



Natural Language Processing & Professional Services

Investigating the Automation Potential of Office Jobs in the United States

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April 2018

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The American Jobs Project

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Abstract

This report examines the technical feasibility for applications using natural language processing (NLP) to substitute for human performance of office job tasks in the US professional services sector. The state of the art in natural language processing capabilities was assessed; using objective and subjective benchmarks, present-day and likely future natural language processing capabilities were defined. The tasks of twelve office jobs were closely examined, with the objective of drawing a clear connection between observable technical capabilities and language activities required for task performance. An average of 23 percent of the tasks of the twelve occupations were found to be substitutable by natural language processing applications in a likely future scenario. This report then analyzes the potential for worker displacement due to task substitution as new NLP capabilities are adopted in the workplace, and recommends policies that leaders may consider to address this displacement. This report concludes by assessing the limits of task substitutability analysis in estimating the impact of information and communications technology on labor markets, and recommends avenues for further research.

Introduction

In recent years, advances in artificial intelligence (AI) have sparked concern about the impact of information and communications technologies (ICT) on jobs. Many people believe that automation of human labor will cause widespread unemployment. Others are concerned about how automation may exacerbate income polarization and other undesirable economic phenomena. As a result, studies have been undertaken to quantify ICT's potential employment impact. Many of these studies have been national or global in scope. This report will contribute to the ongoing discussion by assessing the technical feasibility of natural language processing to automate tasks in twelve occupations in the US professional services sector.

National and global studies have informed helpful discussions about the range and scale of potential effects, but are too broad to closely examine how progress in specific computer capabilities interacts with occupational tasks. The most famous of these studies, by Michael Osborne and Carl Benedikt Frey of Oxford University, judged subjectively whether each of 70 occupations was "computerizable" based on consultations with machine learning experts, but did not describe what technological capabilities were relevant to an occupation's tasks or why they thought that technological capability was likely to exist in the near future.¹ Another study, by the McKinsey Global Institute (MGI), estimated for each of eighteen fields of AI whether the state of the art machine performance is below, even with, or above median human performance, but did not describe how progress in each capability was measured.² By contrast, this report will describe how progress in a specific field of AI can apply to specific job tasks in order to paint a detailed picture of the technical feasibility of automation. In doing so, it will draw a bright line between observable technical capabilities and the details of what professional services workers do on the job. Analysis with such narrow focus can provide color to the debate over ICT's impact on jobs and inform more precise measures to counter potential labor disruption.

It is important to note that this report will consider only the potential technical feasibility of technology to substitute for human performance of tasks. While technical feasibility is a prerequisite for the automation of tasks performed today by humans, it is far from the only factor. As has been noted in the MGI study and in much other research, numerous other considerations affect a company's decision to adopt a technology in the workplace, including cost, labor market dynamics and regulatory acceptance.

It's also important to note that high rates of technically feasible substitutability, even if technology is adopted quickly into the workplace, are not the end of the story for the labor market. As has been well documented across decades of economic research, new technologies often lead to the creation of new jobs as they automate tasks once performed by humans. This pattern has a high probability of repeating to some degree or

another with natural language processing. Readers should bear in mind that, even as some occupations are assessed in this report to have a high likely future substitutability, displaced workers may have new labor market opportunities that didn't exist before. At the expense of building a realistic adoption timeline and predictions of net job loss or gain, this report instead aims to examine technical feasibility as closely as possible.

While concern about the automation of physical tasks by technology in the form of robots is widespread, concern has also arisen about the impact of advancing ICT on occupations primarily comprised of non-physical work, such as office jobs in the professional services sector.³ Case studies of these jobs can provide a useful perspective on the effects of ICT's impending development.⁴ Furthermore, use of language is an essential function of office workers – whether they are writing memos, talking on the phone, or giving a presentation. Natural language processing is a subfield of computer science that will probably have a broad impact on these workers. An assessment of natural language processing's impact on these workers' job tasks will be particularly relevant to the question of ICT's future impact.

This report will begin with descriptions of today's state of the art performance in natural language processing and a likely near future scenario for natural language processing capabilities. Next, case studies will analyze each core job task for each of twelve office jobs in the professional services sector against current and future natural language processing capabilities. The percentage of each occupation's tasks evaluated to be substitutable by natural language processing applications in each scenario will be given. In conclusion, this report will assess the potential implications of its findings for individual workers and for occupations as a whole, and recommend areas of focus for policymakers. This report will also evaluate the limits of this kind of task substitutability analysis and suggest avenues for further research.

Natural Language Processing

Natural language processing (NLP) is a subfield of computer science.⁵ It describes algorithms that enable computer applications to understand, process, and generate communications in human language.⁶ In other words, NLP allows machines to read, write, listen, and understand. NLP is broken down into two categories: natural language understanding (NLU), where computer programs comprehend the meaning behind written text, turning language into data; and natural language generation (NLG), where computer programs create written text by turning data into language.⁷

Most of today's state of the art NLP algorithms use machine learning methods such as deep learning.⁸ These algorithms function accurately only after analyzing training data, or large numbers of examples that demonstrate correct performance of the assigned task.⁹ Lack of training data availability can be a constraint on NLP performance. It's worth noting that not all NLP algorithms use machine learning, and other strategies may lead to new NLP advances in the future. However, machine learning underlies most of the algorithms discussed in this report.

