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KNOWLEDGE AND SKILLS ESSENTIAL FOR AUDITORS IN THE AGE OF BIG DATA – THE EARLY EVIDENCE FROM A SURVEY

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Abstract[1]

Constant technological breakthroughs change the way we do business. A wide variety of timely data can be used to help with reporting, auditing, and obtaining business insight. The accounting profession is transforming to take advantage of these advanced technologies. To respond to the drastic shift in knowledge and skills required for the job market, college accounting curriculum as well as professional training programs must respond quickly and appropriately. We conducted a survey in the summer of 2017 to help college educators and enablement professionals in redesigning their curriculum. This is the report of our survey.

Keywords: big data, data analytics, accounting education, auditor, accounting education

[1] This paper is an extension of Chapter 6 of Katherine Korol's Honors Thesis conducted at Elon University in 2017.

Introduction

Rapid technological innovations made transacting businesses faster, more efficient, and more convenient for both consumers and companies small and large. However, technological advances also transformed the ways in which criminals commit frauds. To combat accounting frauds, an increasing number of corporations and public accounting firms are taking advantage of available Big data tools. These tools vary widely in their functionality and objectives. There are tools to extract data from various resources, tools to assemble data from different sources and transform them into one accessible form, tools to help visualize the data and tell stories, tools for sophisticated statistical analyses, just to name a few.

The conventional skill set possessed by accountants no longer satisfies the demand in the job market (Drew 2019, PwC 2015, Tysiac 2019). To meet such demand, accounting firms added analytics into their training programs, and colleges rushed to add analytics courses into their course offerings. However, anecdotal evidence suggests that only a small number of accounting programs added analytics courses in 2017. Nowadays more accounting programs are offering analytics courses. Yet, the contents of these analytics courses varied widely from skills taught to tools used, which include Excel, Tableau, ACL, and Structured Query Language (SQL). In a professional discipline that is already filled with huge body of content knowledge, the accounting educators, who are also challenged with limited resources, need to be judicial in determining the most valuable new course(s) to offer to prepare new and experienced accountants for job market demand. Therefore, the objective of our research is to identify the most useful knowledge and skills in the age of Big data, so that accounting educators and the enablement professionals can be more strategic in offering college courses and/or training programs for accountants at different career stages and paths. To achieve our research objective, we conducted a survey of accountants at the end of summer 2017 to get a pulse of the knowledge and skills that were most useful in training auditors. This is a report of our findings.

The remainder of the paper is organized as follows: Section 2 provides a brief history of analytics education in accounting; Section 3 reports our survey methodology and the results; We offer concluding thoughts in the last section.

A Brief History of the Analytics Education in Accounting

The fierce competition in the global market promoted the use of analytics in business in early 2000 or even earlier. Davenport (2006) analyzed how industry leaders use analytics to gain competitive advantages and become the frontrunners in their fields. In the accounting profession, internal auditors and Internal Revenue Services (IRS) were the first to adopt big data analytics (High 2014). Internal auditors used data analytical tools to continuously monitor internal control mechanisms, and IRS used the

technologies to detect tax frauds (Alles et. al. 2012, Clark 2012, High 2014). Despite the increasing use in the profession at that time, the accounting curriculum in higher education had not kept pace with the technological advancement and market demand (Agnew 2016). Vasarhelyi (2012) made a clarion call for accounting educators to progressively advancing and integrating into main accounting offerings contents representing the modern enterprise environment.

Realizing the need to train the trainers, American Accounting Association, one of the largest associations of accounting educators, held the first "Accounting is Big data" conference in September of 2015 in New York City. The "Big data" conference continued for two more years and was transformed into an annual summer training workshop in data analytics for college professors beginning in 2018. To meet the shortage of talents with the right skill sets, KPMG, one of the Big Four accounting firms, in 2016 launched its inaugural KPMG Master of Accounting with Data and Analytics program in partnership with business schools at the Ohio State University and Villanova University initially (McCabe 2017). That program has now grown to nine schools nationwide. In sum, higher education's response to the change in demand for the right talents was neither timely nor appropriate.

The accounting professional organizations' response to the seismic change in the demand for new knowledge and job skills was not any better. In 2018, six years after Vasarhelyi (2012), the Association of International Certified Professional Accountants (AICPA) and National Association of State Board of Accountancy (NASBA), recognizing the "rapidly changing skills and competencies" required of today's practicing accountants, finally launched a joint initiative, "CPA Evolution," to explore ways to integrate technology and analytics into the CPA licensure model. After three years of studies and feedback from various stakeholders, they proposed a new "core + discipline" licensure model, which begins with "a deep and strong core in accounting, auditing, tax, and technology that all candidates would be required to complete, followed by a discipline (from business analysis and reporting, tax, and information systems) chosen by the candidate. Their recommendations identified several competencies, including understanding of information systems, data flows and internal controls as well as having an analytical and data-driven mind set (AICPA 2019). In support of the recommendations by the CPA Evolution Initiative, on May 26, 2020, NASBA released the proposed revisions to the Uniform Accountancy Act Model Rules related to education requirements for licensure. One of the significant revisions to the model is the addition of "data analytics or related courses to basic subject matter" (Baker, 2020).

A recent survey by Richardson and Shan (2019) indicates that nearly 60% of accounting department chairs plan to include an accounting data analytics course as part of the accounting curriculum. Though the accounting profession has acknowledged the need for a Big data skillset among its future accounting

practitioners, a large number of college accounting programs have yet to expand their accounting curriculum to include the requisite knowledge demanded by employers. While each Big 4 accounting firm has devoted resources to help accounting students develop analytical skills in the classroom, little academic focus has been placed on which tools and skills are demanded by companies of accounting graduates. This paper seeks to fill this gap by providing results of a survey of the skills and tools used by practicing accounting professionals across different size accounting firms and domains.

Research Methodology and Results

The Survey Instrument

To identify the most critical missing content knowledge in the accounting curriculum, we chose the survey methodology because there was no data available at the time of our inquiry. The survey instrument we created was approved by the appropriate Institutional Review Board. In addition to the page describing the purpose and nature of the research, the names of the principal investigators, and obtaining participants' consent, the survey instrument consisted of two main parts. The first part of the survey asked participants to provide general demographic information about their gender, the type(s) of employer(s) at which they had worked in the most recent three years, the field(s) of their work, and years of experience in each field. The second part of the survey asked the participant to rate the usefulness of the data tools or skills. In the Appendix, we include survey questions that are relevant to this paper.

