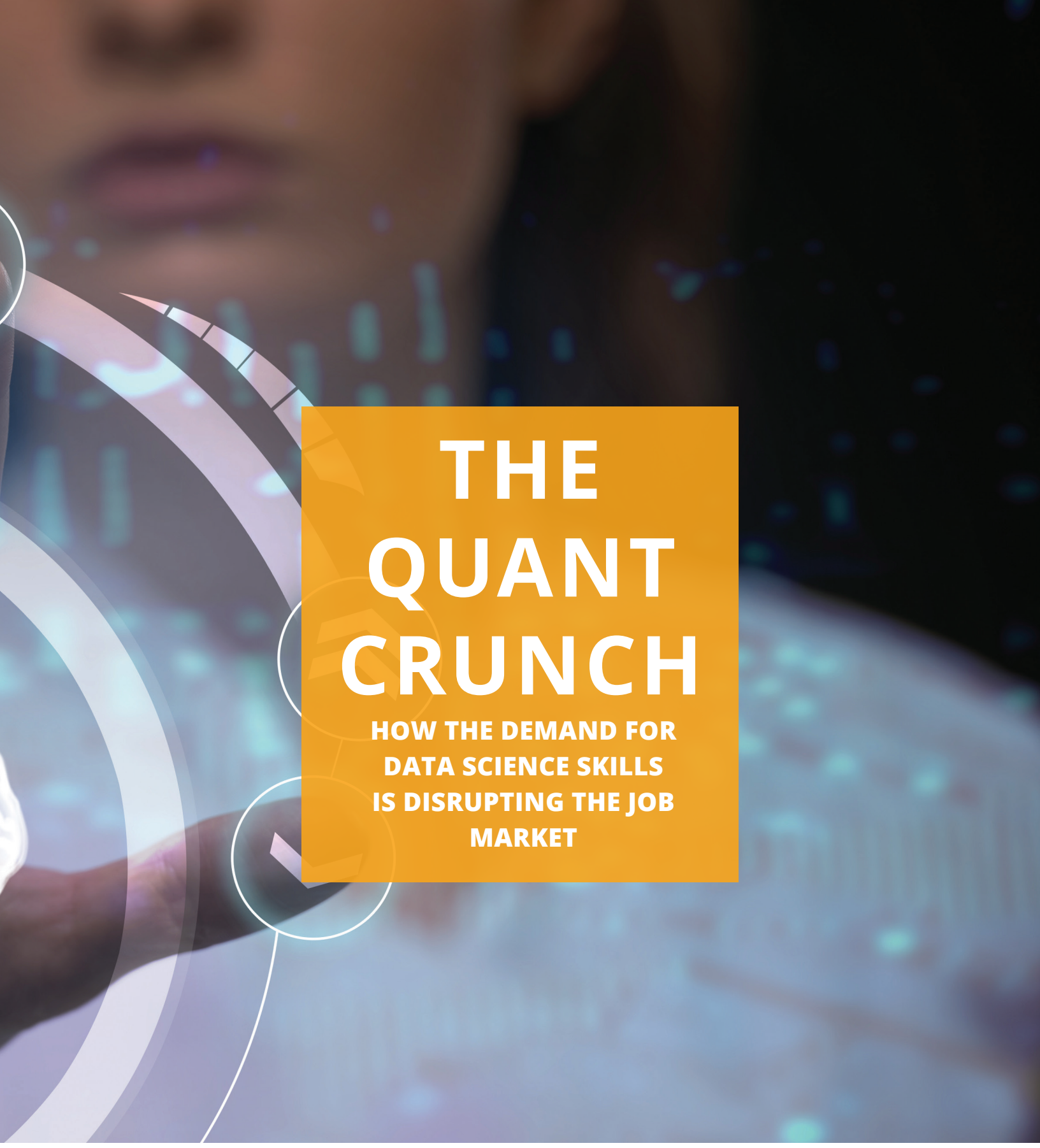

THE QUANT CRUNCH

HOW THE DEMAND FOR DATA SCIENCE SKILLS IS DISRUPTING THE JOB MARKET

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PREFACE

In 2016 the number of job postings specifically for a data scientist (+5%) or data engineer (-2%) shifted slightly. The bigger finding is that certain skills transcend the position. These data-centered skills saw significant growth in 2016:

Clinical Data Analysis:	**+54%**
Data Science:	**+40%**
Quantitative Data Analysis:	**+38%**
Data Visualization:	**+31%**
Data Engineering:	**+28%**
A/B Testing:	**+22%**
Machine Learning:	**+17%**

Jobs specifying machine learning skills pay an average of $114,000. Advertised data scientist jobs pay an average of $105,000 and advertised data engineering jobs pay an average of $117,000

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The democratization of data is transforming our world. Sensors are everywhere. Cities are measuring and acting upon a wide variety of data sources. Governments at all levels are opening their data to their citizens. Old businesses are being transformed by data. Dynamic new businesses are powered by data. Anyone with a smart phone now carries with them a sensor platform generating data.

In response, workforce needs have shifted rapidly. Demand for a new breed of professionals skilled in data, analytics, machine learning, and artificial intelligence requires a requisite response from both higher education and workforce development. To help guide workforce development programs, IBM and Business-Higher Education Forum partnered with Burning Glass to develop a deep understanding of current job market demand shifts.

We project that by 2020 the number of positions for data and analytics talent in the United States will increase by 364,000 openings, to 2,720,000. In 2020, job openings for data scientists and similar advanced analytical roles will reach 61,799. This is a significant number, but it represents just 2% of the projected demand across all job roles requiring data and analytics skill.

To close the gap, workforce development and higher education must look beyond the data scientist to develop talent for a variety of roles, such as data engineer, data governance and lifecycle and data privacy and security specialist, and data product developer. Data democratization impacts every career path, so academia must strive to make data literacy an option, if not a requirement, for every student in any field of study.

Demand for data-driven decision makers, such as data-enabled marketing managers, will comprise one-third of the data savvy professional job market, with a projected increase of 110,000 positions by 2020. To lead analytics teams or craft a company's digital strategy, executives will need a foundational understanding of data and analytics.

To meet this explosive demand, businesses need to rethink hiring, training, and partnerships. Higher education needs to be nimble and responsive, and its bachelor's, graduate, certificate, and executive-level programs have to be responsive to workforce needs.

INTRODUCTION

Data Science and Analytics are no longer just buzzwords- they are essential business tools. Every day, 2.5 quintillion bytes of data are created,[1] and IDC estimates that by 2019 the Big Data Analytics market—just one slice of the larger Data Science and Analytics (DSA) market—will grow to over $187 billion.[2] The benefits to firms that embrace analytics are well documented. Research by Andrew McAfee and Erik Brynjolfsson from MIT states, "companies in the top third of their industry in the use of data-driven decision making were, on average, 5% more productive and 6% more profitable than their competitors."[3]

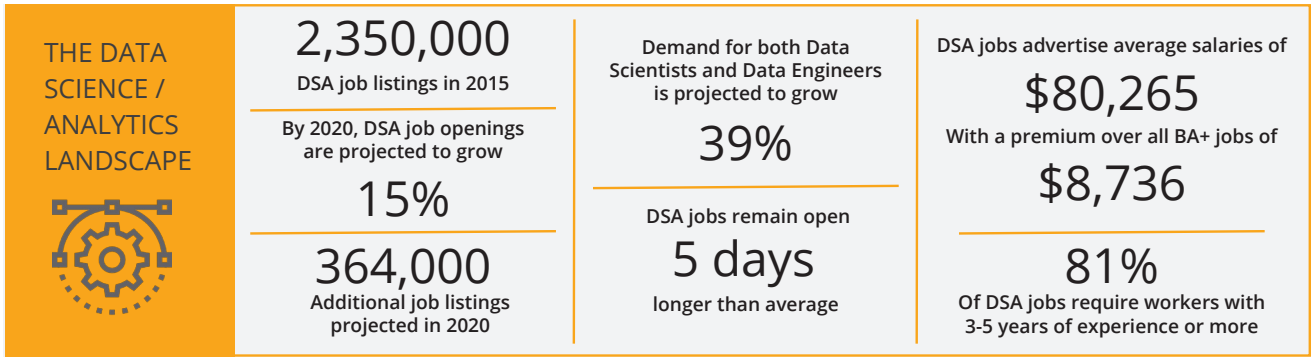
As DSA technologies and methods make a dent in the economy, so too are they making a dent in the job market. The Age of Big Data has transformed the tools and skills employees utilize, and workers across job functions now require analytical aptitude. In 2011, McKinsey predicted that by 2018 there would be 2.8 million workers with either deep analytical talent or data-savvy skillsets.[4] By 2015, however, there were already over 2,350,000 job listings for core Data Science and Analytics (DSA) jobs in the United States, and by 2020 the number of DSA job listings is projected to grow by nearly 364,000 listings, to about 2,720,000 openings. If McKinsey's predicted supply of 2.8 million analytically savvy workers is accurate, then nearly every one of these workers must change jobs annually to fill open DSA positions.