For purposes of this report, it is assumed that NLP applications will be able to accurately convert human speech into text for processing. State of the art voice transcription algorithms have exceeded human performance in ten tests of speech recognition.¹⁰ Further improvements in the ability of computers to read and listen will likely be based on improvements in algorithms that understand intent behind text, rather than algorithms that simply convert speech into text.

In addition, this report does not evaluate or consider progress in machine translation capabilities. While these capabilities will undoubtedly have a profound impact on workplaces, they are beyond the scope of this report.

How to Measure NLP Capabilities and Progress

Both NLG and NLU can be measured by subjectively evaluating software applications at market that use NLU and/or NLG for task performance. In addition, NLU can be measured using objective tests of reading comprehension that were designed specifically to evaluate the relative capabilities of NLU algorithms. Both of these measurement strategies are described in detail below.

NLU

A common objective measure of machine reading comprehension is question answering.¹¹ In this test format, an algorithm is presented with a sample passage, followed by a question.¹² The algorithm is successful if it can answer the question correctly.¹³ This test format is commonly used to measure human reading comprehension ability on standardized tests.¹⁴ There are a variety of question answering tests used to benchmark natural language understanding performance. Differences among these tests include the form of their questions, the length, range of vocabulary, and complexity of the sentences contained in the sample passage, and other factors.

Test questions vary by the kind of verbal reasoning required of an algorithm to determine the correct answer.¹⁵ For example, some questions can be answered simply by matching a keyword from the question with the same word in the sample passage, while other questions might require a reader to infer the answer based on two distinct pieces of information.¹⁶ Frequently, algorithms will successfully answer most questions requiring word matching while failing to answer questions that require inference. Sometimes, algorithms will be able to successfully answer all questions requiring inference when the sample passage is very short and of a very narrow range of vocabulary, while failing to answer any questions requiring inference when sample passages are longer and more complex.¹⁷ Differences in performance at different types of verbal reasoning in different contexts provide insight into what kind of occupational tasks NLU algorithms can address.

Tests that require algorithms to guess the final word of a multi-sentence passage can also be used to measure NLU performance.¹⁸ There are fewer of these kinds of tests than there are question answering tests, but they provide useful additional insight into what NLU algorithms are really doing. Question answering tests require summary understanding of a sample passage; in contrast, to be able to guess the final word of a passage, an algorithm needs to have word-by-word understanding of the development of a dialogue or narrative.¹⁹ Algorithms with this level of understanding ability would have potentially significant workplace implications.

NLG

The only agreed-upon method of evaluating NLG performance is for humans to subjectively evaluate the usefulness or quality of a machine-generated text. Such evaluations are expensive and time-consuming for researchers. NLG measurement remains the subject of significant study.²⁰ Researchers have attempted to automate measurement of NLG performance using the BLEU metrics used to evaluate machine translation.²¹ BLEU metrics compare similarities between large corpora of human and machine-generated text.²² Unfortunately, there has been no correlation between BLEU scores and the readability and usefulness of individual machine-generated texts.²³ Other attempts to tie objective metrics to human evaluations have also failed.²⁴

Fortunately, there are many applications at market today that use NLG to perform work-related tasks. These applications reveal a great deal about the kinds of texts NLG applications can generate, and in what work contexts. This provides a useful basis for evaluating NLG capabilities and progress for the purposes of evaluating potential impact on tasks required of office workers.

Scenarios of NLP Development

Using nine objective reading comprehension tests and solutions available at market as benchmarks of progress, this section will describe state of the art NLP capabilities in the present day and in a likely future scenario. The likely future scenario is built on the assumption that algorithms would match human-level performance in all nine of the objective reading comprehension tests described below, as well as plausible improvement in the sophistication of NLP-powered applications at market. The verbal reasoning skills algorithms would demonstrate by matching human performance on these tests form the basis of the likely future scenario. The likely future scenario is inherently uncertain and is not meant to be predictive, but to provide a reasonable basis for analysis of NLP's future impact.

Present-Day Progress in NLP

NLU

Complexity and predictability of written text are critical factors affecting algorithms' ability to understand it. Algorithms are able to demonstrate sophisticated understanding in extremely limited tests of reading comprehension. In the Facebook bAbI 20QA question answering test, the state of the art algorithm has matched human performance, and demonstrated facility with over 20 verbal reasoning types, from word matching to understanding an agent's motivation.²⁵ However, the total range of vocabulary contained in sample passages in the Facebook bAbI 20QA test is 150 words, and the sample sentences are relatively short.²⁶

Such advanced performance at reading comprehension is not possible when the text that must be comprehended is more than a few sentences long or includes a range of vocabulary that approximates adult human expression. Two tests of reading comprehension with more complex context than Facebook bAbI 20QA are the CNN and Daily Mail datasets. These tests present algorithms with articles from the CNN and Daily Mail websites, and ask them to fill in a missing word in a sentence summarizing the article; the correct answer is limited to one of a handful of terms in the sample passage.²⁷ State of the art algorithms are able to correctly answer questions in the CNN and Daily Mail datasets when the wording of the query is an exact match or close paraphrase of the context immediately surrounding the answer; this demonstrates facility with two of the most basic verbal reasoning types.²⁸ Use of these strategies has allowed algorithms to come close to matching human performance on these tests. However, on tests where the answer is not limited to a narrow range of options, algorithms significantly underperform humans at even these basic types of verbal reasoning.²⁹