We contracted Qualtrics to mass distribute the survey in the months of July, August, and September of 2017 to their panelists who are accountants. Altogether 5,642 email invitations were sent. We received 1,574 responses (response rate is 27.9%). We screened out people who were not CPAs and whose jobs did not involve preventing, detecting, investigating, and assessing the risk of frauds. We also removed responses that did not pass our quality control standards (e.g., incomplete answers, illogical answers, or spent too little time to complete based on the histogram).

Table 1: Qualtrics Survey Distribution and Collection Process

Description	Number	%
Email invitation sent to accountants	5,642	100.0%
Took the Survey	1,574	27.9%
Minus: not a CPA/CMA/CIA who is involve in preventing, detecting, correcting, reporting, or assessing the risk of fraud	-912	16.2%
Minus: did not complete the survey	-146	2.6%
Minus: screened out due to illogical answers, short duration, same IP address	-115	2.0%
Used for analyses	401	7.1%

Table 1 documents the exact number at each step of the screening process. The process resulted in 401 (7.1%) valid responses. Included in the survey were three other demographic questions about their gender and professional experience.

In terms of knowledge and skills helpful for auditor training, we listed six areas and provided two blanks under "other" where the survey taker can write in anything that was not listed. The six areas we specified were data visualization, data analytics, data compliance/vulnerability scanner, data collection/extraction, machine-learning-based utilities, econometrics/statistics, and programming language. For each knowledge area, we gave examples of some commercially available tools and asked survey participants to rate the usefulness of training an auditor in that content knowledge/skill set. The ratings were "extremely useful," "very useful," "moderately useful," "slightly useful," or "not useful at all."

Descriptive Statistics

Table 2: Demographics of 401 Survey Participants

Gender		**Employer(s) over the past three years**		**Worked on the following fields over the past three years**	
Male	46.63%	Big Four *Exclusively Big Four*	27.7% *23.4%*	Assurance and Auditing *Assur. & Audit Only*	52.4% *29.2%*
Female	53.12%	National (operated in more than six states) firms *Exclusively National*	20.4% *15.5%*	Advisory and Consulting *Adv. & Consulting Only*	27.7% *8.7%*
Prefer Not to Answer	0.25%	Regional (operated in less than six states but had 30 or more professional staff) firms *Exclusively Regional*	18.0% *14.5%*	Internal Audit *Internal Audi Only*	26.7% *11.0%*
		Local (had fewer than 30 professional staff) *Exclusively Local*	29.4% *25.2%*	Tax *Tax Only*	37.2% *16.7%*
		Other *Exclusively Other*	14.5% *13.7%*	Others *Others Only*	6.0% *3.7%*
		Worked for Employers of Different Sizes	7.7%	*Two or more Areas*	*30.7%*

Tables 2 and 3 summarize the demographics of the 401 valid responses. Table 2 shows that 53.1% (n=213) were women, 46.6% (n=187)

men, and 0.2% (n=1) chose not to disclose their gender. 28% worked most recently (within three years) at a Big Four firm, 20% had recent experience in a non-Big-Four national firm (operates in six or more or more states), 18% had experience in regional firms (operates in fewer than six states but has more than 30 professional staff), and 29% had recent experience in a local firm. 14% of them had recent experience in the private sector or the government. A little less than 8% of them have worked in firms of two different sizes or sectors, indicating there was little migration between different types of firms among the survey participants. Regarding the most recent field experience within accounting, the right column of Table 2 revealed that 69.3% of the respondents worked exclusively in one field with the following breakdown: 29.2% in assurance and auditing, 16.7% in tax, 11% in internal audit, 8.7% in advisory, and 3.7% in fields not listed above. 30.7% of the respondents had worked in two or more of these fields. Combined together, 52.4% were involved in the field of assurance and auditing, 27.7% in advisory and consulting, 26.7% had experience in internal auditing, and 37.2% in tax.

Table 3: Years of Professional Experience

	Median	Mean	Minimum	Maximum	Stan. Dev.
Assurance and Auditing	5.0	9.0	0	40	9.9
Advisory and Consulting	3.6	7.8	0	40	9.8
Internal Auditing	1.7	6.2	0	40	9.4
Tax	3.3	8.2	0	40	10.7
Corporate Accounting	3.5	7.6	0	40	9.9

Table 3 reports years of experience the participants had in each field. On average, they had 9.0, 7.8, 6.2, 8.2, 7.6 years of experience in assurance, advisory, internal audit, tax, and corporate accounting, respectively. However, the median experiences were much smaller than the averages, suggesting the distribution is right-skewed. For each field, the most experienced had worked in that field for 40 years or more.

Analytical Methods and Results

We tallied the valid responses from all participants, by respondent's field of work, as well as by the type of their employer. We then constructed weighted usefulness score for each knowledge area described in (1) below. Finally, we reduced the usefulness levels from five to three and provided data visualization as discussed in (2) below.

Weighted Usefulness Score

We assigned different weights to each usefulness level to reflect the strength of the usefulness. The weights

assigned were 3 (extremely useful), 2 (very useful), 1 (moderately useful), 0 (slightly useful), and -2 (not useful). We calculated the weighted score for each field of knowledge/skill and reported the weighted scores of all respondents, by respondents' fields of work, as well as by the type of their firms.