As demand for DSA workers grows, this growth puts pressure on the supply of DSA talent to grow in turn. However, there is growing concern that the supply of DSA workers is lagging dangerously behind demand. The Networking and Information Technology Research and Development program (NITRD), for example, argues that we must "improve the national landscape for Big Data education and training to fulfill increasing demand for both deep analytical talent and analytical capacity for the broader workforce." If stakeholders do not act, the supply of DSA talent is in danger of lagging behind growth in demand for DSA workers.

This could bring the productivity gains from Big Data to a grinding halt. Employers are already struggling to fill DSA jobs, as evidenced by the length of time unfilled roles remain open. On average, DSA jobs remain open for 45 days—five days longer than the market average. Some more senior or sophisticated roles, such as Directors of Analytics and Data Scientists, take far longer to fill. Compounding the skill shortage is the hybrid nature of many DSA jobs, which require a mix of disparate analytical skills and domain-specific expertise that may be difficult to develop in traditional training programs. Marketing Analytics Managers, for example, must combine advanced analytical techniques with deep marketing knowledge, but both skillsets may take years to develop.

To mitigate this talent shortage, organizations across the analytics ecosystem must build a detailed understanding of their talent needs. This will enable them to invest strategically in DSA talent pipeline development.

Similarly, educators and training providers must proactively respond to the rising demand for analytics skills with programs that prepare students for the analytics-related roles of today and tomorrow, while existing workers must continuously monitor in-demand analytics technologies and update their skillsets accordingly. If these actions are not taken, the DSA skills gap is in danger of widening, which would continue to undercut the promise of Big Data.



1 Zikopoulos, Paul, et al. "Harness the Power of Big Data: The IBM Big Data Platform" (New York: McGraw-Hill Professional, 2012).
2 International Data Corporation, Worldwide Semiannual Big Data and Analytics Spending Guide (Framingham, MA: IDC, 2016).
3 McAfee, Andrew, et al. Big data: The management revolution. Harvard Bus Rev 90.10 (2012): 61-67.
4 Manyika, James, et al. Big Data: The Next Frontier for Innovation, Competition, and Productivity (New York: McKinsey & Co., 2011).
5 NITRD, NCO. The Federal Big Data Research and Development Strategic Plan (2016).

DEFINING THE DSA LANDSCAPE

The mismatch between supply and demand in the DSA job market is compounded by a lack of a common framework and vernacular for DSA jobs and skills. The Bureau of Labor Statistics—the federal agency tasked with tracking the labor market's key metrics—does not have a clear definition of DSA jobs, and many new and emerging DSA jobs, such as Data Scientists and Data Engineers, are not currently tracked at all. Moreover, job titles are not consistent across many of these positions; an employee called a "Data Scientist" at one company may have a distinctly different skill profile than a "Data Scientist" at another firm, making it difficult to analyze broadly the Data Scientist profile. The lack of traditional labor market data for DSA roles creates an information gap that undercuts educators, employers, and policymakers as they attempt to build a workforce with the skills needed across the DSA landscape.

To overcome this lack of traditional labor market data, Burning Glass mined its database of over 130 million unique current and historical job listings and worked with IBM and Business-Higher Education Forum (BHEF) to identify the key roles and skills that make up the DSA jobs ecosystem. First, Burning Glass identified a set of over 300 analytical skills that represent the key DSA-related tools and competencies requested in the labor market. These skills range from such general analytical competencies as database architecture, data analysis, and data visualization to specific technologies used to perform DSA-related tasks, such as R, Hadoop, and Tableau.

Next, Burning Glass identified occupations that commonly require some mix of these analytical skills, and grouped them in six job categories based upon similarities in skillsets and functional roles within the broader DSA landscape. These categories include Data Scientists and Advanced Analysts, Data Analysts, Data Systems Developers, Analytics Managers, Functional Analysts, and Data-Driven Decision Makers. The final two categories, Functional Analysts and Data-Driven Decision Makers, are less analytical than the other four categories, and may be thought of as data-enabled, rather than pure analytics, roles. Nonetheless, they require many overlapping skillsets with other analytics roles, and are important for organizations consuming and interpreting data. Table 1 shows descriptions and sample occupations for each job category.

Roles within each DSA framework category may vary in terms of required skill and experience, but are grouped together based on their function within an organization. Data Scientists and Economists, for example, belong to the Data Scientists and Advanced Analysts category. Although these roles entail different skillsets, offer different salaries, and require different experience, employees in both are expected to create sophisticated analytical models, work with large datasets, and derive insights from data. The context in which a Data Scientist performs these tasks may differ from that of an Economist, but both roles serve similar high-level functions within an organization and may require similar levels of analytical rigor.

Table 1. Description of DSA Jobs

Analytical Rigor

DSA Framework Category	Functional Role	Sample Occupations
Data Scientists & Advanced Analytics	Create sophisticated analytical models used to build new datasets and derive new insights from data	Data Scientist Economist
Data Analysts	Leverage data analysis and modeling techniques to solve problems and glean insight across functional domains	Data Analysts Business Intelligence Analyst
Data Systems Developers	Design, build and maintain and organization's data and analytical infrastructure	Systems Analyst Database Administrator
Analytics Managers	Oversee analytical operations and communicate insights to executives	Chief Analytics Officer Marketing Analystics Manager
Functional Analysts	Utilize data and analytical models to inform specific functions and business decisions	Business Analyst Financial Analyst
Data-Driven Decision Makers	Leverage data to inform strategic and operational decisions	IT Project Manager Marketing Manager

FINDINGS

In 2015, there were 2,352,681 job listings for all DSA categories (see Table 2). The demand for DSA jobs is projected to grow by 15% over the next five years, which translates to nearly 364,000 new job postings expected nationally by 2020. The fastest-growing roles are Data Scientists and Advanced Analysts, which are projected to see demand spike by 28% by 2020. This category and Analytics Managers are arguably the most visible DSA categories, yet they are also the least demanded in terms of total job postings. However, some of the roles within these categories are among the hardest-to-fill and fastest-growing DSA jobs, raising concerns about building an adequate talent pool for these positions.

Hiring difficulties are widespread for analytics roles, however, and many DSA jobs are among the hardest to fill in the entire market. On average, DSA jobs remain open for 45 days—five days longer than the market average. Among the core DSA job categories, Data Systems Developers—which includes roles such as Database Architects—are the hardest to fill DSA roles on average, with an average posting duration of 50 days. Specific roles, such as Director of Analytics and Systems Analysts, remain open far longer, with average posting durations well over 50 days.

The difficulty employers have filling DSA roles drives up salaries, and relative to other jobs, DSA jobs pay quite well. On average, they advertise an annual salary of $80,265—a premium of $8,736 relative to all bachelor's and graduate-level jobs. Some DSA jobs, such as Data Scientists and Data Engineers, demand salaries well over $100,000. While this is encouraging for prospective DSA workers, this makes it costly for employers to fill open roles.

