Trends in Data Science Job Postings on Stack Overflow

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Introduction

- Data Science becoming a more popular field –> attributes of data science jobs –> summary about most popular coding skills –> summary about Stack Overflow
- ***Harvard Business Review, October 2012:***
  - The term "data science" was coined in 2008 by data analytics leads at Facebook and LinkedIn
  - "Data Scientist" refers to a professional with training and curiosity to make discoveries about the world through big data.
  - HBR compares data scientists to the "quants" of Wall Street in the 1980s ans 1990s, when individuals with rigorous quantitative backgrounds were in high demand to develop algorithms and data strategies for investment banks and hedge funds.
  - Hal Varian, chief Economist at Google, quote: "The sexy job in the next 10 years will be statisticians. People think I'm joking, but who would've guessed that computer engineers would've been the sexy job of the 1990s?"
- ***Quant Crunch Data Science Demand Prediction Report:***
  - By 2020, there'll be an increase of 364,000 job openings for US data professionals, corresponding to a 39% increase in demand for data scientists and data engineers
  - Currently, data science jobs remain open for an average of 45 days, five days longer than other job types
  - 39% of data science jobs require a Masters or PhD
- ***Stack Overflow Developer Survey 2016:***
  - 50,000 respondents
  - Over 40 million people visit Stack Overflow's website every month.
  - 15% of respondents are actively looking for a job, while 78% are interested in hearing about job opportunities.
  - Of those looking for jobs on Stack Overflow, 26% are students
  - Biggest priorities in jobs are salary, work-life balance, and company culture
  - Average data scientist salary was $115,244
  - 9.4% of respondents check Stack Overflow just for job opportunities, and over half of all respondents (56.5%) check Stack Overflow multiple times a day

Research Aim

The purpose of this paper is to examine trends in job postings for "data scientists" on the Stack Overflow job board. This involves determining the most common computing skills that employers look for, along with their preferences of degree types and areas of study. This paper will also locate geographic regions where data science jobs are in highest demand, and if there are substantial differences in job characteristics by location. Finally, trends of these characteristics of job listings will be explored over time.

Methods

Data Collection

Data were made privately available upon request from David Robinson, a Data Scientist at Stack Overflow. The provided data consist of information from jobs posted on the Stack Overflow job board that either have "data scientist" or "data analyst" in their title between August 25, 2010 and September 25, 2017. While company names were censored from the data, the following attributes of each posting were provided in a data frame: job title, original posting date (YEAR-MM-DD), associated tags indicating relevant skills, job location (City, State, Country), salary (when included), whether a company would sponsor a visa, allow remote work, or offer assistance with relocation, and the full text of job descriptions and requirements.

While a fair amount of variables were already provided in a dataframe, additional information was extracted from the data and cleaned. The `geocode` function in the `ggmap` package was used to gather latitude and longitude coordinates for each job location. Preferences of academic backgrounds were extracted from the job requirements section. This included any mentions of type of degree (Bachelors, Masters, PhD) along with mentions of favorable majors and departments. To detect relevant majors, a dictionary was compiled using a comprehensive list of STEM fields provided by **Stemdegreelist.com**. Additionally, for jobs that mentioned multiple degrees (i.e, "Bachelor's degree required, Master's degree preferred"), the "highest degree preferred" for a job listing was determined. For listings that did not provide job requirement sections, the job descriptions section was used to check for these attributes.

Exploratory Data Analysis

Exploratory data analysis was conducted to summarize the most commonly listed attributes in the job postings. Skill tags, areas of study, and job locations were tabulated across all postings and ranked to determine the most common skills sought by employers, and where the most employment opportunities were geographically located. Hex maps were generated to view the distribution of the number of jobs posted by geographic location. To visualize the changes in the top ten tags, areas of study, and job locations over the last five years, code to generate a change-in-ranking plot was modified from a function described on **this Stack Overflow forum**. Number of job postings were also tabulated by year and geographic region to determine if there were any changes in frequency of postings by region over time.

Statistical Analysis

In order to assess any differences in jobs by location, proportions of jobs that offer visa sponsorship, allow remote work, and assist with relocation were compared between jobs listed in the US and Europe, the two geographic regions with the highest numbers of job listings, using two-sample t-tests. The distributions of highest degree preferred were compared across regions with a Pearson's Chi-squared test.

Results

The number of yearly data science job listings posted on Stack Overflow has increased over time, most notably more than doubling between 2013 (n=75) and 2014 (n=174) (Figure 2). Figure 1 displays the overall top ten skill tags, areas of study, and cities, while Figure 4 contains the top ten lists by year, and depicts how the rankings have changed over time. Differences between jobs listed in the United States and jobs listed in Europe are described in Table 1, and the geographic distributions of jobs in both regions are portrayed in Figure 3.