As Table 4 Panel A shows, accountants across different field specialties all ranked data visualization, data extraction, and data analytics tools as the three most useful skills. Table 4 Panel A also reveals that programming language was ranked at the bottom, suggesting that, to accountants, being able to program/code was not as helpful as the other data skills. Next to the bottom is econometrics and machine-learning utilities. The reason that programming language received this low ranking could be that accounting firms hired specialists,

Table 4: Weighted Usefulness Ranking of Data Tools
(weighted usefulness scores in *italic*)[2]

Panel A: Weighted Usefulness Rating by Field[3]

Tools/Skills	All respondents (n=401)	Assurance & Auditing (n=208)	Advisory & Consulting (n=108)	Internal Auditing (n=105)	Tax (n=147)
Data Visualization	**1** *(721)*	**2** *(391)*	**1** *(226)*	**1** *(215)*	**2** *(252)*
Data Extraction	**2** *(720)*	**3** *(384)*	**3** *(208)*	**2** *(206)*	**3** *(246)*
Data Analytics	**3** *(719)*	**1** *(394)*	**2** *(222)*	**3** *(193)*	**1** *(264)*
Compliance	**4** *(489)*	**4** *(373)*	**4** *(172)*	**5** *(140)*	**4** *(194)*
Machine-Learning based Utilities	**5** *(438)*	**5** *(226)*	**6** *(149)*	**4** *(146)*	**5** *(176)*
Econometrics	**6** *(432)*	**5** *(226)*	**5** *(153)*	**6** *(129)*	**5** *(175)*
Programming Language	**7** *(365)*	**7** *(197)*	**7** *(135)*	**7** *(123)*	**7** *(128)*

[2] We assigned the following weights to different level of usefulness: 3 (extremely useful), 2 (very useful), 1(moderately useful), 0 (slightly useful), -2 (not useful). The weights were multiplied by the number of responses in each usefulness group and then summed across to obtain the weighted usefulness score.
[3] 30.7% of the respondents worked in two or more fields between 2014 and 2017.

Panel B: Weighted Usefulness Rating by Type of Firms

Tools/Skills	All respondents (n=401)	Big Four (n=111)	National Firms (n=82)	Regional Firms (n=72)	Local Firms (n=118)
Data Visualization	**1** *(721)*	**1** *(219)*	**3** *(147)*	**2** *(137)*	**1** *(204)*
Data Extraction	**2** *(720)*	**2** *(201)*	**1** *(158)*	**3** *(136)*	**3** *(185)*
Data Analytics	**3** *(719)*	**3** *(186)*	**2** *(157)*	**1** *(142)*	**2** *(197)*
Compliance	**4** *(489)*	**4** *(127)*	**4** *(124)*	**4** *(98)*	**4** *(143)*
Machine-Learning based Utilities	**5** *(438)*	**6** *(110)*	**6** *(100)*	**5** *(89)*	**5** *(123)*
Econometrics	**6** *(432)*	**7** *(100)*	**5** *(117)*	**6** *(88)*	**5** *(123)*
Programming Language	**7** *(365)*	**5** *(111)*	**7** *(99)*	**7** *(101)*	**7** *(86)*

e.g., software engineers and data scientists, who were experienced in coding programs, if and when necessary. Similarly, the low ranking of econometrics as a data skill to auditors could be that accounting firms may have little difficulty in hiring trained mathematicians, statisticians, or data scientists to perform sophisticated analyses and did not need the auditors to perform those tasks. Byrnes et. al (2015) predicted that future auditors "will be obliged to depend even more on professionals who have the skills traditionally-trained auditors lack." Anecdotally, we know people who majored in math, economics and engineering being recruited to Big Four to serve as data scientists. Table 4 Panel B reports the weighted usefulness score by the type of the firms at which the survey participants worked. Data visualization, data extraction, and data analytics tools were still the top three most useful skills; however, the usefulness rating was slightly different for different types of firms, with the national firm employees finding data extraction tools more useful than data analytics and data visualization; whereas the Big Four employees seemed to find data visualization tools more useful than all the others. However, skills in data visualization, data extraction, and data analytics kept the top three spots in the rank order.

In Table 4 Panel A, the responses from people whose work involved more than one accounting field (e.g., assurance and consulting) were counted in each field they were engaged in. To see if the results would be different for single-specialty respondent, we calculated

the weighted usefulness score by using the responses from single-specialty respondents only, the results remain qualitatively the same: data visualization, data analytics, and data extraction were deemed the most useful data skills for auditors (with the only exception occurs in the advisory and consulting field). Usefulness of programming language skills and econometrics were still ranked at the bottom.

In Table 4, Panel B, the responses from people who had worked in more than one type of firms were counted in each firm type they had worked. We also conducted similar sensitivity analyses. The results of our sensitivity analyses were no different: data visualization, data analytics, and data extraction were rated most useful, and programming language, econometrics, and machine-learning based utilities were among the least useful.

Visualization of Simple Count (no weight)

To effectively visualize the data, we reduced the number of usefulness groups to three from five (to reduce cognitive load) (Kahneman 2013, Whitney 2013). Specifically, the "extremely useful" and "very useful" groups were combined into a new group "useful;" the "moderately useful" and "slightly useful" were combined into a new group called "somewhat useful;" the "not useful" group remained unchanged. The visualizations reflecting the simple count at each regrouped level are provided in Figures 1, 2, and 3.

Figure 1 depicts the ratings by the respondents in percentage (calculated bas the simple count in each regrouped usefulness rating level divided by total responses). It shows that, overall, data skills in visualization and analytics were rated most useful. The same percentage of respondents rated visualization and analytics skills as very useful (66%), somewhat useful (29%), and not useful (5%). These two data skills were closely followed by data extraction. The content knowledge and data skills regarded as least useful are machine-learning-based utilities, econometrics, and programming language.

Overall, the results using simple count are similar to the results using weighted usefulness score in Table 4. In cases where the ranks of the top three data skills (Data Extraction, Data Visualization, and Data Analytics) changed positions, they remained in the top three. In cases where the ranks of the bottom three data skills (Machine Learning-based Utilities, Econometrics, and Programming Language) changed positions, they remained in the bottom three.

Sensitivity Analyses

To see if the ranking of the knowledge varies with the respondent's field of work, the type of firms, and years of experience, we did the following additional analyses.

