



Quantum Computing:

*Technologies and Global
Markets to 2022*

August 2018

Andrew McWilliams



Report Code: IFT149A

Table of Contents

- Chapter 1: Introduction 2
 - Study Goals and Objectives..... 2
 - Reasons for Doing This Study..... 2
 - Scope of Report..... 3
 - Information Sources..... 3
 - Methodology..... 4
 - Geographic Breakdown..... 4
 - Analyst’s Credentials..... 8
 - Related BCC Research Reports..... 8
- Chapter 2: Summary and Highlights..... 10
- Chapter 3: Market and Technology Background 13
 - General Description 13
 - History 13
 - Properties 15
 - Technologies 16
 - Types of Quantum Computers 16
 - Qubits 18
 - Applications of Quantum Computers 20
 - Quantum Simulation 20
 - Quantum-Assisted Optimization 23
 - Quantum Sampling..... 26
 - End Users of Quantum Computing 26
 - Research and Education 26
 - Governments/Nonprofits..... 27
 - Military and Defense 27
 - Aerospace..... 28
 - Healthcare 29
 - Geology/Energy 29
 - Financial Services..... 30
 - Transport and Logistics 30
 - Manufacturing..... 31
 - Digital Media/Online Services 32
 - Other 33
- Chapter 4: Market Breakdown by Technology 35
 - Current Market 35
 - Market Trends, 2017-2027 37
- Chapter 5: Market Breakdown by End Use 40
 - Current Market 40
 - Market Trends, 2017-2027 41
- Chapter 6: Market Breakdown by Application 46
 - Current Market 46
 - Market Trends, 2017-2027 46
- Chapter 7: Market Breakdown by Region 51

Current Market	51
Market Trends, 2017-2027	51
Chapter 8: Patent Review/ New Developments	54
Overview	54
Patent Trends Over Time	56
Patent Assignee Characteristics	57
Type of Entity	57
Nationality	58
Patent Portfolios	59
D-Wave Systems	61
IBM	64
Microsoft	66
Northrop Grumman	68
Toshiba	68
Hewlett Packard	69
Japan Science and Technology Agency (JSTA)	70
University of California	71
NEC	72
MagiQ	73
Qucor	74
Hypres	74
Other Noteworthy Patents	75
Chapter 9: Analysis of Market Opportunities	78
Overview	78
Government and Academic Research Institutions	78
Commercial Users	82
Promising Sectoral Markets	82
Early Adopters	85
Software	87
Cloud-Based Quantum Computing	90
Killer Apps	91
Chapter 10: Sources of Financing	94
Venture Financing	94
Chapter 11: Company Profiles	101
Quantum Computing Pure Plays	101
Diversified Players	113
Non-commercial Research Programs	123
Chapter 12: Patent Portfolios	142
D-Wave Systems	142
International Business Machines	150
Microsoft	154
Northrop Grumman	157
Toshiba	159
Hewlett-Packard	162
Japan Science and Technology Agency	164
University of California	165
NEC	166

MagiQ.....	167
Qucor	168
Hypres	169
About BCC Research	170
About BCC Research.....	171
BCC Membership	171
BCC Custom Research	171

List of Tables

Summary Table: Global Commercial Quantum Computing Market, by Type, Through 2027 (\$ Millions) .	10
Table 1 Global Commercial Quantum Computing Market, by Type, 2016 (\$ Millions).....	36
Table 2 Global Commercial Quantum Computing Market, by Type, Through 2027 (\$ Millions)	37
Table 3 Global Commercial Quantum Computing Market, by End-Use, 2016 (\$ Millions)	40
Table 4 Global Commercial Quantum Computing Market, by End-Use, Through 2027 (\$ Millions).....	42
Table 5 Global Commercial Quantum Computing Market Shares, by End-Use, 2016-2027 (%)	43
Table 6 Global Commercial Quantum Computing Market, by Application, Through 2027 (\$ Millions).....	47
Table 7 Global Commercial Quantum Computing Market Shares, by Application, 2016-2027 (%)	48
Table 8 Global Commercial Quantum Computing Market, by Region, Through 2027 (\$ Millions)	51
Table 9 Global Commercial Quantum Computing Market Shares, by Region, 2016-2027 (%)	52
Table 10 U.S. Patents and Applications for Quantum Computing-Related Inventions (Patents Granted and Applications Filed as of Oct. 1, 2017) (No./%)	54
Table 11 Number of Quantum Computing-Related U.S. Patents Issued, by Year, 2008-2017.....	56
Table 12 Quantum Computing-Related U.S. Patent Holders, by Type of Entity (Number of Patents).....	57
Table 13 Quantum Computing-Related U.S. Patent Holders, by Nationality (Number of Patents)	58
Table 14 Quantum Computing-Related U.S. Patent Publication Holders (Number of Publications)	60
Table 15 IBM vs. D-Wave Patent Publications, 2015-2017 (Number of Patent Publications).....	64
Table 16 National Government Spending on Quantum Technology Research, 2016* (\$ Millions)	79
Table 17 Government Investments in Quantum Computing vs. Selected Other Emerging Technologies (\$ Millions)	81
Table 18 Companies with an Early Commercial Interest in Quantum Computing	86
Table 19 Other Quantum Computing Open-Source Software.....	88
Table 20 Quantum Computing Venture Financing Trends, 2012-2017 (Number of Deals)	94
Table 21 Individual Company Shares of Total Quantum Computing Venture Financing, 2012-2016 (\$ Millions/%).....	95
Table 22 Venture Capital Investors with Investments in Quantum Computing Companies	96
Table 23 Venture Capital Investments in Quantum Computing vs. Selected Other Technologies, 2016* (\$ Millions)	98
Table 24 D-Wave U.S. Patent Publications, 2002-2017	142
Table 25 IBM U.S. Patent Publications, 2002-2017	150
Table 26 Microsoft U.S. Patent Publications, 2006-2017	154
Table 27 Northrop Grumman U.S. Patent Publications, 2009-2017.....	157
Table 28 Toshiba U.S. Patent Publications, 1993-2017	159
Table 29 Hewlett-Packard U.S. Patent Publications, 2005-2016	162
Table 30 Japan Science and Technology Agency U.S. Patent Publications, 2005-2016	164
Table 31 University of California U.S. Patent Publications, 2002-2017	165
Table 32 NEC U.S. Patent Publications, 2002-2014	166
Table 33 MagiQ U.S. Patent Publications, 2004-2011	167
Table 34 Qucor U.S. Patent Publications, 2006-2013.....	168
Table 35 Hypres U.S. Patent Publications, 2012-2017.....	169