Table 2. Summary Demand Statistics

DSA Framework Category	Number of Postings in 2015	Projected 5-Year Growth	Estimated Postings for 2020	Average Time to Fill (Days)	Average Annual Salary
All	2,352,681	15%	2,716,425	45	$80,265
Data-Driven Decision Makers	812,099	14%	922,428	48	$91,467
Functional Analysts	770,441	17%	901,743	40	$69,162
Data Systems Developers	558,326	15%	641,635	50	$78,553
Data Analysts	124,325	16%	143,926	38	$69,949
Data Scientists & Advanced Analysts	48,347	28%	61,799	46	$94,576
Analytics Managers	39,143	15%	44,894	43	$105,909

Exacerbating the talent shortage for many DSA roles are the heightened education and experience requirements for many new and emerging positions. Overall, 81% of all DSA job postings request workers with at least three years of prior work experience. The strong demand for experienced candidates, combined with the strong growth of many DSA roles, creates a chicken-and-egg problem within the DSA job market: there aren't many opportunities for workers to gain the DSA-related experience that employers are requesting.

Compounding this pipeline problem are the heightened education requirements for some DSA roles, especially Data Scientists and Advanced Analysts (see Table 3). Overall, 39% of Data Scientists and Advanced Analysts require a master's or Ph.D. These degrees take additional years of schooling to complete, so it will take a significant time investment to train a larger pool of workers. Therefore, because these roles are already undersupplied and projected to grow rapidly, the skills shortage is in danger of worsening.

Table 3. Workforce Entry Requirements

DSA Framework Category	Postings Requesting Experienced Workers (at least 3 Years Prior Work Experience)	Postings Requiring Master's or Higher
All	81%	6%
Data-Driven Decision Makers	88%*	5%
Functional Analysts	71%	6%
Data Systems Developers	84%	3%
Data Analysts	76%	6%
Data Scientists & Advanced Analysts	78%	39%
Analytics Managers	94%*	11%

*Note: Although certain managerial jobs are classified as entry level, these numbers typically reflect the years of managerial experience required, as opposed to the overall years of work experience required.

DSA DEMAND DIFFERS ACROSS SECTORS

The business need for Data Science and Analytics varies significantly across different industries, and some sectors are embracing DSA jobs and skills faster than others. The greatest demand for DSA jobs is in Finance and Insurance, Professional Services, and IT; together, these three industries alone account for 59% of all DSA job demand. DSA jobs factor most prominently in the Finance and Insurance industry, where they account for 19% of all openings in that sector. The Professional Services and IT industries follow with 18% and 17% relative demand for DSA jobs, respectively. [6]

Investigating demand for DSA jobs across sectors provides insight into the main industries that drive big data demand nationally. Table 4 presents the percentage of jobs within each framework category that fall into each of the top industries, and shows that the Finance and Professional Services industries are the primary drivers of DSA demand. Together, these industries account for over half of all DSA jobs.

6 See Appendix 1 for complete DSA demand data by industry.

Table 4. Share of DSA Category Demand by Industry

DSA Framework Category	Professional Services	Finance & Insurance	Manufacturing	Information	Health Care & Social Assistance	Retail Trade
Data-Driven Decision Makers	23%	17%	16%	10%	6%	6%
Functional Analysts	23%	34%	9%	5%	8%	4%
Data Systems Developers	41%	14%	14%	10%	5%	3%
Data Analysts	34%	25%	9%	6%	7%	3%
Data Scientists & Advanced Analysts	31%	23%	12%	10%	6%	4%
Analytics Managers	21%	41%	9%	9%	6%	3%

Key: 41+% | 31-40% | 21-30% | 11-20% | 6-10% | 0-5%

Differences in salary and hiring difficulty also arise across industries. As shown in Table 5, the Finance industries consistently offer higher pay for DSA jobs than other industries. Possibly related to these above-average salaries, DSA jobs in Finance remain open for far shorter time periods, on average. By contrast, DSA jobs in Professional Services are consistently harder to fill than in other industries. On average, DSA jobs in Professional Services remain open for 53 days, eight days longer than the overall DSA average.

Table 5. Time-to-Fill by Industry

DSA Framework Category	Top Industries (by Demand Volume)	Average Time to Fill (Days)	Average Annual Salary
Data-Driven Decision Makers	Professional Services	50	$96,845
	Finance & Insurance	37	$98,131
	Manufacturing	43	$93,641
Functional Analysts	Finance & Insurance	35	$71,937
	Professional Services	48	$69,135
	Manufacturing	39	$72,571
Data Systems Developers	Professional Services	51	$82,447
	Finance & Insurance	35	$87,039
	Manufacturing	43	$81,138
Data Analysts	Professional Services	47	$74,917
	Finance & Insurance	31	$83,209
	Manufacturing	41	$72,742
Data Scientists & Advanced Analysts	Professional Services	51	$97,457
	Finance & Insurance	43	$106,610
	Manufacturing	45	$92,543
Analytics Managers	Finance & Insurance	38	$113,754
	Professional Services	53	$107,185
	Manufacturing	40	$106,926

DSA SKILLS DIFFER ACROSS THE MARKET

Just as the nature of DSA job categories differs across industries, the nature of the individual skills and competencies required for these roles varies across the analytics landscape. The DSA framework groups together jobs requiring analytical expertise, but these roles fall along a spectrum of analytical capability, with some roles requiring familiarity with a far greater range of core analytical skills than others. To distinguish between the types of analytical competencies required within the DSA landscape, Burning Glass scored individual jobs from 0 to 100 based upon their level of analytical rigor.

Jobs were assessed based on the proportion of jobs calling for analytical skills and the relative value of these skills in the market. Analytical skills were identified from Burning Glass's taxonomy of 15,000 skills, of which more than 300 are core analytical skills. These skills may cut across multiple job categories—such as SQL, Data Analysis, and Business Intelligence—while others are more specialized and are primarily confined to very specific roles, such as Machine Learning and Apache Hadoop for Data Scientists, and Financial Modeling and SAS for Financial Quantitative Analysts. The resulting analytical scores are shown in Table 6 for the top analytical jobs in 2015.

Table 6. Top Analytical Occupations

DSA Framework Category	Occupation	Analytical Score (2015)
Data Scientists & Advanced Analysts	Data Scientist	100
Data Scientists & Advanced Analysts	Data Engineer	98
Data Scientists & Advanced Analysts	Biostatistician	91
Data Systems Developers	Database Architects and Developers	91
Data Scientists & Advanced Analysts	Statistician	88
Analytics Managers	Human Resources Analytics Manager	87
Analytics Managers	Chief Analytics Executives	87
Analytics Managers	Directors of Analytics/ Data	86
Data Scientists & Advanced Analysts	Financial Quantitative Analyst	86
Data Systems Developers	Database Administrator	86

Data Scientists are the most analytical roles in the market. They require proficiency with a large range of specialized analytical skills and tools, such as Machine Learning, Apache Hadoop, and Data Mining, in addition to generalized DSA skills like SQL, R, and Data Analysis. Data Engineers and Biostatisticians—which also fall into the Data Scientists and Advanced Analysts category—round out the top three analytical roles in the market. Multiple Analytics Managers also are among the most analytical roles, and these positions must combine analytical abilities with strong managerial experience. Chief Analytics Executives, for example, is an emerging c-suite role that must incorporate executive responsibilities with deep analytical knowledge.

While the analytical scores provide insight into skills requirements and the extent to which DSA skills drive the demand in each occupation, they also illustrate how skill requirements can differ markedly across the DSA landscape. To dig deeper into specific analytics skills valued by the market, and how they are combined with other domain-specific competencies, the top skills across the market were evaluated. Table 7 shows the key analytics and specialized skills demanded across each DSA category.

Although some analytics skills span multiple DSA categories—such as data analysis and SQL—each category is defined by a unique combination of skills. Data Scientists and Advanced Analysts, for instance, must be familiar with sophisticated analytical methods and tools—such as Machine Learning and Apache Hadoop—

while Functional Analysts require more general Data Analysis and Business Intelligence skills. There is also a divide between DSA jobs that require more established analytics skills, such as SQL, and newer disruptive skills, such as Hadoop. Data Scientists and Advanced Analysts, for example, fall into the latter camp of jobs that requires skills on the vanguard of DSA technologies, while Data Analysts still are more likely to require SQL, Business Intelligence, and other legacy DSA skillsets. Data Systems Developers, on the other hand, must balance a need for both older and newer analytical skillsets as IT departments grapple with the need to adopt newer technologies while maintaining existing infrastructure.