Figure 1: Rating of Usefulness of Data Tools by All Participants

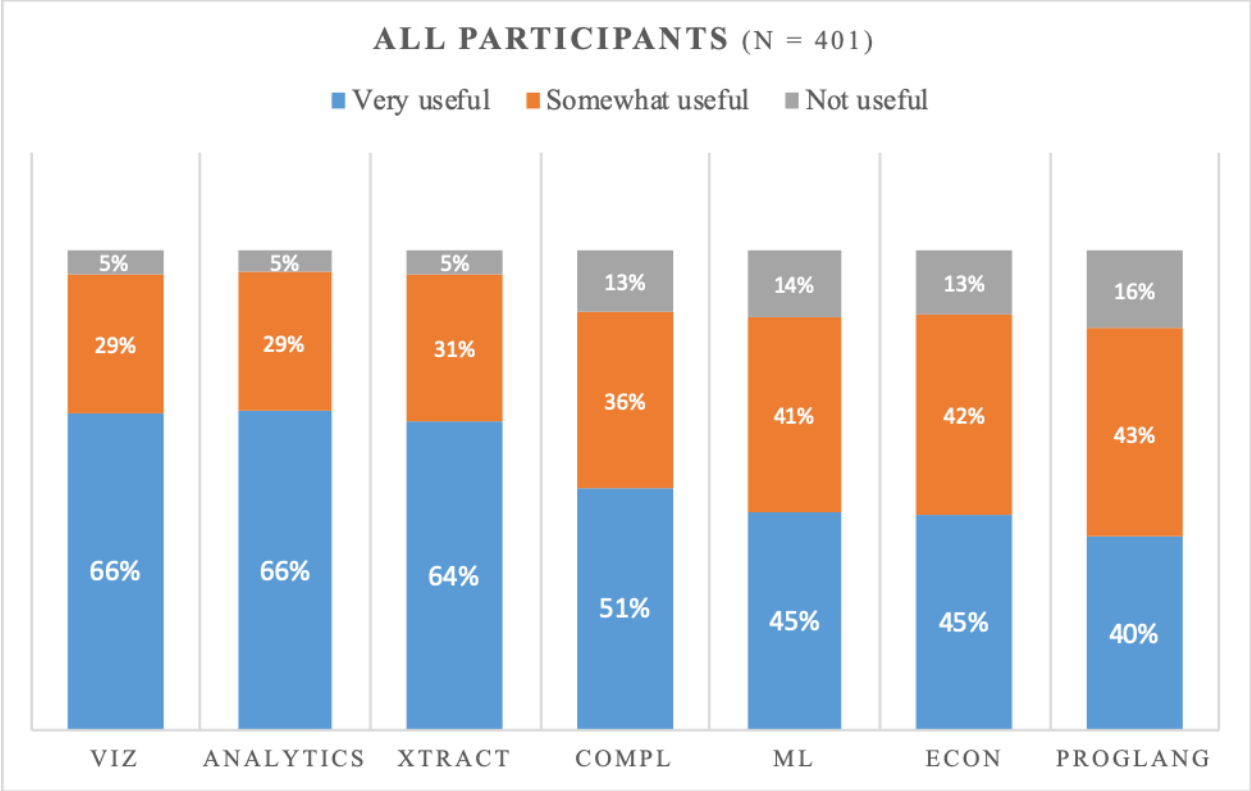


Table 4: Weighted Usefulness Ranking of Data Tools
(weighted usefulness scores in *italic*)[4]

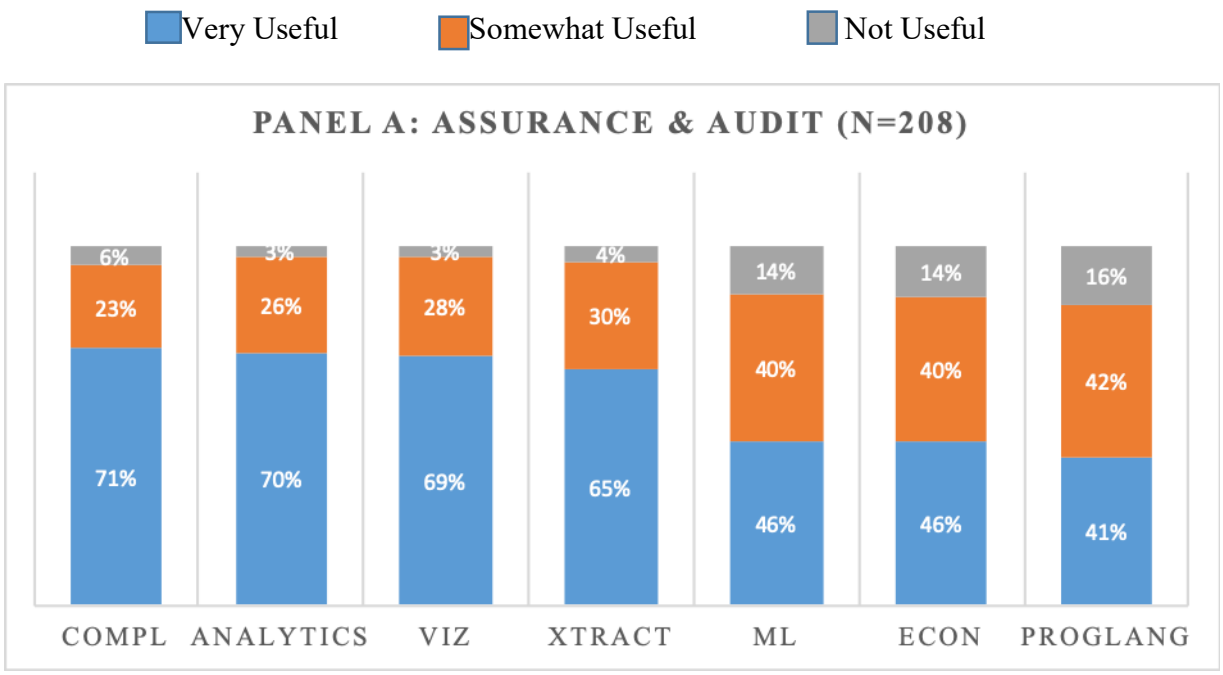
Panel A: Weighted Usefulness Rating by Field[5]

