The Quantum Leap
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How to Invest in Quantum Computing

For some of you that have been following these posts, or others that have been learning about the power and potential of Quantum Computing, you may be wondering how to invest in this emerging opportunity. Unfortunately, there are not many ways for individual investors to participate, although that is an evolving situation. I will cover some of the ways you can make direct investments, some options for some indirect investments, and a few situations where publicly traded securities should be available later this year. For this post, I will not be expressing any investment opinion but rather want to showcase the various avenues for making investments today (or soon). I will be covering the investment strengths and weaknesses in future posts for some of the companies noted below.

Quantum Focused Public Companies

IonQ: Today, there is only one significant pure-play Quantum Computing company publicly traded, and that is IonQ **($IONQ)**, the College Park, MD based firm founded in 2015. The Company was launched with seed funding from New Enterprise Associates, a pre-eminent venture investor, and a license to core technology from Duke University and the University of Maryland. IonQ has built ion trap based working Quantum Computers which can be accessed directly or through cloud partnerships with Microsoft, Amazon, and Google. In October 2021, IonQ began trading on the NYSE, and as of 2/11/21 had a market capitalization of $3 billion. The stock has had some recent gyrations and will likely be dragged down a bit near-term as other players go public (see Rigetti and D-Wave below) and investors re-allocate some of their QC exposure from IONQ to those other firms, but this is an essential component of any long-term QC portfolio.

Rigetti: While Rigetti Computing is not quite public, they have signed a definitive agreement to merge with a SPAC called Supernova Partners Acquisition Company II **($SNII)**, which values Rigetti equity at approximately $1.5 billion and will provide over $450 million in cash proceeds to Rigetti. Rigetti is another full-stack Quantum Computing provider, but they use superconducting loops for their qubits. While the formal merger date has not been announced, a formal shareholder vote is scheduled for February 28, 2022, and the merger should be completed shortly thereafter. Investors hoping to get in early can buy SNII today, or watch for it to trade post-merger, at which point its symbol will be RGTI.

D-Wave: Similar to Rigetti, D-Wave has signed an agreement to merge with a SPAC, this one called DPCM Capital **($XPOA)**. For this transaction, D-Wave equity is valued at $1.2 billion, and it will provide $300 million in cash. D-Wave is a different type of Quantum Computing company that offers quantum annealing as opposed to gate-based algorithms. While annealing is less powerful than gate-based systems, it is easier to operate and scale and D-Wave has 25 customers from among the Forbes Global 2000, so is one of the current Quantum Computing companies with meaningful current revenues. Investors hoping to get in early can buy XPOA today or watch for it to trade post-merger as QBTS.

Quantinuum: In June of 2021, after a series of successful collaborations, Cambridge Quantum C**omputing (CQC)** reached an agreement to be acquired by **Honeywell** for $300m, representing a $545m post-money valuation. Honeywell merged CQC with its **Honeywell Quantum Solutions (HQS)** division and in November of 2021, spun out the combined businesses into a new stand-alone company called "**Quantinuum**". Quantinuum has the benefit of CQC's software and algorithm expertise combined with HQS's hardware expertise, creating the largest full stack dedicated quantum computer company. Company executives have been quoted as confirming a 2022 targeted IPO, although there has been no official company announcement.

PsiQuantum: While currently private without any publicized plans to go public, PsiQuantum has been the most venture funded QC company in the US. To date they have raised nearly $750m, most recently at a $3.15 billion post-money valuation. While they are not in immediate need of liquidity, nor have they announced a desire to go public, the broad investor base and recent completion of a "D-Round" hint at an IPO some time in the not-too-distant future.

Among the five companies noted in this section, only one **($IONQ)** is a currently traded pure-play quantum investments. Two have committed to going public via SPAC sometime this year, one has announced plans to go public but has not taken formal steps and the fifth is not necessarily going public this year, but they are worth watching for an IPO announcement in the future. Interestingly, should all five become public, it would represent a broad bet on qubit construction (a mix of superconducting (Rigetti), ion traps (IonQ and Quantinuum) and photonics (PsiQuantum) so would enable diversification among these leading QC hardware strategies.

Exchange Traded Funds/Mutual Funds

In addition to these five pure-play companies, there are professionally managed, publicly traded funds with a focus on Quantum Computing and/or advanced computing. Many of these have portfolios with considerable over-lap, so the best strategy here would be to select one of these funds as your "advanced computing" vehicle to provided diversified exposure to QC.