Table 7. Top Analytical and Specialized Skills by DSA Framework Category

DSA Framework Category	Occupation	Analytical Score (2015)
Analytics Managers	Financial Analysis SQL SAS Data Analysis Business Intelligence	Budgeting Project Management Risk Management Accounting Financial Planning
Data Analysts	Data Analysis SQL Business Intelligence Data Warehousing SAS	Project Management Microsoft Access Business Process SAP Business Analysis
Data Systems Developers	SQL Database Administration Extraction, Transformation, and Loading Data Warehousing Apache Hadoop	Project Management LINUX Software Development UNIX JAVA
Data Scientists & Advanced Analysts	Apache Hadoop Machine Learning Big Data R Data Science	Python JAVA Economics C++ Project Management
Data-Driven Decision Makers	SQL Financial Analysis Data Analysis Data Management Data Validation	Budgeting Project Management Accounting Supervision Product Management
Functional Analysts	Financial Analysis SQL Data Analysis Data Management SAS	Budgeting Accounting Business Analysis Business Process Economics

Some DSA jobs require a mix of deep domain-specific expertise and general competence across a broad range of functions—a so-called "T-shaped" skill distribution. This is true of Analytics Managers, who must not only have knowledge of a specific functional domain—such as Human Resources or Marketing—but also must possess analytical skills, project management skills, and financial planning and budgeting skills. Preparing workers for these roles is problematic, since these skills cut across a diverse mix of functional areas.

Hybrid jobs that require deep expertise in multiple functional areas also present unique challenges for employers and training providers. These roles often require a mix of deep analytical expertise and strong

domain-specific knowledge, both of which may take years to develop. Marketing Analytics Managers, for example, require analytics skills such as SQL, Big Data, and Predictive Modeling along with expertise in marketing, product management, and market strategy. Candidates with all these skills are rare, so new training methods to prepare workers for these roles must be developed.

Although the range of analytics skills requested throughout the market makes it difficult for training providers and employers to isolate specific competencies to address with training and recruiting resources, they can direct these resources by focusing on the most critical skills across the DSA ecosystem. To pinpoint these skills, this study identifies the most demanded, fastest growing, highest paying, and hardest to fill analytics skills.

Table 8. Top Analytical Skills Within the DSA Landscape

Skill Name	Total Postings in 2015
SQL	338,555
Data Analysis	166,285
Financial Analysis	155,331
Data Management	113,807
Mathematics	107,297
Data Warehousing	97,797
SQL Server	93,630
Database Administration	92,256
Business Intelligence	88,603
Extraction, Transformation, and Loading (ETL)	82,920

Table 9. Fastest Growing Analytical Skills (with at Least 7,500 Postings)

Skill Name	Predicted 2-Year Growth
Data Science	93%
Machine Learning	56%
Tableau	52%
Big Data	50%
Data Visualization	44%
R	41%
Apache Hive	41%
Predictive Analytics	39%
Apache Hadoop	35%
Pivot Tables	34%

Table 8 shows that analytics skills that cut across DSA-related job categories—this includes skills such as SQL, Data Analysis, and Business Intelligence—are in the most demand, but data infrastructure skills—such as Data Warehousing, Database Administration, and ETL—are also among the most-demanded analytics skills.

Although the skills listed in Table 8 are the most important analytics skills in terms of sheer volume of demand, the analytical skills projected to grow the fastest are in greater danger of facing widening skill gaps. The skills projected to grow the fastest include advanced analytical competencies—such as Data Science and Machine Learning—as well as Data Visualization–related skills and basic analytical tools, such as Pivot Tables in Excel, that are increasingly required across job categories (see Table 9).

Identifying the highest-paying analytical skills will interest students and existing workers who want to maximize their earning potential. These highly lucrative analytical skills include advanced analytical and Big Data skills, such as MapReduce, Machine Learning, Apache Hadoop, Data Science, and MongoDB, all of which have average salaries above $100,000 (see Table 10).

Table 10. Highest Paying Analytical Skills (with at Least 7,500 Postings)

Skill Name	Average Salary
MapReduce	$115,907
PIG	$114,474
Machine Learning	$112,732
Apache Hive	$112,242
Apache Hadoop	$110,562
Big Data	$109,895
Data Science	$107,287
NoSQL	$105,053
Predictive Analytics	$103,235
MongoDB	$101,323

Table 11. Hardest-to-Fill Analytical Skills (with at Least 7,500 Postings)

Skill Name	Predicted 2-Year Growth
Enterprise Data Management	69
Database Schemas	69
Data Governance	59
Database Architecture	59
Apache Hive	56
Big Data	56
MapReduce	55
SAP Analytics	55
Online Analytical Processing (OLAP)	54
Apache Pig	53

For employers, it is critically important to know which skills are the hardest to fill, and how long it will take to find workers with these skills, so as to mitigate hiring difficulties. Across all analytics skills, those taking the longest for employers to hire include data infrastructure and management skills, such as Enterprise Data Management and Database Architecture; Big Data–related skills, such as Apache Hive and Pig; and Data Governance (see Table 11).

Understanding where and how these skills manifest in the market is critical for developing a pool of workers possessing the key competencies needed for the most important and hardest-to-fill DSA jobs. Table 12 shows that some roles, such as Data Scientists and Data Engineers, require combinations of skills that individually are hard to find—such as Data Science and Machine Learning for Data Scientists, or Apache Hadoop and Python for Data Engineers. Finding candidates with all these skills compounds the difficulty for employers.

Moreover, context matters when it comes to hiring difficulty. In some roles, an analytical skill may be a common or assumptive skill, but in others it is rarely found. The statistical programming language R, for example, is one of the most commonly requested skills for Data Scientists; for Finance and Risk Analytics Managers, however, it is less common, making it both harder to find and one of the highest-paying skills for Finance and Risk Analytics Managers.

Analytical skills are not just confined to the core DSA jobs included in the framework, however. Extending the analytical scoring analysis to jobs outside of the DSA framework shows that demand for analytical skills is spreading to disparate corners of the job market, and employers must source analytically literate workers for a variety of roles. In some cases, existing roles are absorbing new analytical skills—as is the case when Graphic Designers are expected to have data visualization skills or IT workers to understand Big Data and database infrastructure. In other cases, roles such as Engineers and Scientists, which have always had a quantitative focus, are utilizing newer analytical tools and methods.

The Finance industry has already recruited Physicists and workers from other highly quantitative disciplines for positions as Financial Quantitative Analysts. Similarly, Engineers and Scientists may represent an untapped pool of talent for Data Scientists and Advanced Analysts or other advanced analytics roles. Directing workers from these back grounds into the DSA talent pipeline could help alleviate hiring difficulties for many of the hardest-to-fill DSA roles (see Table 13).

