emerging quantum computing technologies present significant opportunities for countries with a strong foundation in innovation, research, and a robust economic framework. To harness the full potential of this transformative technology, nations should consider adopting key investment strategies:

- **Public-private collaboration:** establish stronger partnerships between governmental agencies, academic institutions, and the private sector. Leading research institutions can collaborate with domestic firms and global players to drive innovation. Government funding for joint research initiatives and tax incentives for quantum startups can help cultivate a thriving quantum ecosystem.
- **Targeted venture capital and private equity support:** encourage venture capital and private equity firms to diversify their portfolios with investments in quantum computing startups. By providing early-stage financing, a nation can develop its existing quantum startup ecosystem and attract international talent, leveraging the country's reputation for stability and innovation.
- **Developing its quantum research hubs:** create dedicated research hubs focused on applied quantum technologies in sectors such as finance, healthcare, and cryptography. These hubs could attract foreign investment and position a nation as a leader in specialized applications of quantum computing, with a focus on real-world use cases.
- **Focus on talent development:** building a local talent pool skilled in quantum technologies is essential. A nation should invest in education programs preparing students and professionals for quantum computing careers, focusing on interdisciplinary physics, engineering, and finance skills.
- **Strategic partnerships:** as quantum computing requires massive infrastructure and resources, a nation should strategically partner or develop existing partnerships with global quantum leaders, such as the USA and the EU, to share research and technological advancements. This will allow firms to stay competitive and on the cutting edge of quantum developments.

By aligning policies, investment strategies, and educational initiatives, nations can secure a leading role in the global quantum computing industry. This strategic approach can drive innovation, attract economic benefits, and position them as key players in shaping the future of this groundbreaking technology.

19.6 Conclusion

Quantum computing is poised to transform industries such as cryptography, materials science, and complex system simulations, but its development requires sustained, large-scale investments due to the technology's high uncertainty and long-term horizon. This chapter analyzes the investment landscape in quantum computing, showing how financial backing from private equity, venture capital, and major tech firms has surged over the past decade. Key players like IBM, Google, Rigetti, and IonQ have driven innovation through internal research and external funding.

Investment trends show a sharp rise in funding since 2017, with significant growth in the number and size of financing rounds. Valuations of quantum startups have similarly increased, reflecting rising investor confidence. However, the volatility in post-money valuations and the concentration of investments in the USA and China highlight the sector's uncertainties and regional dynamics.

Although the market is still immature, with high variability in startup performance and a lack of reliable financial data from private firms, quantum computing investments appear to be on a robust growth trajectory. Financial support, especially from the public and private sectors, will drive future advancements. In the future, more sophisticated financial models will be necessary to assess the risk and returns associated with investments in this cutting-edge field.

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