Defiance Quantum ETF: Defiance Quantum **($QTUM)** is an exchange traded fund with a portfolio of investments in advanced technology companies that operate in Quantum Computing as well as artificial intelligence and machine learning. While not purely "quantum" the companies in its portfolio should all benefit from increasing commercialization of Quantum Computing. The fund trades at or near its "net asset value", in other words it is a relatively efficient way to own a diversified portfolio of about 70 companies. Holdings of QTUM include Teradata, Lockheed Martin, Airbus, HP, IBM, IonQ and others.

Fidelity Select Technology Portfolio ($SFPTX): This non-diversified fund invests primarily in equity securities, especially common stocks of companies that are engaged in offering, using, or developing products, processes, or services that will provide or will benefit significantly from technological advances and improvements. Some of the fund's top quantum holdings include Google, Nvidia, Microsoft and Micron Technology.

Fidelity Select Software & IT Services Portfolio ($FSCSX): This non-diversified fund invests a majority of its assets in common stocks of companies engaged in research, design, production or distribution of products or processes that relate to software or information-based services. Some of the fund's top quantum computing holdings are Microsoft, Google and International Business Machines.

T. Rowe Price Global Technology Fund ($PRGTX): aims for long-term capital growth. This non-diversified fund invests most assets in the common stocks of companies that will generate a majority of revenues from the development, advancement and use of technology. Some of the fund's top quantum computing positions are Alibaba, Advanced Micro Devices, Micron Technology and NXP Semiconductors.

Franklin DynaTech Fund Class A ($FKDNX): The fund invests primarily in common stocks with a focus on companies that are leaders in innovation, take advantage of new technologies, have superior management, and benefit from new industry conditions. Some of the fund's top quantum computing investments are Google, Nvidia, Microsoft and Alibaba.

Technology Select Sector SPDR Fund ($XLK): Seeks to provide exposure to companies from technology hardware, storage, and peripherals; software; communications equipment; semiconductors and semiconductor equipment; IT services; and electronic equipment, instruments, and components. Top holdings include Apple, Microsoft, NVIDIA, Broadcom, and Cisco.

Public Companies with Quantum Initiatives

None of the following publicly traded companies are pure-play quantum investments, but each has major Quantum Computing initiatives, and a varying level of reliance on successful penetration of the QC market.

International Business Machines ($IBM)**:** As a leading legacy company focused on computing hardware, IBM seems like a natural company to lead QC efforts. In fact, they have created the IBM Q Experience which enables more than 100 customers to access IBM's quantum resources via cloud-based access. In addition, IBM has developed Qiskit, one of the more popular open-source quantum SDKs (software development kits). Their latest 127-qubit Eagle quantum processor is one of the more robust QCs available and it is being utilized by major firms including Goldman Sachs, Samsung, JPMorgan Chase, ExxonMobil, and Boeing, among others. IBM features its quantum initiatives prominently in its corporate materials, so I expect QC to be an ever-increasing part of its value.

Microsoft ($MSFT)**:** As a leading software company, it makes sense that MSFT would be working on quantum software. Specifically, they have a widely used SDK called Q# (pronounced Q Sharp) and have been offering access to the quantum hardware systems offered by Honeywell, IonQ and QCI via their Azure Quantum cloud-based quantum platform. And, via their M12 corporate venture arm, are investors in PsiQuantum. By remaining agnostic to the quantum hardware used, and by developing an open-source SDK, MSFT is well positioned to enjoy the growing usage and needs for access to QCs regardless of which hardware technologies ultimately gain the most traction. However, despite Microsoft's clear commitment to Quantum Computing through their Azure Quantum platform and their Q# SDK, in their latest 10-K annual

report as of June 30, 2021, there is zero mentions of "quantum" or "Q#" so it may be difficult in the near term for MSFT's quantum efforts to move their equity value.

Honeywell International ($HON)**:** As noted above, Honeywell spun its Honeywell Quantum Solutions (HQS) division out into Quantinuum, with a stated plan to take Quantinuum public. However, until that spinout occurs, it is possible to obtain QC exposure via a direct investment in Honeywell. Even once Quantinuum goes public itself, it is expected that Honeywell will retain a significant ownership in Quantinuum so acquiring shares of HON now is an early way to get in on the upside possible in Quantinuum.