Table 12. Key Skills and High-Paying Skills by Occupation

Occupation	Key Skills	High-Paying Skills
Data Scientist	Data Science Machine Learning Python R Apache Hadoop	Pattern Recognition Database Schemas Quantitative Analysis Object-Oriented Analysis and Design Database Administration
Data Engineer	Data Engineering Big Data Apache Hadoop JAVA Python	Spark Programming Oozie Predictive Models Apache Flume PIG
Finance and Risk Analytics Manager	Risk Management Financial Analysis and Planning Forecasting and Financial Modeling Project Management SQL	MATLAB Mergers and Acquisitions Data Warehousing Project Management R

Table 13. Analytical Scores and Key Analytical Skills in non-DSA Occupation

Occupation		Analytical Score	Key Analytical Skills
Science	Epidemiologist	80	SAS Data Analysis Biostatistics
	Physical Scientist	75	Advanced Mathematics Data Analysis MATLAB
Engineering	Biomedical Engineer	68	Advanced Mathematics Data Validation MATLAB
	Optical / Laser Engineer	67	MATLAB Data Validation Data Analysis
IT	Computer Scientist	70	Advanced Mathematics Data Analysis Machine Learning
	Network Administrator	67	VMware SQL Database Administration
	Software Developer	67	SQL Database Design Data Management
Design	UI / UX Designer / Developer	56	SQL Web Analytics Data Visualization
	Graphic Designer	32	Data Visualization Data Validation SQL

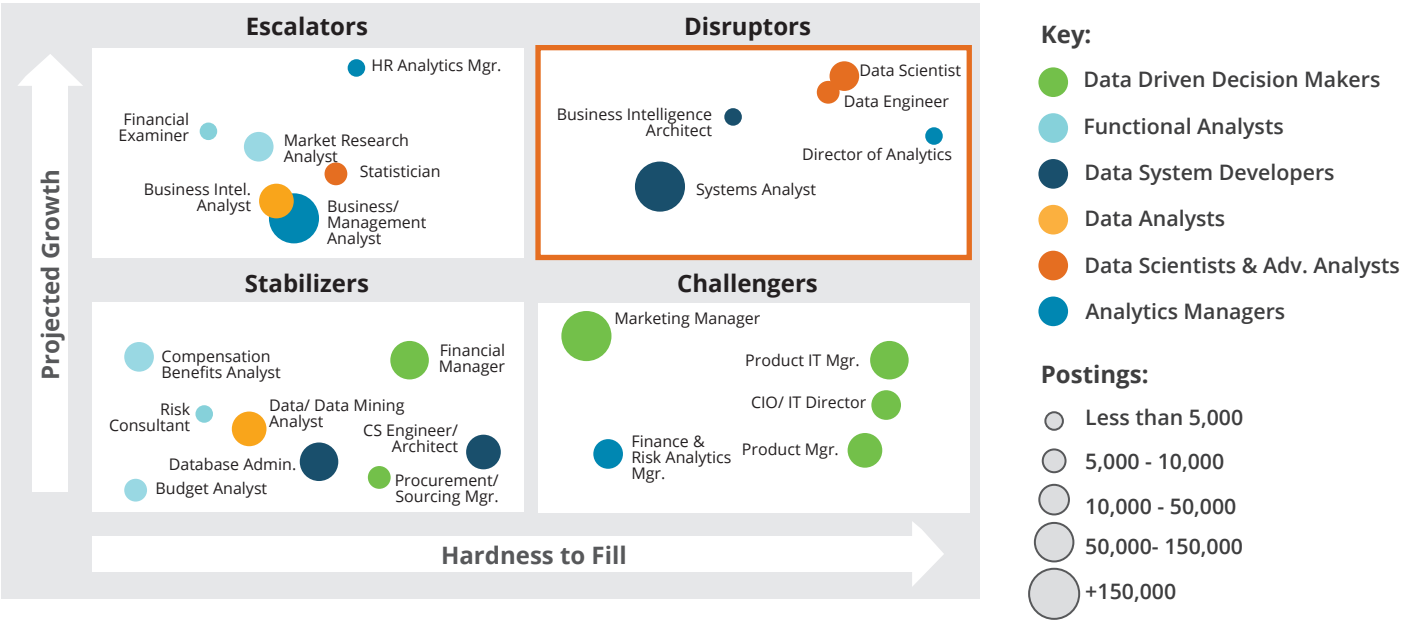
CONTEXTUALIZING THE DISRUPTION

Identifying the hardest-to-fill and fastest growing DSA jobs and skills is critically important for employers, educators, and other stakeholders, but this information does not, in and of itself, suggest where resources should be directed. To contextualize how jobs and skills should be prioritized for workforce development initiatives, this study creates a 2x2, four-category matrix of DSA jobs and skills (Figure 1). The matrix is organized by growth and hardness to fill. The four categories are Disruptors, Escalators, Challengers, and Stabilizers.

Figure 1. DSA Job and Skill Matrix

At the top right of the matrix are the Disruptors—jobs that are projected to grow at a high rate, and at the same time are the most difficult to fill. Disruptors present the biggest concern; in the near future, they are the jobs most likely to suffer from supply shortages, which could prevent firms from utilizing Big Data to its full potential. Key Disruptors jobs include Data Scientists, Data Engineers, and Directors of Analytics. Escalators and Challengers are also in danger of eroding the gains that firms can realize from Big Data. Key jobs in Escalators are Business Intelligence Analysts and Human Resources Analytics Managers, and key jobs in Challengers are Finance and Risk Analytics Managers and Marketing Managers (see Figure 2).

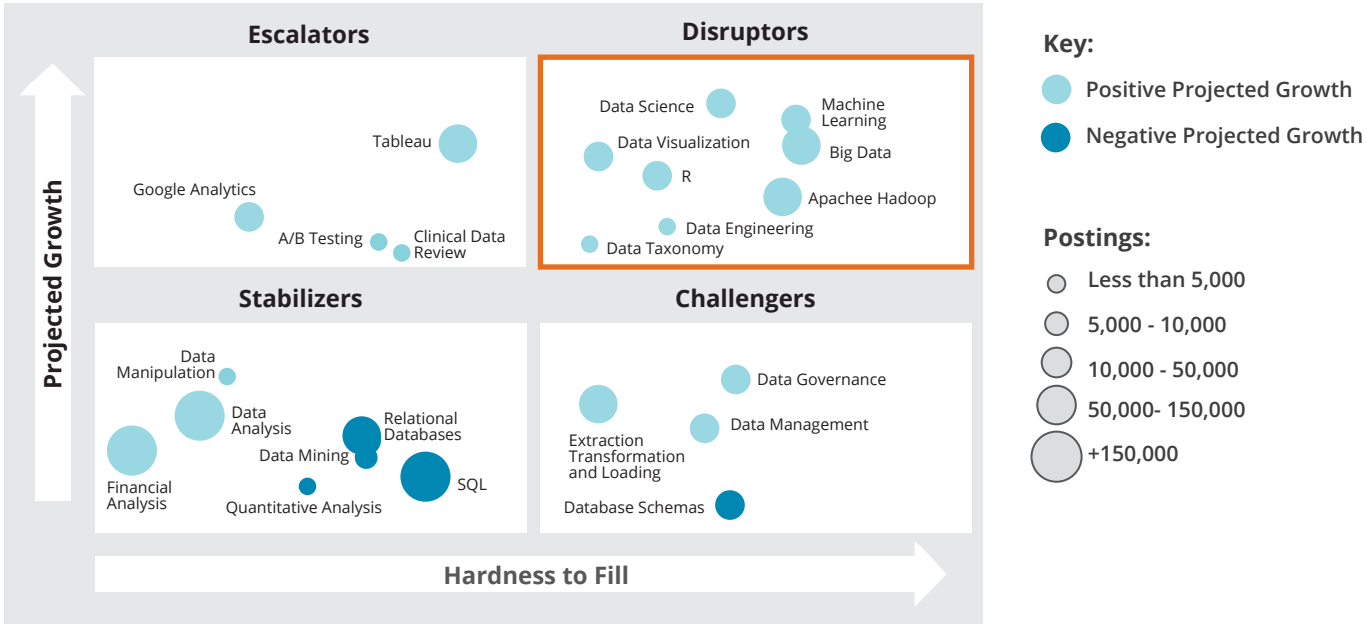
Figure 2. DSA Jobs Matrix



Focusing on skills, important Disruptors include Apache Hadoop, Machine Learning, and Data Engineering. Escalators include skills such as A/B Testing, Google Analytics, and Clinical Data Review; this reflects the growing demand for both digital marketing skills and data-driven approaches to clinical care. Key Challengers include skills related to enterprise-wide data management, such as Data Architecture and Data Governance (see Figure 3).