Performance on the Facebook bAbI 20QA test demonstrates the potential for applications that have deep and precise understanding short passages within a highly specific subject domain. Meanwhile, the more modest abilities proven on the CNN and Daily Mail tests demonstrate that algorithms can extract only very shallow meaning from texts of varied length and subject matter, such as news articles. Present-day algorithms fall far short of human performance on tests that demand more advanced reasoning, have open-ended questions, or have sample passages that represent a greater variety in the style and visual format of sample passages.

NLG

NLG applications currently available at market are able to generate texts based on highly structured data, or data that is organized in tables.³⁰ These kinds of solutions can write reports of sports games, weather events, or financial performances.³¹ These NLG applications do little more than summarize data; they are confined to narrating numbers in the table and cannot apply context outside of their input information or training data.

Table 1. Summarizing State of the Art Performance at Objective NLU Tests in the Baseline Scenario

Test	Reasoning Types Covered	Complexity	Question Type	Algorithmic Performance	Human Performance
Facebook bAbl 20 QA ³²	Synthesis, inference, word matching, paraphrase identification	Very Low	Open-ended	99%	97%
CNN Dataset ³³	Word matching, paraphrase identification, inference	Low	Fill-in-the-blank, multiple choice	78%	83%*
Daily Mail Dataset ³⁴	Word matching, paraphrase identification, inference	Low	Fill-in-the-blank, multiple choice	81%	83%*
MCTest ³⁵	Word matching, paraphrase identification, synthesis	Low	Multiple choice	71%	100%
Stanford Question Answering Dataset (SQuAD) ³⁶	Word matching, paraphrase identification, synonymy, synthesis, inference, applying world knowledge	Medium	Open-ended	83%	81%
NewsQA ³⁷	Word matching, paraphrase identification, inference, synthesis, synonymy, applying world knowledge	Medium	Open-ended	50%	69%
TriviaQA ³⁸	Word matching, paraphrase identification, inference, synthesis, synonymy, applying world knowledge	High	Open-ended	58%	80%
Children's Book Test ³⁹	Synthesis, inference	Low	Guess the last word of a passage	73%	100%
LAMBADA Dataset ⁴⁰	Synthesis, inference, synonymy	Medium	Guess the last word of a passage	55%	91%

*maximum theoretical human performance due to many questions being ambiguous or unanswerable⁴¹

Present-day NLG applications can also generate documents with identical structure and content, save for a small number for variables that a user provides.⁴² These applications use algorithms with reasoning capacity requiring little more than filling out a form.⁴³ One example of this kind of applications in use today is DoNotPay, which generates letters contesting traffic violations based on answers to a few questions.⁴⁴ However, DoNotPay is quick to divert users to a Google search as soon as the query extends beyond its narrow expertise.⁴⁵

Likely Future Progress in NLP

NLU

Matching human performance in all nine reading comprehension tests would demonstrate drastic increases in the length and complexity of texts that algorithms can read and in the precision of their understanding. One particularly challenging test is the TriviaQA dataset, which asks algorithms to answer human-designed trivia questions based on analysis evidence texts, an average of six per question.⁴⁶ Evidence texts are sourced from across the internet and represent a wide range of content structure and visual format.⁴⁷ The LAMBADA dataset, a difficult test that doesn't use the question answering format, requires algorithms to guess the final word in a passage.⁴⁸ Sample passages have an average length of 4.6 sentences, and are filtered to exclude any passages whose answers could be deduced based on analysis of only the passage's final phrases.⁴⁹

Table 2. Examples of NLP Business Applications at Market in Baseline Scenario

Solution Name	Solution Area	Likely NLP Capabilities Used
Clarabridge ⁵⁰	Large-scale content analysis for analyzing customers' social media posts, their survey responses (to deliver an easier survey experience with better questions), and interpreting customer feedback (which is a different business case than the survey but is basically the same thing)	Word matching, paraphrase identification, synonymy identification
Siri ⁵¹	Virtual personal assistant	Word matching, paraphrase identification, synonymy identification, generating text based on limited potential variables or structured data
ROSS Intelligence ⁵²	Legal research assistance	Word matching, paraphrase identification, synonymy
Narrativa ⁵³	Generating reports of sports games, captioning photos, generating product descriptions	Text creation based on structured data
DoNotPay ⁵⁴	Generating letters contesting traffic violations for citizens	Generating texts that vary only by a small number of variables that users provide