Skill Tags

The top three computing skills listed as tags on job listings are `Python`, `R` and `SQL` (Figure 1a). Of the 995 jobs listed, 448 jobs (45%) use the `Python` tag, 281 jobs (28.2%) use the `R` tag and 249 jobs (25%) use the `SQL` tag. While Python has consistently been the most tagged skill in data science job postings, R has become increasingly more important to employers hiring data scientists over the last three years, as it has jumped from the 5th-most frequent tag to the 2nd-most frequent tag from 2013 to 2017 (Figure 4a). Similarly, knowledge of machine learning algorithms has gained more popularity among employers hiring data scientists in a similar timeframe.

Areas of Study

Employers' focus on coding abilities are also highlighted in the top three preferred areas of study for data science job candidates (Figure 1b): Computer Science (n = 469, 47.1%), Statistics (n = 436, 43.8%) and Engineering (n = 301, 30.3%). Few to no changes in preferred areas of study of job candidates have occurred in the past five years, indicating that employers hiring data scientists have consistently sought candidates with quantitative and programming-based backgrounds (Figure 4b).

Location

In both the United States and Europe, the highest number of job listings appear to cluster regions where there are major cities. As seen in Figure 3, darker reds appear over big cities like New York and San Francisco (Figure 3a), and London and Berlin (Figure 3b), indicating higher numbers of job listings, while less dense and less industrial areas either have lighter shades of yellow or are white, indicating few to zero data science job opportunities. Interestingly, while New York and San Francisco are the two cities with the most overall job listings (Figure 1c), and have consistently ranked in the top two cities between 2013-2016, they have dropped to the fourth and fifth spots in 2017, as European cities like Berlin and London have risen to the top (Figure 4c). This geographic trend is also noticable in figure 2, where it is apparent that the proportion of jobs posted in 2017 that are located in Europe is much larger than that of earlier years.

While there are similarities in the types of cities with the most jobs in the US and Europe, there are

several differences between the job benefits and characteristics by region. European employers are more likely to offer visa sponsorship (EU: 20.8%, USA: 5.9%, $p < .01$) and to offer assistance with relocation (EU: 35.5%, USA: 26.6%, $p < .01$) than US employers. US employers are more likely to allow employees to work remotely (USA: 9.2%, EU: 2.8%, $p < .01$) and offer more jobs for candidates with Bachelor's Degrees only ($p < .01$) than European employers (Table 1).

Discussion/Limitations

There are several limitations to this work. First, these results do not generalize to *all* data science job listings on job boards and company pages. The trends seen here are specific to the job board on Stack Overflow, and may be biased towards particular industries, geographic regions, or any mechanism by which Stack Overflow obtains job listings to post on their site. Second, there is potential for under-estimation in the prevalence of computing skills in job listings. Skills were detected through tags on the job listings; it is possible that additional skills and computing languages were mentioned in the job description or requirements sections. Similarly, there is potential for error in scraping job descriptions for areas of study and degree types, since there may be some variability in how job descriptions are written and structured. Finally, since the data for 2017 are incomplete, trends over time may change once full data for the year are available.

Discussion:

Figure 1: Most Popular Attributes of Job Listings

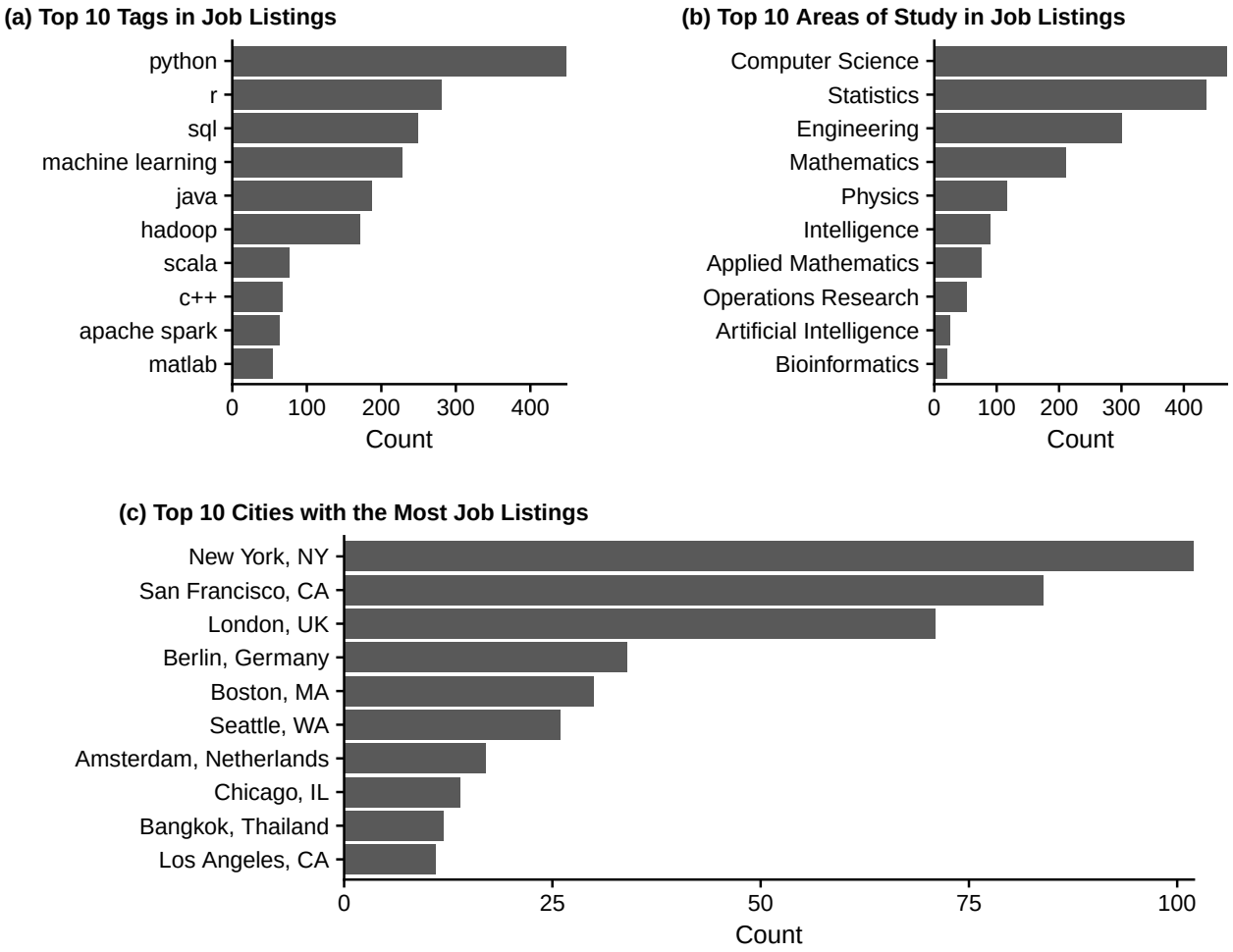


Figure 2: Number of Job Listings by Year and Geographic Region

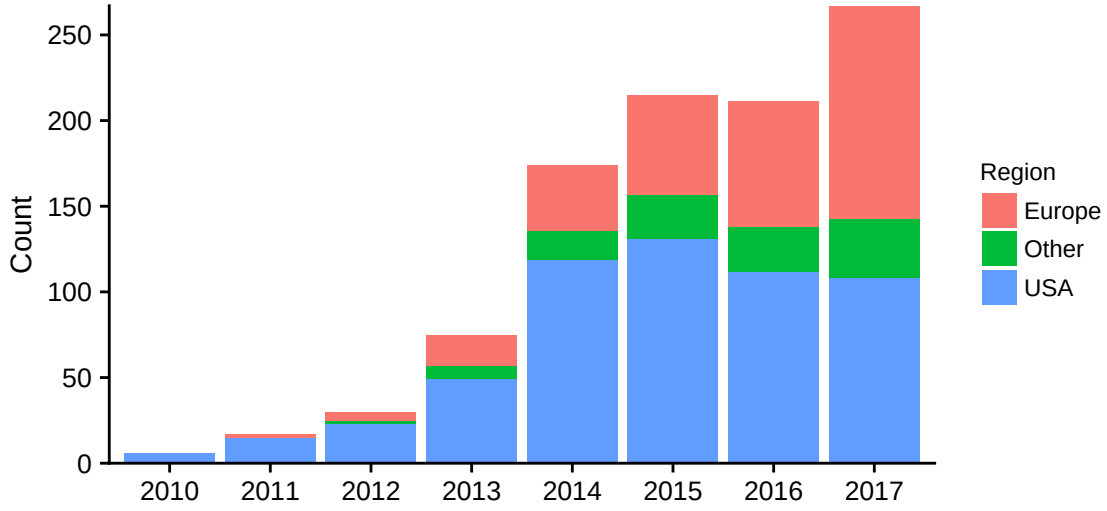


Figure 3: Geographic Distribution of Jobs in the USA vs. Europe

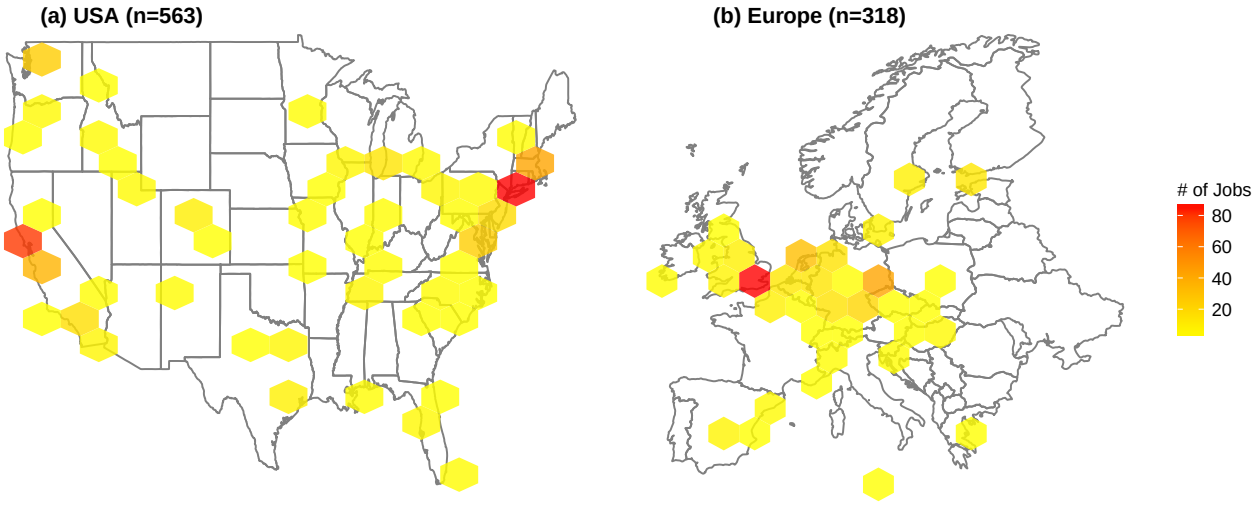


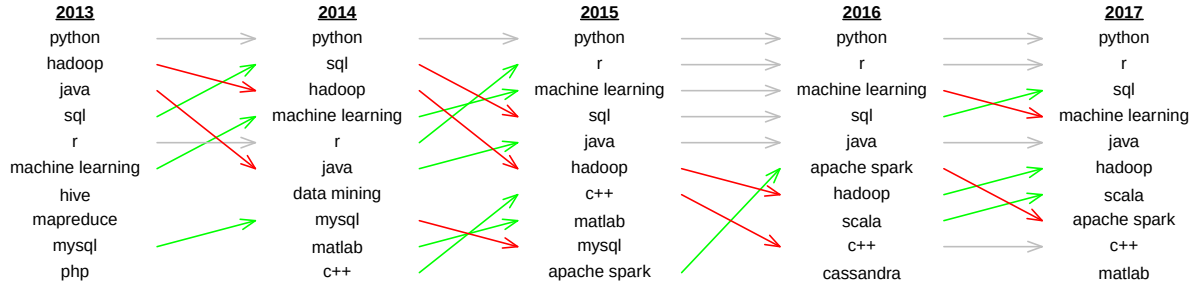
Table 1: Differences between Job Listings in the USA vs. Europe

	USA	Europe	P-value
Visa Sponsorship	33 (5.9%)	66 (20.8%)	3.81e-11