Alphabet ($GOOG, $GOOGL)**:** Alphabet/Google has been a major quantum headline grabber over the past couple of years, especially after it published the breakthrough paper in *Nature* describing how its Sycamore quantum processor was the first QC able to achieve "quantum supremacy." In addition to the Sycamore claims, Google maintains a robust quantum offering, including its Cirq SDK, cloud-based QC access and various libraries of quantum resources and algorithms. However, like other large companies included in this section, Alphabet is a huge, diversified conglomerate, so the relative contribution of QC to the broader Alphabet valuation is likely modest.

Intel ($INTL)**:** Intel has been a leading player in computing hardware since it was founded by Gordon Moore and Robert Noyce in 1968, so they are another corporate candidate for meaningful quantum exposure. Additionally, as "Moore's Law" begins to bump up against physics constraints, Quantum Computing seems like a natural extension of their technology, in order to continue to produce ever more powerful computing chips. In fact, in 2019 Intel announced Horse Ridge, a cryogenic control chip designed to speed the development of full-stack QC systems. Intel is hoping to leverage this chip, along with its legacy expertise around interconnect technologies, to become a major player in the QC realm.

Amazon ($AMZN)**:** Like Microsoft, Amazon has a broad cloud-based quantum platform within its Amazon Web Services (AWS) offering, known as Braket. It provides access to systems from D-Wave, Rigetti and IonQ. They also have an AWS Center for Quantum Computing in partnership with the California Institute of Technology among others. However, Amazon is a massive business with many interests and "quantum" is not often featured in its corporate description materials nor was it mentioned in their 2020 annual report, so its overall equity exposure to QC may not be very significant.

Nvidia ($NVDA): Founded in 1999 with a focus on advanced gaming, Nvidia's GPU's (graphics processing units) are now also being utilized for deep learning, parallel processing, and artificial intelligence, so they have become an important player in advanced computing. A newly announced cuQuantum for quantum computing enables large quantum circuits to be simulated dramatically faster, allowing quantum researchers to study a broader space of algorithms and applications. Developers can simulate areas such as near-term variational quantum algorithms for molecules and error correction algorithms to identify fault tolerance, as well as accelerate popular quantum simulators from Google and IBM. Given their success in becoming significant players in advanced computing generally, it seems likely they will have success leveraging these assets in Quantum Computing. Currently, "quantum" is a very modest focus within Nvidia's

press or shareholder reports, so it is unlikely to have a near-term major impact on its stock value, but this may be worth taking a modest, long-term position.

Summary

For those of you anxious to invest in the evolving Quantum Computing industry, there are a few publicly available options. Some will provide a direct, pure-play investment, while others should enjoy enhanced returns based on their QC exposure. The following table summarizes the public company investments (and stock symbols) that would provide decent portfolio exposure to Quantum Computing upside:

Pure Play Stocks	Funds	Indirect Stock Exposure
Available now or soon: IONQ, RGTI, QBTS	QTUM SFPTX PRGTX KFDNX XLK	MSFT IBM HON GOOG, GOOGL AMZN INTL NVDA
Available in future: Quantinuum, PsiQuantum		

Those seeking meaningful investment exposure to QC should certainly maintain positions in IONQ, RGTI and QBTS and likely at least one of the funds noted. For added exposure to a broader advanced computing portfolio that also adds QC exposure, you may consider adding some or all of MSFT, IBM, HON, GOOG, GOOGL, AMZN, INTL and/or NVDA.

***Disclosure**: I maintain personal long positions in IONQ, SNII, QTUM and XLK, but do not have any business relationship with any company mentioned in this post. I wrote this article myself and express it as my own opinion.*

References:

Nvidia Press Release, Introducing cuQuantum: Acclerating State Vector and Tensor Network-based Quantum Circuit Simulation, November, 2021.

Zacks Equity Research, 4 Funds to Shine as Quantum Computing Comes Into Play, July 8, 2021

Intel Corporation Press Release, "Intel Introduces 'Horse Ridge' to Enable Commercially Viable Quantum Computers," December 9, 2019.

Taulli, Tom, InvestorPlace, "These 7 Quantum Computing Stocks Are Futuristic Buys," June 15, 2020.

Gecgil, Tezcan, InvestorPlace, "The 7 Best Quantum Computing Stocks to Buy for February 2022," February 4, 2022.

Hajjar, Alamira J., AI Multiple, "33+ Public & Private Quantum Computing Stocks in 2022", published May 5, 2021 and updated Jan 11, 2022.

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