Solving these two tests will demonstrate that algorithms can read almost any document or website to respond to genuine human information seeking, as opposed to questions that are designed to test machine comprehension.⁵⁵ Solving them will also demonstrate an ability to go beyond the basic verbal reasoning algorithms can perform in present-day scenario; in the likely future scenario, algorithms will be able to infer knowledge based on multiple distinct pieces of information from multiple sentences within the passage, provided that those sentences are in reasonably close proximity to one another.⁵⁶ Algorithms that can determine the most plausible next step in a narrative or dialogue will demonstrate significant understanding of individual words, beyond just comparing a span of words in a question to spans of text in the sample passage and identifying the most probable match.⁵⁷ Solving these and other tests like the SQuAD dataset and NewsQA dataset will further demonstrate the ability to apply outside knowledge -- for example, by knowing that a "first name" refers to the first, but not the second, word of a name, or that an entity named "Annie" is probably female.⁵⁸

These capabilities will not enable human-level reading comprehension. Algorithms will likely have difficulty inferring knowledge based on distinct pieces of information that are more than several sentences apart. In addition, algorithms will report only what the text literally says; matching human performance on even the most difficult tests will not enable comprehension beyond face-value meanings of the words in the text, such as facts or figures. Algorithms will not likely be able to “read between the lines,” or infer beyond what is objectively clear.

NLG

In the likely future scenario, NLG will move beyond simple summaries of highly structured data. NLG applications will be able to write text based on unstructured data where the desired text and source data are within a very specific subject matter and have extremely consistent length, structure, tone, and strategic intent. In such limited context, writing can be generated that synthesizes written work from multiple sources into a cohesive summary report or, in some cases, persuasive argument. NLG applications will also be able to generate text from structured data that is more sophisticated than in the present-day scenario.

Unstructured data that algorithms synthesize into a consistent narrative will be limited to information that is objectively stated in the source material, such as facts or figures, or information contained in training data. Applications in this scenario will not be able to apply creative thinking, social intelligence, or general world knowledge in their writing.

Analysis

Methodology

This report analyzes the potential for NLP capabilities described in the present-day and likely future scenarios to substitute for human performance of tasks in the following twelve occupations, taken from the Bureau of Labor Statistics’ O*NET 2010 taxonomy. These occupations represent diverse functions and levels of seniority within office workers in the professional services sector:

- Receptionists and Information Clerks
- Customer Service Representatives
- Paralegals and Legal Assistants
- Accountants
- Bookkeeping, Accounting, and Auditing Clerks
- Financial Analysts
- Lawyers
- Secretaries and Administrative Assistants, Except Legal, Medical, or Executive (hereafter referred to as “Administrative Assistants”)
- Tax Preparers
- Loan Officers
- Legal Secretaries
- Management Analysts

Each task was given a substitutability score for both the present-day and likely future scenarios for NLP development, ranging from zero through four:

- 0: Not at all substitutable
- 1: Slightly substitutable
- 2: Partially substitutable
- 3: Mostly substitutable
- 4: Completely substitutable

Substitutability scores are qualitative estimates of how much of a worker’s time and energy would be saved in performing a given task if state of the art NLP algorithms were applied to that task, relative to the amount of time and energy spent on that task without the introduction of any new technology. In some cases, tasks were comprised of a single activity that NLP applications could address. In many other cases, tasks were comprised of more than one activity; within these tasks, NLP applications could often address some of these activities, but not others. The number of activities within each task that was addressable by NLP was taken into account when assigning a substitutability score.

To provide an overall snapshot of the impact of NLP on each occupation, the percentage of each occupation’s tasks that were evaluated to be substitutable by NLP was calculated. This was done by dividing the sum of all tasks’ substitutability scores for each occupation by the sum of the maximum possible substitutability scores.

A few additional notes warrant mention:

- This analysis focuses only on tasks classified by O*NET as “core” to job performance, and leaves out tasks classified as “supplemental.”
- The O*NET database does not provide a breakdown of how much time a worker in a given occupation spends on each task relative to others. This limits the precision of each occupation’s substitutability percentage as an assessment of NLP’s effect.
- This report does not attempt to project the speed with which technologies are adopted, and recognizes that state of the art technical capabilities often take a significant amount of time to be applied in the workplace.

Task Categories

In analyzing each task description, it was found that reading, writing, speaking, and listening were most often used for three functions: gathering facts and objective information, interfacing with humans, and creating written documents. All but six tasks were assigned to one of three categories based on which of these language functions the task required. NLP applications performing similar functions were found to draw on similar technical capabilities as described in the “Scenarios for NLP Development” section.

The three task categories are described in detail below. The category descriptions will also describe the technical capabilities enabling task substitution. These descriptions are intended to provide a framework for attributing each task’s substitutability score to a specific measure of technical progress.

Fact Finding: tasks that require workers to search for and read documents, websites, and other written content to discover objective information.

Present-Day Scenario

Algorithms’ ability to match words and identify paraphrases enables time saving research applications. These applications can identify spans of words within longer texts that have a high probability of relevance to the question at hand. ROSS Intelligence is an application at market today that makes use of this capability to reduce the time spent conducting research by workers in the legal profession.⁵⁹

However, these applications work best when the wording of the question is very similar to the wording of the immediate context of the correct answer. In addition, these applications work best when text they analyze has consistent format, structure, and subject matter. Even in optimal circumstances, these applications require supervision: they may return highlighted passages that are not relevant to the question, or miss relevant information because of their limited facility with higher categories of verbal reasoning, such as inference or synthesis.