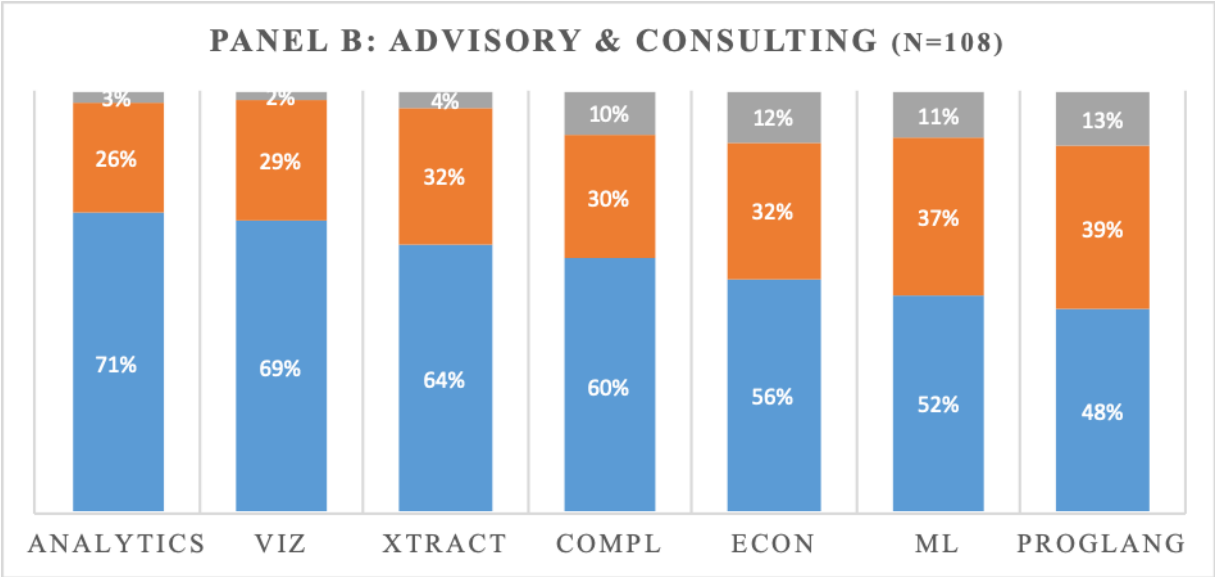
Tools/Skills	All respondents (n=401)	Assurance & Auditing (n=208)	Advisory & Consulting (n=108)	Internal Auditing (n=105)	Tax (n=147)
Data Visualization	**1** *(721)*	**2** *(391)*	**1** *(226)*	**1** *(215)*	**2** *(252)*
Data Extraction	**2**	**3**	**3**	**2**	**3**

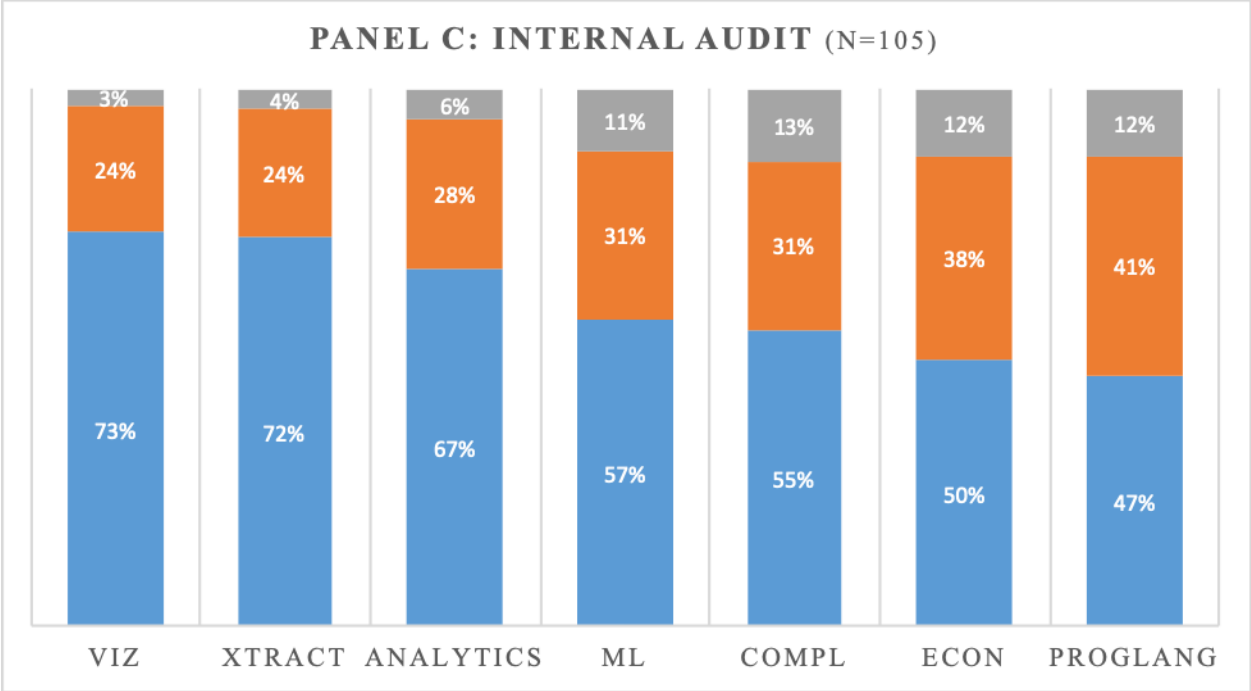
[4] We assigned the following weights to different level of usefulness: 3 (extremely useful), 2 (very useful), 1(moderately useful), 0 (slightly useful), -2 (not useful). The weights were multiplied by the number of responses in each usefulness group and then summed across to obtain the weighted usefulness score.
[5] 30.7% of the respondents worked in two or more fields between 2014 and 2017.