The jobs and skill matrices pinpoint the gaps in the current DSA market that warrant the greatest attention from employers, training providers, and workforce development officials. If these gaps are not mitigated, the consequences include higher costs for organizations as they struggle to find adequate talent for the roles that are most in demand, and more turnover as workers move to firms and industries where these skills are most highly valued. DSA jobs are already heavily concentrated in select industries, and if this trend continues then there is a threat of an "analytical capabilities divide." The majority of the destabilizing jobs and skills identified require significant time and effort to develop, so if they are not addressed immediately the talent shortage is in danger of persisting indefinitely.

Figure 3. DSA Skills Matrix



RECOMMENDATIONS

Mitigating these gaps will take a concerted effort from all the stakeholders, and there is no one-size-fits-all solution. The following, however, are a few actions that could alleviate the DSA talent shortage.

Data Literacy for Everyone: Data and analytics skills are spreading to new corners of the job market, and the torrents of information that firms are collecting will enable workers at all levels to make better data-driven decisions. However, organizations will only benefit from their data if workers across the value chain possess at least foundational data literacy. Otherwise, potential insights and innovations will go unnoticed, or even worse, misinterpretation of data will lead to poor decisions.

To achieve widespread data literacy, next generation students must be exposed to data and its relevance and applicability early. Ideally, students graduating from high school should already have reached a baseline data literacy that they can then apply across college and university departments. For those already in post-secondary education or in the workforce, data literacy can be factored into degree programs, online learning, or employer programs.

New DSA-Focused Education Programs: Education or experience requirements are particularly high for many emerging DSA roles, such as Data Scientists and Data Engineers. Data Scientist positions, for instance, require 42% of candidates to have a graduate degree, and more than 20% of candidates are expected to have more than six years of experience. Such demanding employer requirements block the talent pipeline for these roles by preventing a steady flow of new workers into the talent pool.

Accelerated development of new learning pathways which are specifically targeted at preparing candidates for DSA roles are needed. A variety of pathways are needed to match individual needs. These include new DSA degree programs, boot camps, or internal training programs. All programs must focus on competencies and mastery.

Continuous developments of competences and skills: Technologies change quickly. This reality requires a new type of workforce and attitude from both employers and employees around continuous learning and mastering skills that will enable employees to be prepared for not-yet-arrived jobs of the future. It is clear from the data that closing the DSA talent gap will require new strategies for up-skilling and re-skilling the incumbent workforce. New graduates alone will not close this gap. Whenever possible, employers should pair new graduates of emerging DSA education programs with experienced mentors to speed career development.

Initiate data labs: Data labs are creative spaces bringing together learners, experts from industry and academia, open data, and data systems to collaborate on challenging problems. Data labs can exist anywhere. Their purpose is to support the needs of a community, which could be a university, a city, a company, or a coalition of organizations. Data labs bring together the human capital, technology, and data to serve as a central resource whose mission is to help the community become data-driven and more importantly speed talent development. Academic data labs that serve the broader community exist, such as at the University of Edinburgh, which acts as a public/private co-laboratory for Scotland. Many more are needed to foster development of data-savvy professionals.

Top-down action plans for organizations: Organizations should define the DSA job roles and requisite skills for each, then analyze existing workforce readiness. Key steps include naming a chief data and/or analytics officer, identifying talent already well suited for DSA roles, identifying those ready for up-skilling initiatives, and identifying organizational gaps to prioritize recruiting efforts. Leaders can also go further and create learning pipelining programs to support staff progression. For example, pipeline programs could be tailored to individual employee needs by focusing on key workforce segments: such as employees new to an organization, new to an industry, new to data and analytics, or ready to reach the next level of analytical mastery.

APPENDIX

Appendix 1: DSA Demand by Industry

Industry	Industry Job Openings that Fall within the DSA Framework
Finance and Insurance	19%
Professional, Scientific, and Technical Services	18%
Information	17%
Management of Companies and Enterprises	13%
Manufacturing	12%
Utilities	10%
Wholesale Trade	9%
Mining, Quarrying, and Oil and Gas Extraction	9%
Public Administration	7%
Other Services (except Public Administration)	6%
Agriculture, Forestry, Fishing and Hunting	6%
Educational Services	5%
Real Estate and Rental and Leasing	5%
Administrative and Support and Waste Management and Remediation Services	5%
Arts, Entertainment, and Recreation	4%
Retail Trade	3%
Transportation and Warehousing	3%
Construction	3%
Accommodation and Food Services	3%
Health Care and Social Assistance	3%

Appendix 2: DSA Postings and Location Quotients by State

	Data-Driven Decision Makers		Functional Analysts		Data Systems Developers		Data Analysts		Data Scientists & Advanced Analysts		Analytics Managers	
	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ
AK	1,123	0.6	1,351	0.7	679	0.5	109	0.4	40	0.3	58	0.6
AL	4,686	0.4	5,454	0.5	4,602	0.6	566	0.3	186	0.3	131	0.2
AR	3,165	0.5	3,339	0.5	2,193	0.5	532	0.5	132	0.3	100	0.3
AZ	18,477	1.2	19,748	1.4	15,003	1.4	3,199	1.4	532	0.6	803	1.1
CA	134,201	1.5	103,547	1.2	84,739	1.4	19,868	1.4	11,407	2.1	5,978	1.4
CO	19,979	1.4	18,747	1.4	17,000	1.7	2,735	1.2	762	0.9	930	1.3
CT	13,229	1.4	13,598	1.5	9,656	1.4	2,577	1.7	729	1.3	926	2.0
DC	10,321	2.6	14,299	3.8	10,822	4.0	1,974	3.2	1,335	5.6	562	2.9
DE	2,901	1.1	4,347	1.8	2,733	1.6	760	1.9	285	1.9	461	3.7
FL	34,353	0.7	35,188	0.8	24,583	0.8	4,907	0.7	1,031	0.4	1,347	0.6
GA	25,561	1.1	24,854	1.1	19,917	1.2	4,555	1.2	1,050	0.7	1,194	1.0
HI	1,464	0.4	1,457	0.4	750	0.3	134	0.2	36	0.2	28	0.2
IA	6,356	0.7	8,130	1.0	4,534	0.7	1,406	1.0	289	0.5	294	0.7
ID	1,998	0.5	1,771	0.5	1,074	0.4	225	0.4	65	0.3	46	0.3
IL	45,128	1.3	44,084	1.3	27,827	1.2	7,323	1.4	2,149	1.0	2,263	1.4
IN	9,653	0.6	8,673	0.5	5,723	0.5	1,417	0.5	395	0.4	258	0.3
KS	4,504	0.6	4,441	0.6	3,385	0.6	699	0.6	133	0.3	142	0.4
KY	5,484	0.5	5,596	0.5	3,235	0.4	684	0.4	97	0.2	211	0.4
LA	4,285	0.4	3,816	0.4	2,176	0.3	376	0.2	79	0.1	128	0.2
MA	29,229	1.5	26,090	1.4	17,992	1.3	4,006	1.3	3,064	2.6	1,590	1.6
MD	14,243	0.9	17,289	1.2	16,312	1.6	2,436	1.0	1,364	1.5	618	0.8
ME	2,099	0.6	2,285	0.7	1,310	0.5	357	0.7	52	0.3	117	0.7
MI	20,119	0.8	19,817	0.9	16,436	1.0	3,237	0.9	775	0.5	671	0.6
MN	17,771	1.1	19,229	1.2	12,541	1.1	3,262	1.3	620	0.6	742	0.9
MO	10,142	0.6	10,591	0.7	7,903	0.7	1,812	0.7	593	0.6	378	0.5
MS	2,012	0.3	1,743	0.3	873	0.2	191	0.2	48	0.1	54	0.2
MT	1,365	0.5	1,195	0.5	648	0.4	140	0.3	41	0.3	65	0.5
NC	21,440	0.9	22,758	1.0	18,819	1.1	4,849	1.3	1,196	0.8	1,201	1.0
ND	867	0.3	900	0.4	394	0.2	86	0.2	11	0.1	24	0.2
NE	3,417	0.6	4,053	0.8	2,486	0.6	539	0.6	148	0.4	148	0.5
NH	2,255	0.6	1,990	0.6	1,832	0.7	328	0.6	63	0.3	111	0.6
NJ	38,944	1.7	35,216	1.6	25,575	1.6	5,835	1.7	2,736	2.0	2,117	1.9
NM	1,978	0.4	2,109	0.5	1,248	0.4	214	0.3	71	0.3	55	0.2
NV	4,583	0.6	3,827	0.6	2,617	0.5	425	0.4	101	0.2	224	0.6