Taking these limitations into account, tasks primarily comprised of fact finding activities were estimated to be slightly or partially substitutable by NLP in the present-day scenario.

Likely Future Scenario

Algorithms that can apply sophisticated verbal reasoning to texts of highly varied visual format, length, vocabulary, and syntactic complexity will enable powerful fact-gathering applications. The applications will be able to gather and analyze written content from across the internet to answer questions. If one out of two conditions are met, the answer will almost always be correct. The first condition is that the answer is stated as a standalone fact. The second condition is that the answer can be inferred by synthesizing pieces of information that are stated within three to four sentences of each other. For example, researchers will be able to instruct an application, “look on the Energy Information Administration website and tell me Louisiana’s total electricity consumption in the most recent year;” because this information is clearly stated on this website as a standalone fact, the application will quickly return the correct answer.

These applications will not work if the correct answer cannot be found in the analyzed text. They will also not work if the distinct pieces of information required to infer the correct answer to a question are more than a few sentences apart. For these reasons, workers will still be needed to supervise these applications and fill in research gaps.

Considering these advantages and limitations, tasks primarily comprised of fact finding activities were estimated to be partially or mostly substitutable by NLP in the likely future scenario. Activities requiring fact finding from texts with very low variability in subject matter, vocabulary, or syntactic complexity were estimated to be fully substitutable.

Table 3. Slightly, Partially, Mostly, or Completely Substitutable Tasks Requiring Fact Finding

Task Detail	Occupation	Present-Day Substitutability	Likely Future Substitutability
Conduct searches to find needed information, using such sources as the Internet.	Administrative Assistants	0	3
Monitor fundamental economic, industrial, and corporate developments by analyzing information from financial publications and services, investment banking firms, government agencies, trade publications, company sources, or personal interviews.	Financial Analysts	2	3
Monitor developments in the fields of industrial technology, business, finance, and economic theory.	Financial Analysts	2	3
Study Constitution, statutes, decisions, regulations, and ordinances of quasi-judicial bodies to determine ramifications for cases.	Lawyers	0	1
Search for and examine public and other legal records to write opinions or establish ownership.	Lawyers	1	3
Analyze applicants' financial status, credit, and property evaluations to determine feasibility of granting loans.	Loan Officers	0	2
Gather and organize information on problems or procedures.	Management Analysts	0	1
Gather and analyze research data, such as statutes, decisions, and legal articles, codes, and documents.	Paralegals and Legal Assistants	1	3

Consult tax law handbooks or bulletins to determine procedures for preparation of atypical returns.	Tax Preparers	1	3
Review financial records such as income statements and documentation of expenditures to determine forms needed to prepare tax returns.	Tax Preparers	0	3

Human Interfacing: tasks that require workers to interact with humans with the purpose of conveying or receiving objective information, such as interviews, surveys, or answering questions.

Present-Day Scenario

Many tasks require workers to conduct brief interactions with people regarding limited subject matter. Algorithms' ability to match words and identify paraphrases, as well as to perform higher forms of verbal reasoning in limited contexts, enables applications that can substitute for humans in many of these interactions. In extremely predictable circumstances, applications can interact with humans with a high degree of consistency, accuracy, and depth. Clara, an appointment scheduling service which functions like an executive assistant on an email chain, is one such application at market today.⁶⁰ Other examples include customer service chat bots that answer the most common support questions.⁶¹

However, these applications cannot interact in contexts where input from humans is unpredictable. Workers must always be available to take over the interaction when unusual questions arise. In addition, these applications are limited to communicating about objective information.

Given these limitations, tasks comprised primarily of interacting with humans were estimated to be partially or fully substitutable in the present-day scenario depending on the predictability of the interactions and the importance of non-verbal social cues.

Likely Future Scenario

Algorithms will have sophisticated verbal reasoning abilities in contexts with a much greater range of visual format, vocabulary, and syntactic complexity. These abilities will extend the range of interactions that NLP applications can competently handle. For example, in the likely future scenario, applications will be able to answer questions from prospective loan applicants about the lending process, partially substituting for one of the loan officers' tasks.

However, applications will still be limited to exchanges of factual information. In addition, there will still be social barriers to the use of NLP applications for interactions with humans, such as interactions where a human's social comfort or experience of a personal connection is a business priority. In tasks that have a significant social dimension, even a leap forward in NLP capabilities does not significantly increase the task's overall substitutability.

Because of these limitations, no tasks were estimated to be fully substitutable in the likely future scenario that weren't already estimated to be fully substitutable in the present-day scenario. However, the number of tasks comprised of human interfacing activities that were estimated to be partially substitutable grew significantly.

Document Creating: tasks that require workers to create written content, such as: describing data tables, synthesizing unstructured data, and completing forms or other documents of consistent structure.