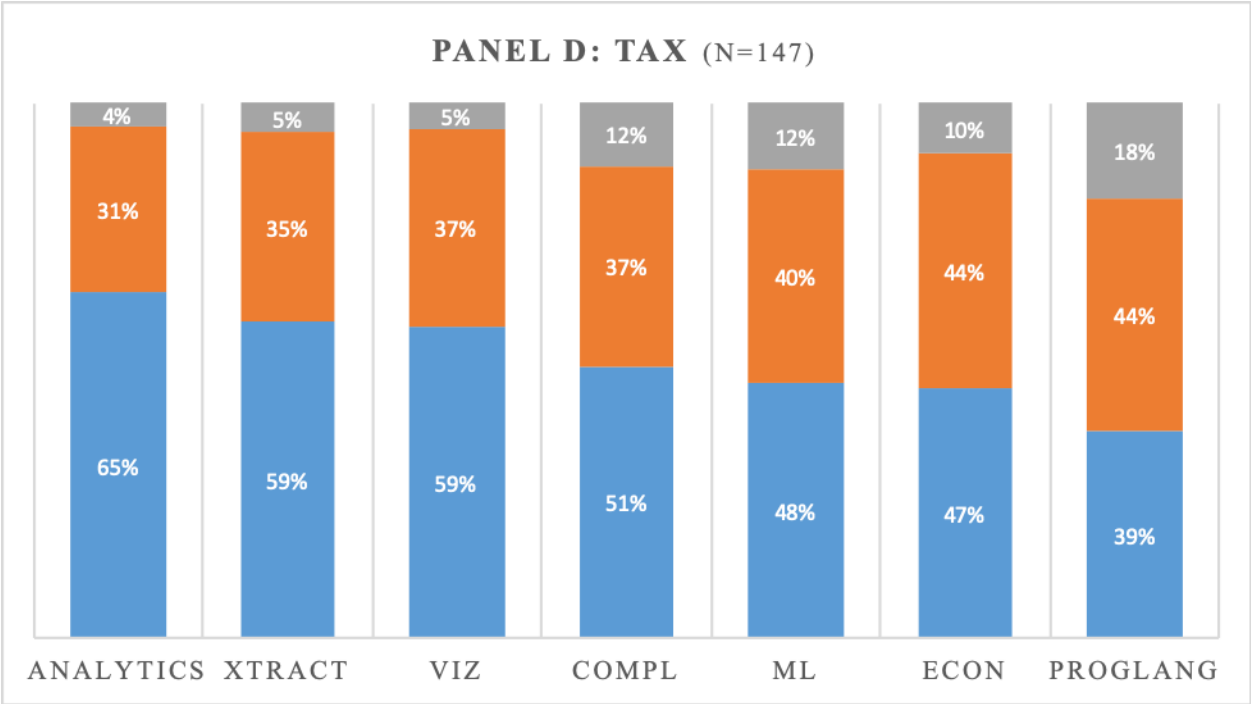
	(720)	*(384)*	*(208)*	*(206)*	*(246)*
Data Analytics	**3** *(719)*	**1** *(394)*	**2** *(222)*	**3** *(193)*	**1** *(264)*
Compliance	**4** *(489)*	**4** *(373)*	**4** *(172)*	**5** *(140)*	**4** *(194)*
Machine-Learning based Utilities	**5** *(438)*	**5** *(226)*	**6** *(149)*	**4** *(146)*	**5** *(176)*
Econometrics	**6** *(432)*	**5** *(226)*	**5** *(153)*	**6** *(129)*	**5** *(175)*
Programming Language	**7** *(365)*	**7** *(197)*	**7** *(135)*	**7** *(123)*	**7** *(128)*

Figure 2: Rating of Usefulness of Data Skills & Knowledge, Results by Field




PANEL B: ADVISORY & CONSULTING (N=108)
3%
26%
71%
2%
29%
69%
4%
32%
64%
10%
30%
60%
12%
32%
56%
11%
37%
52%
13%
39%
48%
ANALYTICS
VIZ
XTRACT
COMPL
ECON
ML
PROGLANG


PANEL C: INTERNAL AUDIT (N=105)
3%
24%
73%
4%
24%
72%
6%
28%
67%
11%
31%
57%
13%
31%
55%
12%
38%
50%
12%
41%
47%
VIZ
XTRACT
ANALYTICS
ML
COMPL
ECON
PROGLANG



Does the Usefulness of Data Skills Vary by Field of Accounting?

Figure 2 Panels A to D illustrate the simple count at each usefulness level by the field(s) of the participants' recent professional experience. Panel A shows the results of people who worked in assurance and auditing within three years (between 2014 and 2017) of the time they took the survey. Result in this Panel indicates that slightly more people in assurance and auditing regard data compliance skill was very useful than skills in data visualization, data analytics, and data extraction; however, respondents gave higher usefulness rating ("extremely useful") to data visualization, data analytics, data extraction than data compliance skills. The higher count for data compliance skills came from the count in "very useful" rating instead of "extremely useful" rating, yielding higher count but smaller weighted score. For example, the ratings given by the assurance group for the knowledge in data compliance were 65 for "extremely helpful," 83 for "very helpful," 36 for "moderately helpful," 12 for "slightly helpful" and 12 for "not helpful at all"– yielding a weighted score of 373 (65*3+83*2+36*1+12*0+12*(-1)). On the other hand, the ratings given by the same group for the skills in data analytics were 69 for "extremely helpful," 77 for "very helpful," 47 for "moderately helpful," 8 for "slightly helpful" and 7 for "not helpful at all"– yielding a weighted score of 394 (69*3+77*2+47*1+8*0+7*(-1)), higher than the score for data compliance. However, the count in the combined

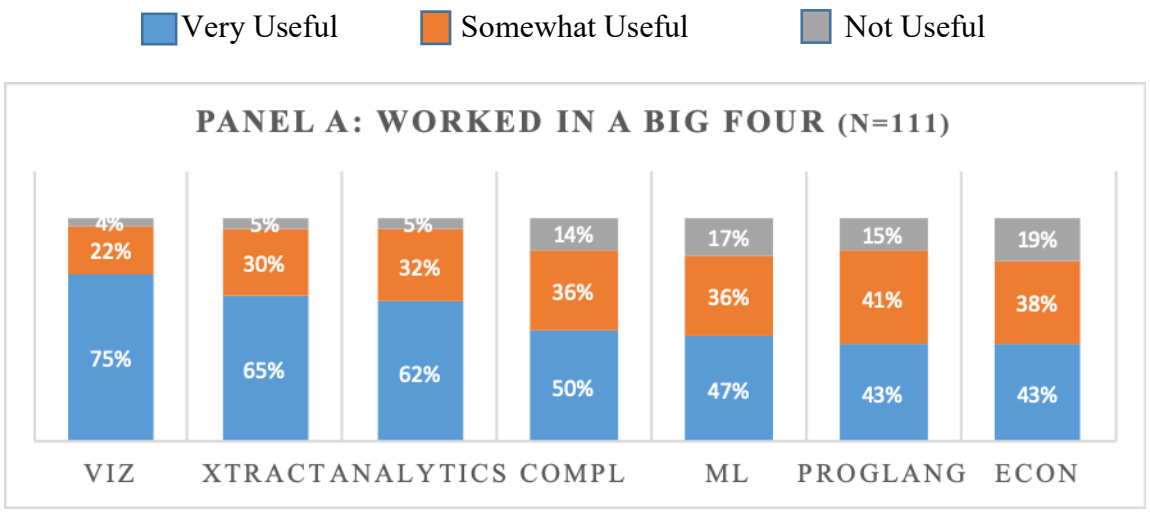
"very useful" group for data compliance is 148 (65+83), higher than 146 (69+77) for data analytics.