Appendix 2: DSA Postings and Location Quotients by State (Continued)

	Data-Driven Decision Makers		Functional Analysts		Data Systems Developers		Data Analysts		Data Scientists & Advanced Analysts		Analytics Managers	
	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ
NY	70,405	1.3	66,106	1.3	35,316	1.0	10,375	1.3	5,757	1.8	6,078	2.4
OH	29,281	0.9	27,380	0.9	18,248	0.9	4,152	0.9	1,027	0.6	1,092	0.7
OK	3,342	0.4	3,377	0.4	2,321	0.4	572	0.4	64	0.1	119	0.3
OR	14,302	1.4	13,485	1.4	8,940	1.3	1,868	1.2	610	1.0	478	1.0
PA	26,735	0.8	24,083	0.8	16,155	0.7	3,864	0.8	1,631	0.8	1,167	0.7
RI	3,736	1.3	3,257	1.2	2,226	1.2	537	1.3	136	0.8	372	2.8
SC	5,478	0.5	4,959	0.5	3,635	0.5	668	0.4	154	0.2	138	0.3
SD	2,197	0.9	2,221	1.0	880	0.5	299	0.8	56	0.4	73	0.6
TN	10,575	0.6	10,548	0.7	6,982	0.6	1,582	0.6	291	0.3	365	0.5
TX	56,792	0.8	54,641	0.8	38,874	0.8	8,409	0.8	1,969	0.5	2,286	0.7
UT	6,411	0.8	5,823	0.8	3,884	0.7	773	0.6	411	0.9	201	0.5
VA	22,071	1.0	28,901	1.4	27,654	1.9	3,916	1.2	1,629	1.3	1,269	1.2
VT	1,046	0.6	811	0.5	483	0.4	75	0.3	24	0.2	31	0.4
WA	25,977	1.5	18,109	1.1	14,127	1.2	3,126	1.2	2,066	2.0	947	1.1
WI	12,250	0.8	11,779	0.8	6,734	0.6	1,755	0.7	244	0.3	418	0.5
WV	988	0.2	1,154	0.3	701	0.2	99	0.2	22	0.1	17	0.1
WY	547	0.3	426	0.3	244	0.2	31	0.1	19	0.2	21	0.3

Note: LQ is the location quotient, representing the concentration of demand relative to national demand.

Appendix 3: DSA Postings and Location Quotients for the Top 20 Metro Areas

	Data-Driven Decision Makers		Functional Analysts		Data Systems Developers		Data Analysts		Data Scientists & Advanced Analysts		Analytics Managers	
	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ	Postings	LQ
New York, NY	92,865	1.7	84,389	1.7	50,311	1.4	13,855	1.7	7,565	2.4	7,347	2.9
San Francisco, CA	43,529	3.4	30,682	2.5	22,705	2.6	6,931	3.5	5,533	7.2	2,478	4.0
Los Angeles, CA	42,441	1.3	35,106	1.1	27,408	1.2	6,016	1.2	2,184	1.1	1,590	1.0
Chicago, IL	42,008	1.6	40,731	1.6	25,028	1.4	6,691	1.7	2,091	1.3	2,145	1.7
Washington, DC	30,448	1.7	40,478	2.4	37,510	3.1	5,555	2.1	3,506	3.3	1,801	2.1
Dallas, TX	26,895	1.4	25,500	1.4	19,808	1.5	4,602	1.5	913	0.8	1,241	1.3
Boston, MA	26,733	1.7	23,872	1.6	16,829	1.6	3,698	1.6	2,919	3.2	1,482	2.0
Seattle, WA	22,696	2.1	14,695	1.4	11,968	1.6	2,833	1.7	1,948	3.1	844	1.6
Atlanta, GA	21,708	1.5	20,630	1.5	17,496	1.7	4,014	1.8	946	1.1	1,052	1.5
San Jose, CA	20,491	3.4	12,322	2.2	16,636	4.1	3,327	3.6	2,225	6.3	1,042	3.6
Philadelphia, PA	19,822	1.2	19,200	1.3	12,866	1.2	3,301	1.3	1,661	1.7	1,301	1.7
Phoenix, AZ	15,808	1.4	16,931	1.6	12,956	1.7	2,848	1.7	434	0.7	710	1.3
Minneapolis, MN	14,918	1.3	16,420	1.6	10,996	1.4	2,955	1.7	547	0.8	675	1.3
Denver, CO	15,202	1.9	14,419	1.9	12,662	2.3	2,261	1.8	576	1.2	739	1.9
Houston, TX	13,944	0.8	14,558	0.9	7,805	0.7	1,792	0.7	461	0.4	572	0.7
Detroit, MI	12,708	1.1	13,470	1.3	12,117	1.6	2,460	1.4	548	0.8	512	0.9
Miami, FL	13,113	0.9	12,269	0.9	7,636	0.8	1,728	0.8	342	0.4	568	0.8
Charlotte, NC	10,949	1.7	11,739	1.9	10,097	2.2	3,222	3.2	364	0.9	797	2.5
Portland, OR	11,374	1.8	11,192	1.8	7,652	1.7	1,624	1.7	534	1.4	376	1.2
Cincinnati, OH	10,433	1.7	9,723	1.7	5,307	1.3	1,522	1.6	419	1.2	361	1.2

Appendix 4: Demand by DSA Framework Category and Top Occupations

Framework Category	Occupation	Number of Postings in 2015	Projected 5-Year Growth	Average Time to Fill (Days)	Postings Requiring Master's or Higher	Postings Requesting Experienced Workers (at Least 3 Years Prior Work Experience)	Average Annual Salary
Analytics Managers	Analytics Product Manager	1,812	14%	50	9%	90%	NA
	Chief Analytics Executives	457	16%	NA	13%	95%	NA
	Director of Analytics/Data	1,662	26%	73	4%	98%	NA
	Finance and Risk Analytics Manager	23,623	12%	40	13%	94%	$102,568
	Human Resources Analytics Manager	848	44%	NA	5%	96%	$111,095
	IT Manager - Data & Analytics	6,067	18%	37	6%	92%	$99,051
	Marketing Analytics Manager	4,674	16%	46	15%	97%	$123,591
Data Analysts	Business Intelligence Analyst	58,116	19%	37	6%	80%	$72,859
	Data / Data Mining Analyst	66,209	13%	38	7%	72%	$67,396
Data Analysts	Business Intelligence Architect	4,366	27%	47	2%	53%	$99,970
	Computer Systems Engineer / Architect	117,979	11%	46	4%	88%	$86,883
	Data Warehousing Specialist	32,025	12%	43	5%	87%	$77,911
	Database Administrator	152,470	11%	43	3%	84%	$74,657
	Database Architects and Developers	46,255	20%	39	5%	89%	$89,611
	Systems Analyst	205,231	19%	58	3%	81%	$73,811
Data Scientists & Advanced Analysts	Biostatistician	5,416	22%	51	68%	78%	$83,588
	Data Engineer	9,911	39%	46	4%	88%	$108,808
	Data Scientist	14,394	39%	48	43%	82%	$105,676
	Economist	3,097	12%	45	51%	65%	$80,865
	Financial Quantitative Analyst	5,653	6%	43	47%	70%	$103,620
	Statistician	9,876	20%	43	36%	71%	$69,265
Data-Driven Decision Makers	Chief Executive Officer	28,643	2%	39	20%	92%	$97,391
	Chief Information Officer / Director of IT	35,242	14%	56	5%	95%	$102,928
	Compensation and Benefits Manager	13,716	6%	40	3%	86%	$81,992
	Financial Manager	122,798	16%	41	5%	89%	$88,805
	Human Resources Manager	70,929	14%	40	3%	89%	$86,529
	IT Project Manager	175,661	15%	60	4%	92%	$94,164
	Marketing Manager	153,117	16%	45	6%	89%	$92,225
	Operations Manager	48,906	15%	39	63%	71%	$83,513
	Procurement Manager	19,711	8%	42	3%	93%	$83,446