Present-Day Scenario

Applications today can write content that summarizes structured data, or information organized into tables. One example is Narrativa, a Brazilian product that uses statistics about soccer games to create written reports.⁶² Applications can also create written documents whose content varies only by a small number of human-provided passages. DoNotPay, a website that automates the creation of letters contesting traffic citations, is an example of such an application in use today.⁶³

Table 4. Slightly, Partially, Mostly, or Completely Substitutable Tasks Requiring Human Interfacing

Task Detail	Occupation	Present-Day Substitutability	Likely Future Substitutability
Greet visitors or callers and handle their inquiries or direct them to the appropriate persons according to their needs.	Administrative Assistants	1	2
Open, read, route, and distribute incoming mail or other materials and answer routine letters.	Administrative Assistants	1	2
Answer telephones and give information to callers, take messages, or transfer calls to appropriate individuals.	Administrative Assistants	2	2
Schedule and confirm appointments for clients, customers, or supervisors.	Administrative Assistants	4	4
Provide services to customers, such as order placement or account information.	Administrative Assistants	4	4
Perform general office duties, such as filing, answering telephones, and handling routine correspondence.	Bookkeeping, Accounting, and Auditing Clerks	1	2
Access computerized financial information to answer general questions as well as those related to specific accounts.	Bookkeeping, Accounting, and Auditing Clerks	2	3
Resolve customers' service or billing complaints by performing activities such as exchanging merchandise, refunding money, or adjusting bills.	Customer Service Representatives	2	3
Complete contract forms, prepare change of address records, or issue service discontinuance orders, using computers.	Customer Service Representatives	4	4
Schedule and make appointments.	Legal Secretaries	4	4
Explain to customers the different types of loans and credit options that are available, as well as the terms of those services.	Loan Officers	1	1
Meet with applicants to obtain information for loan applications and to answer questions about the process.	Loan Officers	1	2
Interview personnel and conduct on-site observation to ascertain unit functions, work performed, and methods, equipment, and personnel used.	Management Analysts	1	1
Meet with clients and other professionals to discuss details of case.	Paralegals and Legal Assistants	0	1

Hear and resolve complaints from customers or the public.	Receptionists and Information Clerks	1	1
Greet persons entering establishment, determine nature and purpose of visit, and direct or escort them to specific destinations.	Receptionists and Information Clerks	1	2
Operate telephone switchboard to answer, screen, or forward calls, providing information, taking messages, or scheduling appointments.	Receptionists and Information Clerks	2	2
Schedule appointments and maintain and update appointment calendars.	Receptionists and Information Clerks	4	4
Provide information about establishment, such as location of departments or offices, employees within the organization, or services provided.	Receptionists and Information Clerks	4	4
Answer questions and provide future tax planning to clients.	Tax Preparers	1	1
Furnish taxpayers with sufficient information and advice to ensure correct tax form completion.	Tax Preparers	0	1

However, NLP applications cannot create written content without highly structured inputs. Because of this limitation, no tasks comprised primarily of writing activities were estimated to be more than partially substitutable in the present-day scenario, and only two such tasks were estimated to be more than slightly substitutable.

Likely Future Scenario

Algorithms' improved fact-finding ability will enable the creation of structured data tables of information found in text. This ability will enable applications that synthesize multiple sources of written information into a single narrative. In addition, there will be improvements over the present-day scenario in the variability of written content that algorithms are able to create. Overall, these abilities will enable applications that can create most workplace documents that have consistent structure and format, and that convey objective information only, such as many deeds and contracts.

However, these applications will not be capable of creativity or argument, or taking into account context beyond specified inputs. Many tasks comprised primarily of writing activities require creativity, argument, or extensive world knowledge, such as the writing of briefs or affidavits. These tasks will not be substituted for by NLP applications in the likely future scenario.

Many tasks primarily comprised of preparing routine or strictly objective documents were estimated to be mostly substitutable in the likely future scenario. Tasks comprised of activities requiring creativity, strategy, and application of outside context were estimated to be slightly substitutable or not at all substitutable.

Other Tasks

Five tasks that were addressable by NLP in the likely future scenario did not fall neatly within one of the above task categories. These tasks were not composites of activities found in two or more of the above categories, but required activities of reading, writing, listening, or speaking that were unique within the analyzed task structures.

Table 5. Slightly, Partially, Mostly, or Completely Substitutable Tasks Requiring Document Creating

Task Detail	Occupation	Present-Day Substitutability	Likely Future Substitutability
Report to management regarding the finances of establishment.	Accountants	1	1
Prepare, examine, or analyze accounting records, financial statements, or other financial reports to assess accuracy, completeness, and conformance to reporting and procedural standards.	Accountants	1	2
Compose, type, and distribute meeting notes, routine correspondence, or reports, such as presentations or expense, statistical, or monthly reports.	Administrative Assistants	1	2
Operate 10-key calculators, typewriters, and copy machines to perform calculations and produce documents.	Bookkeeping, Accounting, and Auditing Clerks	1	2
Classify, record, and summarize numerical and financial data to compile and keep financial records, using journals and ledgers or computers.	Bookkeeping, Accounting, and Auditing Clerks	2	2
Present oral or written reports on general economic trends, individual corporations, and entire industries.	Financial Analysts	1	2
Examine legal data to determine advisability of defending or prosecuting lawsuit.	Lawyers	1	2
Prepare, draft, and review legal documents, such as wills, deeds, patent applications, mortgages, leases, and contracts.	Lawyers	1	3
Prepare and process legal documents and papers, such as summonses, subpoenas, complaints, appeals, motions, and pretrial agreements.	Legal Secretaries	1	2
Complete various forms, such as accident reports, trial and courtroom requests, and applications for clients.	Legal Secretaries	1	3
Obtain and compile copies of loan applicants' credit histories, corporate financial statements, and other financial information.	Loan Officers	1	1
Analyze data gathered and develop solutions or alternative methods of proceeding.	Management Analysts	1	1
Document findings of study and prepare recommendations for implementation of new systems, procedures, or organizational changes.	Management Analysts	0	1
Prepare legal documents, including briefs, pleadings, appeals, wills, contracts, and real estate closing statements.	Paralegals and Legal Assistants	1	2
Analyze data to determine answers to questions from customers or members of the public.	Receptionists and Information Clerks	1	3
Compute taxes owed or overpaid, using adding machines or personal computers, and complete entries on forms, following tax form instructions and tax tables.	Tax Preparers	1	2