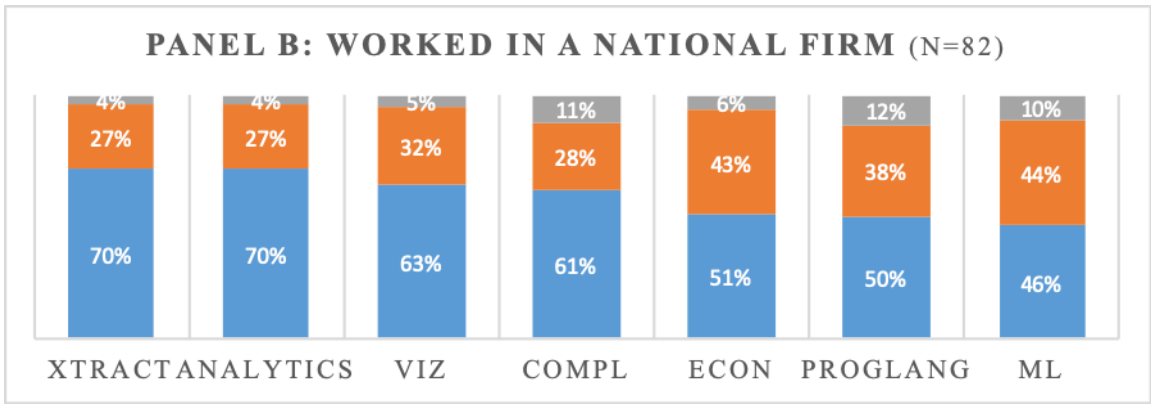
Panels B, C, D are the results for advisory and consulting, internal audit, and tax, respectively. The results are consistent with Table 4. Data analytics, data visualization, and data extraction skills were considered to be the top three most useful skills by all specializations except for audit and assurance, which had compliance, analytics, and visualization as the top three. Programming language, knowledge in econometrics, and skills in machine-learning based utilities remained at the bottom.

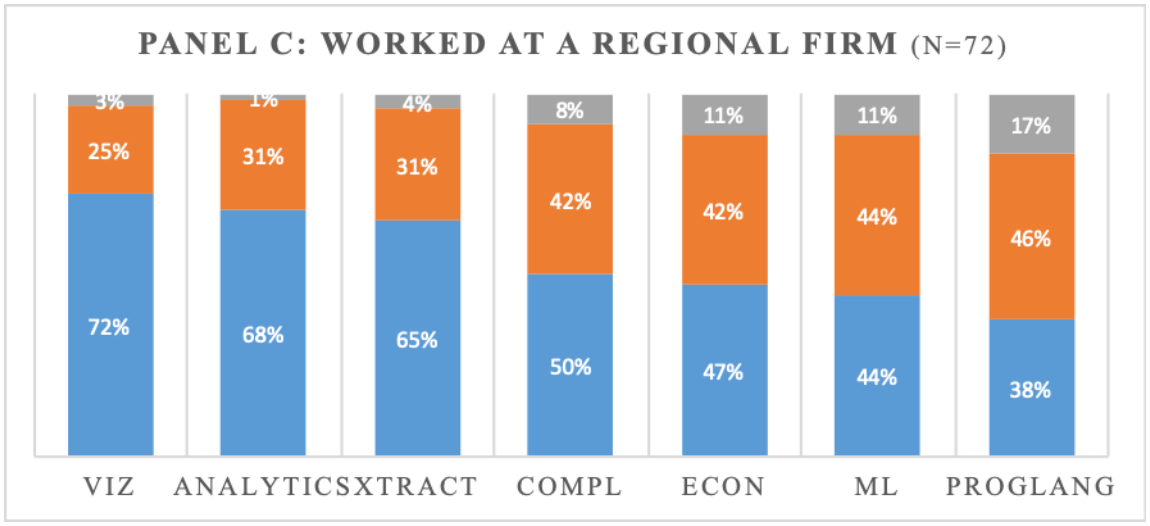
Does the Usefulness of Data Skills Vary by the Type of Firms?

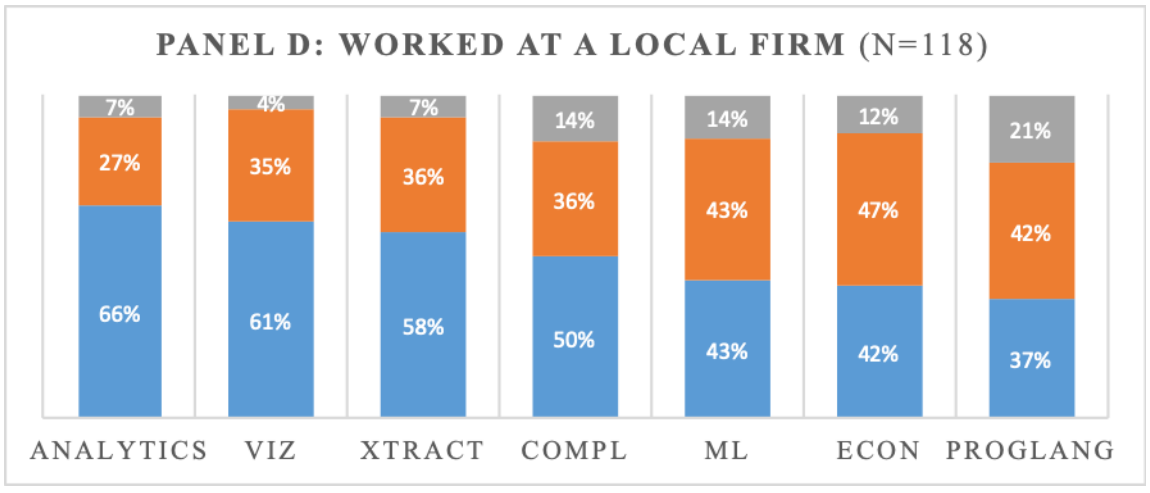
Figure 3 Panels A to D document the percentage of simple counts at each useful level by the type of employers of the participants. The results were slightly different from the weighted score method but data visualization, data extraction, and data analytics skills remain to be the three most useful skills while the skill in machine-learning utilities, programming language and econometrics were viewed as not as useful. For those who worked in more than one type of firm, their responses were counted multiple times. (For example, if J. Smith indicated that they had worked for a national firm and a Big Four firm between 2014 and 2017, their responses were counted both in the national firm group and in the Big Four group) Because only 7.7% of our survey respondents worked at firms of two or more sizes; we did not expect the ranking of the usefulness by participants who worked exclusively at any given type of firms to be different from Figure 3.