Allows Remote Work	52 (9.2%)	9 (2.8%)	5.42e-04
Offers Relocation	150 (26.6%)	113 (35.5%)	7.08e-03
Highest Degree Preferred:[1]			
Bachelors	122 (35%)	26 (19.4%)	3.32e-03
Masters	79 (22.6%)	34 (25.4%)	
PhD	148 (42.4%)	74 (55.2%)	

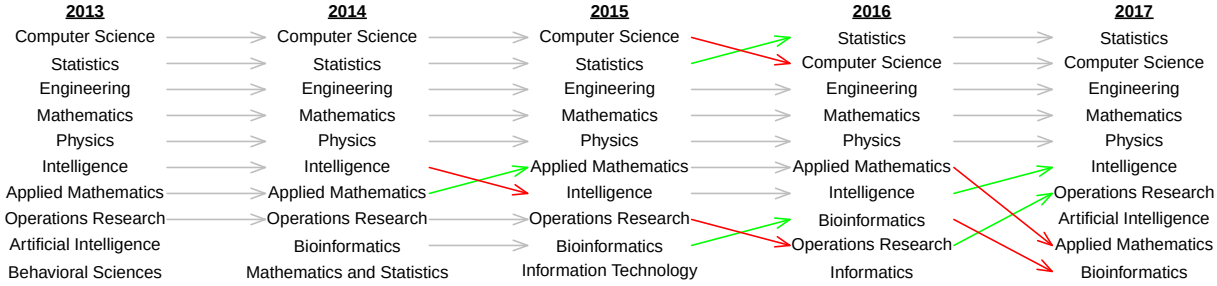
[1] Due to missingness, percents are calculated from totals of 349 for USA and 134 for Europe.

Figure 4: Changes in Job Listing Attributes over the Last Five Years

(a) Top 10 Tags by Year



(b) Top 10 Areas of Study by Year



(c) Top 10 Cities by Year