Table 6. Other Slightly, Partially, Mostly, or Completely Substitutable Tasks

Task Detail	Occupation	Present-Day Substitutability	Likely Future Substitutability
Create, maintain, and enter information into databases.	Administrative Assistants	0	1
Review work done by others to check for correct spelling and grammar, ensure that company format policies are followed, and recommend revisions.	Administrative Assistants	0	1
Perform administrative support tasks, such as proofreading, transcribing handwritten information, or operating calculators or computers to work with pay records, invoices, balance sheets, or other documents.	Receptionists and Information Clerks	0	1
Use all appropriate adjustments, deductions, and credits to keep clients' taxes to a minimum.	Tax Preparers	1	2
Prepare or assist in preparing simple to complex tax returns for individuals or small businesses.	Tax Preparers	1	2

Case Studies

This section analyzes in detail the potential for NLP to substitute for human labor in the twelve occupations, each identified by its Standard Occupational Classification (SOC) code. Tables describe the substitutability of each task in the present-day and likely future scenarios. Tasks are organized according to their category of language function as described in the previous section. Tasks in the same categories were often assigned the same substitutability estimate; however, substitutability estimates for tasks in the same categories still varied depending on other factors, such as occupation-specific workplace characteristics, unique task requirements, or additional task activities that are not related to language use. To explain the substitutability estimates, each case study contains a summary that makes frequent reference to the task category descriptions in the previous section.

Administrative Assistants (SOC 43-6014.00)

Present-Day Scenario: 15% substitutability

Likely Future Scenario: 25% substitutability

2016 Total US Employment: 2,295,510⁶⁴

NLP can address many tasks of administrative assistants. Most of these tasks fall in the “human interfacing” category, such as “answer telephones and give information to callers, take messages, or transfer calls to appropriate individuals,” “schedule and confirm appointments for clients, customers, or supervisors,” and “provide services to customers, such as order placement or account information.” These are tasks that require workers to process highly predictable language content in short interactions with humans. NLP-powered applications can already completely substitute for workers in the performance of these tasks, and will be able to increasingly do so in the likely future scenario.

However, tasks in this category indicating a significant social component, including “greet visitors or callers and handle their inquiries or direct them to the appropriate persons according to their needs,” were evaluated to be only partially substitutable even in the likely future scenario. In addition, administrative assistants perform several tasks in support of workplace administration that are not addressable by NLP. These include “Manage

projects or contribute to committee or team work” and “Order and dispense supplies.” “Maintain scheduling and event calendars” was considered to comprise of functions that are not addressable by NLP, such as making sure schedules are aligned with managerial and business priorities. Language-related scheduling functions, such as receiving and responding to appointment requests, were considered to be captured by the “schedule and confirm appointments” task, as mentioned above.

Administrative assistants have one task of which fact-finding is a core component: “conduct searches to find needed information on the internet.” Research tools with the ability to perform advanced verbal reasoning within content of varied structure and visual format will be able to mostly substitute for this task in the likely future scenario. Algorithmic capabilities at predicting the final word of a paragraph in the likely future scenario will enable applications that can perform the first round of editing and proofreading, slightly substituting for “review work done by others to check for correct spelling and grammar, ensure that company format policies are followed, and recommend revisions.”

Table 7. Administrative Assistants’ Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Conduct searches to find needed information, using such sources as the Internet.	■■■■ Not Substitutable	■■■■ Fact Finding
Greet visitors or callers and handle their inquiries or direct them to the appropriate persons according to their needs.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Open, read, route, and distribute incoming mail or other materials and answer routine letters.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Answer telephones and give information to callers, take messages, or transfer calls to appropriate individuals.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Schedule and confirm appointments for clients, customers, or supervisors.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Provide services to customers, such as order placement or account information.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Compose, type, and distribute meeting notes, routine correspondence, or reports, such as presentations or expense, statistical, or monthly reports.	■■■■ Document Creating	■■■■ Document Creating
Create, maintain, and enter information into databases.	■■■■ Not Substitutable	■■■■ Other
Review work done by others to check for correct spelling and grammar, ensure that company format policies are followed, and recommend revisions.	■■■■ Not Substitutable	■■■■ Other
Use computers for various applications, such as database management or word processing.	■■■■ Not Substitutable	■■■■ Not Substitutable
Set up and manage paper or electronic filing systems, recording information, updating paperwork, or maintaining documents, such as attendance records, correspondence, or other material.	■■■■ Not Substitutable	■■■■ Not Substitutable
Operate office equipment, such as fax machines, copiers, or phone systems and arrange for repairs when equipment malfunctions.	■■■■ Not Substitutable	■■■■ Not Substitutable
Maintain scheduling and event calendars.	■■■■ Not Substitutable	■■■■ Not Substitutable