List of Figures

Summary Figure: Global Commercial Quantum Computing Market, by End-Use, 2016-2027 (\$ Millions)	11
Figure 1 Global Commercial Quantum Computing Market, by Type, 2016 (%)	36
Figure 2 Global Commercial Quantum Computing Market, by Type, 2016-2027 (\$ Millions)	38
Figure 3 Global Commercial Quantum Computing Market, by End-Use, 2016 (%).....	41
Figure 4 Global Commercial Quantum Computing Market Shares, by End-Use, 2016-2027 (%).....	44
Figure 5 Global Commercial Quantum Computing Market Shares, by Application, 2016-2027 (%).....	49
Figure 6 Global Commercial Quantum Computing Market Shares, by Region, 2016-2027 (%)	52
Figure 7 U.S. Patent and Application Shares of Quantum Computing-Related Inventions (% of Total) ...	55
Figure 8 Number of Quantum Computing-Related U.S. Patents Issued, by Year, 2008-2017	56
Figure 9 Quantum Computing-Related U.S. Patent Holders Share, by Type of Entity (% of Total Patents)	57
Figure 10 Quantum Computing-Related U.S. Patent Holders Share, by Nationality (% of Total Patents)	59
Figure 11 Quantum Computing-Related U.S. Patent Publication Holders (Number of Publications)	61
Figure 12 National Government Spending on Quantum Technology Research, 2016* (\$ Millions)	80
Figure 13 Government Investments in Quantum Computing vs. Selected Other Emerging Technologies (\$ Millions)	81
Figure 14 Promising Sectoral Markets for Quantum Computing	82
Figure 15 Quantum Computing Venture Financing Trends, 2012-2017 (Number of Deals)	95
Figure 16 Individual Company Shares of Total Quantum Computing Venture Financing, 2012-2016 (%)..	96
Figure 17 Venture Capital Investments in Quantum Computing vs. Selected Other Areas, 2016 (\$ Millions)	99



About BCC Research

About BCC Research

With our unparalleled 45-year history, BCC Research provides comprehensive analyses of global market sizing, forecasting and industry intelligence, covering markets where advances in science and technology are improving the quality, standard and sustainability of businesses, economies and lives.

BCC Membership

From market sizing and forecasts, to opportunity assessments and competitive analyses, our ever-expanding library gives you the data, insights and intelligence required to ensure your project is a success. Members benefit from ongoing, unlimited access to the category or collections of their choice, and most membership packages pay for themselves within two to three reports being accessed.

Did you buy this report? You may qualify to apply your purchase price towards a full membership. Call 866/285-7215 or e-mail info@bccresearch.com to request a demo.

BCC Custom Research

Our experts provide custom research projects to those working to identify new markets, introduce new products, validate existing market share, analyze competition and assess the potential for products to impact existing markets. With impressive academic credentials and broad and deep knowledge of global industrial markets, our independent analysts and consultants develop the facts, figures, analysis and assessments to inform the decisions that will move your company ahead. Confidential inquiries to: custom@bccresearch.com or 781/205-2429.

DISCLAIMER

The information developed in this report is intended to be as reliable as possible at the time of publication and is of a professional nature. This information does not constitute managerial, legal or accounting advice, nor should it be considered as a corporate policy guide, laboratory manual or an endorsement of any product, as much of the information is speculative in nature. BCC Research and the author assume no responsibility for any loss or damage that might result from reliance on the reported information or from its use.

ISBN: 978-1-62296-813-8
August 2018