Appendix 4: Demand by DSA Framework Category and Top Occupations (Continued)

Framework Category	Occupation	Number of Postings in 2015	Projected 5-Year Growth	Average Time to Fill (Days)	Postings Requiring Master's or Higher	Postings Requesting Experienced Workers (at Least 3 Years Prior Work Experience)	Average Annual Salary
Data-Driven Decision Makers	Product Manager	64,453	12%	55	5%	89%	$100,124
	Quality Control Systems Managers	39,207	5%	43	3%	90%	$89,980
	Supply Chain / Logistics Manager	30,736	9%	41	3%	82%	$83,857
	Talent Acquisition / Recruiting Manager	8,980	18%	36	2%	81%	$83,146
Functional Analysts	Actuary	13,456	9%	54	3%	74%	$94,719
	Budget Analyst	5,769	5%	32	9%	65%	$66,921
	Business / Management Analyst	297,455	18%	40	5%	76%	$72,483
	Clinical Analyst / Clinical Documentation and Improvement Specialist	14,384	14%	42	1%	71%	$72,690
	Clinical Data Systems Specialist / Manager	30,162	24%	49	4%	78%	$72,399
	Compensation / Benefits Analyst	48,674	15%	36	2%	65%	$57,015
	Credit Analyst / Authorizer	17,663	16%	31	5%	60%	$63,143
	E - Commerce Analyst	17,192	16%	47	2%	78%	$74,619
	Financial Analyst	129,310	16%	40	4%	69%	$67,892
	Financial Examiner	4,629	24%	34	4%	71%	$70,580
	Fraud Examiner / Analyst	3,815	13%	31	2%	49%	$53,014
	Geographer / GIS Specialist	15,657	15%	36	6%	68%	$63,230
	HRIS Analyst / Specialist	4,324	18%	46	0%	74%	$66,239
	Human Resources Analyst	4,507	12%	44	2%	72%	$65,586
	Logistics / Supply Chain Analyst	20,288	14%	38	2%	70%	$64,013
	Market Research Analyst	38,829	23%	40	9%	64%	$69,893
	Operations Analyst	25,322	30%	37	5%	65%	$66,940
	Pricing Analyst	6,471	13%	40	2%	71%	$65,319
	Researcher / Research Associate	31,899	12%	42	27%	54%	$50,321
	Risk Analyst	12,116	14%	26	9%	74%	$78,528
	Risk Consultant	4,161	13%	19	5%	84%	$91,063
	Search Engine Optimization Specialist	12,509	17%	54	7%	62%	$70,402
	Security / Defense Intelligence Analyst	7,063	9%	44	7%	78%	$80,560
	Social Science Researcher	1,852	10%	40	23%	64%	$63,746
	Survey Researcher	2,934	7%	37	22%	63%	$50,443

ABOUT THE PROJECT PARTNERS

The research partnership between Burning Glass Technologies, BHEF, and IBM was motivated by the need to close the data science and analytics skills gap through data driven insights and increased collaboration between higher education and industry.

About Burning Glass Technologies

Burning Glass Technologies is an analytics software company that has cracked the genetic code of an ever-changing labor market. Powered by the world's largest and most sophisticated database of jobs and talent, we deliver real-time data and breakthrough planning tools that inform careers, define academic programs, and shape workforces.

About BHEF

The Business-Higher Education Forum (BHEF) is the nation's oldest membership organization of Fortune 500 CEOs, college and university presidents, and other leaders dedicated to the creation of a highly skilled future workforce. BHEF members collaborate and form strategic partnerships to build new undergraduate pathways; improve alignment between higher education and the workforce; and produce a diverse, highly skilled talent pool to meet demand in emerging fields.

About IBM

Data is transforming industries and professions. IBM offers data and analytics solutions designed for the new data professional. IBM is taking a leading role helping transform education to build a workforce pipeline of data literate professionals and new specialties such as the citizen analyst, data scientist, data engineer, and chief data officer.

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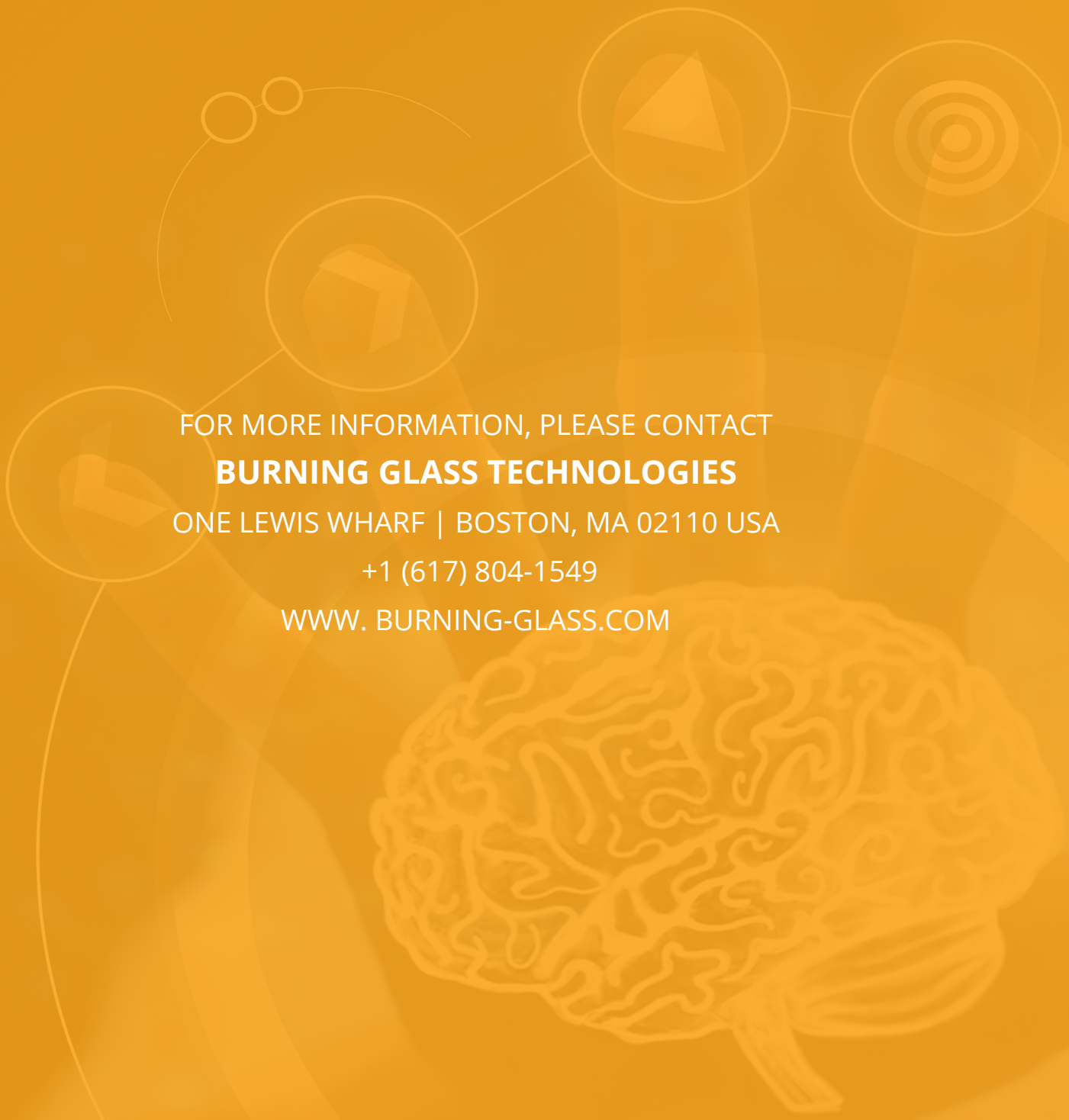

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