Figure 3: Rating of Usefulness of Data Skills & Knowledge, Results by Size of the Firm




PANEL B: WORKED IN A NATIONAL FIRM (N=82)
4%
27%
70%
4%
27%
70%
5%
32%
63%
11%
28%
61%
6%
43%
51%
12%
38%
50%
10%
44%
46%
XTRACT
ANALYTICS
VIZ
COMPL
ECON
PROGLANG
ML


PANEL C: WORKED AT A REGIONAL FIRM (N=72)
3%
25%
72%
1%
31%
68%
4%
31%
65%
8%
42%
50%
11%
42%
47%
11%
44%
44%
17%
46%
38%
VIZ
ANALYTICS
XTRACT
COMPL
ECON
ML
PROGLANG


PANEL D: WORKED AT A LOCAL FIRM (N=118)
7%
27%
66%
4%
35%
61%
7%
36%
58%
14%
36%
50%
14%
43%
43%
12%
47%
42%
21%
42%
37%
ANALYTICS
VIZ
XTRACT
COMPL
ML
ECON
PROGLANG

To ensure our results are not sensitive to the inclusion of respondents who worked at more than one type of firms in each firm type, we performed sensitivity analyses (not tabulated here) using responses from people who worked exclusively in each firm type. The analyses of exclusive firm type responses, not reported here, did not change the rankings much. In cases where the ranks of the top three data skills (Data Extraction, Data Visualization, and Data Analytics) changed positions, they remained in the top three. In cases where the ranks of the bottom three data skills (Machine Learning-based Utilities, Econometrics, and Programming Language) changed positions, they remained in the bottom three.

Does a Person's Tenure Change Their Ratings of Data Skill Usefulness?

To see whether a person's tenure in a field affects how they rate each data skill or domain knowledge, we broke the respondents into four groups based on number of years they had practiced in each field: less than 2 years, 2 to below 5 years, 5 to under 10 years, and 10 years or more. We performed 168 (7 skill sets*6 pair-wise comparisons of four experience groups*4 fields) pairwise Kolmogorov-Smirnov two-sample tests for difference between different tenure groups. As the familywise error rate increases with the number of pairwise comparisons made, we use the Bonferroni correction to adjust our alpha downward to $\alpha = 0.00029$ (adjusted $\alpha = 0.05 / 168$) to account for the increased Type I error. The results, not provided here, show that all pairwise comparisons had no difference in ratings at the 5% significance level except for the following.

In the assurance field, people who had 10 years or more experience and people who had between 5 and 10 years of experience in the field gave different ratings about the usefulness of skills in data analytics; In the advisory field, people who had between 2 and 5 years of experience and those who had between 5 and 10 years of experience gave different usefulness ratings regarding data visualization and data analytics; In the field of tax, people with 10 or more years of experience rated the usefulness of data analytical skills differently from people who had between 5 and 10 years of experience.

However, when we adjust the significance level to 1%, the only pairwise comparison that remained statistically different is in the field of tax between people who had between 5 and 10 years of experience and those that had 10 or more years of experience.

Summary and Concluding Thoughts

Accounting education is at a tipping point. Traditional curriculum that focuses on the GAAP principles, tax regulations, and auditing standards must be updated to integrate new knowledge in data, analytics, and technology. For colleges and universities that are challenged with limited resources, developing a curriculum strategy to meet the changing needs in the job market is necessary. Essential knowledge and critical job skills for an entry-level auditor must be imparted via a redesigned curriculum and

new course offerings. Our survey of accounting professionals contributes to the accounting education literature by providing a better understanding of the skills and knowledge used by practicing accountants across various sized accounting firms and specializations. Our results suggest that new course offerings in data visualization, data extraction, and analytics might be more useful than requiring programming language or machine learning courses.

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Appendix: Survey Instrument Used[6]

Please respond to the following four demographic questions (Q1-Q4) about YOU.

Q1: Gender

❍ Male
❍ Female
❍ Prefer not to answer

Q2: Years of experience in each of the following fields: (If more than 40, please slide to 40.)

_____ advisory and consulting
_____ assurance and auditing
_____ corporate accounting
_____ internal auditing
_____ tax
_____ Other. Specify: _____

Q3: My most current (within three years) accounting experience is with a

- ❑ Big Four accounting firm
- ❑ National accounting firm
- ❑ Regional (has 31 or more accounting professionals but has operations in fewer than six states) accounting firm
- ❑ Local (has between 2 and 30 accounting professionals) accounting firm
- ❑ Other

Q4 My most current (within three years) experience is in the following specialty: (check all that apply)

- ❑ Advisory
- ❑ Assurance and auditing
- ❑ Internal audit
- ❑ Tax
- ❑ Other. Specify:

_____

Q5. In light of the growing use of Big data for fraud detection, what knowledge and skills will be useful in the training of auditors?

- Data visualization tools, e.g., Tableau, Qlik, ACL Analytics, etc. (Optional: specify below)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Data analytic tools, e.g., SAS Enterprise Miner, SAP Analytics, Microsoft Revolution, SPSS, etc. (Optional: Specify below)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Data compliance/vulnerability scanner (Optional: Specify _____)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Data collection/extraction tools, e.g., SQL, Access, Lambda Architecture, streaming, etc. (Optional: Specify _____)

[6] This survey instrument was approved by the Institutional Review Board of the authors' organization in June 2016.

- ❑ Extremely useful
- ❑ Very useful
- ❑ Moderately useful
- ❑ Slightly useful
- ❑ Not at all useful

- Machine-learning-based utilities, e.g., Hadoop ML, Spark ML, MAT-LAB ML, SAP Leonardo ML, etc. (Optional: Specify _____)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Econometrics/statistics, e.g., multi-variate, time-series, etc. (Optional: Specify _____)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Programming language, e.g., Python, Java, R, etc. (Optional: Specify _____)

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful

- Others. Please Specify: _____

  - ❑ Extremely useful
  - ❑ Very useful
  - ❑ Moderately useful
  - ❑ Slightly useful
  - ❑ Not at all useful