Complete forms in accordance with company procedures.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Make copies of correspondence or other printed material.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Locate and attach appropriate files to incoming correspondence requiring replies.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Operate electronic mail systems and coordinate the flow of information, internally or with other organizations.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Manage projects or contribute to committee or team work.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Mail newsletters, promotional material, or other information.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Order and dispense supplies.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Learn to operate new office technologies as they are developed and implemented.	■■■■■ Not Substitutable	■■■■■ Not Substitutable

Receptionists and Information Clerks (SOC 43-4171.00)

Present-Day Scenario: 30% Substitutability
Likely Future Scenario: 39% Substitutability
2016 Total Employment: 997,770⁶⁵

An even greater proportion of receptionists’ tasks than those of administrative assistants fall within the “human interfacing” category. These tasks include “operate telephone switchboard to answer, screen, or forward calls, providing information, taking messages, or scheduling appointments,” “provide information about establishment, such as location of departments or offices, employees within the organization, or services provided,” and “schedule appointments and maintain and update appointment calendars.” Many of these tasks involve short, highly predictable interactions that can be completely substituted for in the present-day scenario.

Of receptionists’ task in the human interfacing category, some have a significant social component, such as “Greet persons entering establishment, determine nature and purpose of visit, and direct or escort them to specific destinations.” These tasks were evaluated to be only partially substitutable by NLP in the likely future scenario. Overall, a large proportion of receptionists’ tasks are addressable by NLP, contributing to high overall task substitutability.

Table 8. Receptionists and Information Clerks’ Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Hear and resolve complaints from customers or the public.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Greet persons entering establishment, determine nature and purpose of visit, and direct or escort them to specific destinations.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Operate telephone switchboard to answer, screen, or forward calls, providing information, taking messages, or scheduling appointments.	■■■■■ Human Interfacing	■■■■■ Human Interfacing

Schedule appointments and maintain and update appointment calendars.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Provide information about establishment, such as location of departments or offices, employees within the organization, or services provided.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Analyze data to determine answers to questions from customers or members of the public.	■ ■ ■ ■ ■ Document Creating	■ ■ ■ ■ ■ Document Creating
Perform administrative support tasks, such as proofreading, transcribing handwritten information, or operating calculators or computers to work with pay records, invoices, balance sheets, or other documents.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Other
File and maintain records.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Receive payment and record receipts for services.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Transmit information or documents to customers, using computer, mail, or facsimile machine.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Collect, sort, distribute, or prepare mail, messages, or courier deliveries.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable

Customer Service Representatives (SOC 43-4051.00)

Present-Day Scenario: 38% Substitutability

Likely Future Scenario: 44% Substitutability

2016 Total Employment: 2,707,040⁶⁶

Half of customer service representatives’ tasks fall within the “human interfacing” category. Of these, “complete contract forms, prepare change of address records, or issue service discontinuance orders, using computers” requires interactions that are limited to one of three possible subjects, and is completely substitutable by NLP in the present-day scenario.

“Resolve customers’ service or billing complaints by performing activities such as exchanging merchandise, refunding money, or adjusting bills” required interactions with less well-defined subject matter parameters. Some service or billing issues will be extremely common, and NLP applications will be able to handle them, while less predictable issues will require human support. For this reason, this task was evaluated to be only partially substitutable in the present-day scenario, and mostly substitutable in the likely future scenario.

Customer service representatives’ other two tasks are perhaps somewhat automatable using other technology, but do not have significant components requiring reading, writing, speaking, or listening, and are not addressable by NLP.

Table 9. Customer Service Representatives’ Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Resolve customers’ service or billing complaints by performing activities such as exchanging merchandise, refunding money, or adjusting bills.	■■■■■ Human Interfacing	■■■■■ Human Interfacing

Complete contract forms, prepare change of address records, or issue service discontinuance orders, using computers.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Check to ensure that appropriate changes were made to resolve customers' problems.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Keep records of customer interactions or transactions, recording details of inquiries, complaints, or comments, as well as actions taken.	■■■■■ Not Substitutable	■■■■■ Not Substitutable

Bookkeeping, Accounting, and Auditing Clerks (SOC 43-3031.00)

Present-Day Scenario: 12% Substitutability by NLP

Likely Future Scenario: 17% Substitutability by NLP

2016 Total Employment: 1,566,960⁶⁷

A relatively low number of bookkeepers' tasks are addressable by NLP. Of these, "Classify, record, and summarize numerical and financial data to compile and keep financial records, using journals and ledgers or computers" and "Classify, record, and summarize numerical and financial data to compile and keep financial records, using journals and ledgers or computers" have components that fall within the document creating task category. In the likely future scenario, these tasks will be partially substituted for by tools that can generate text based on structured and some unstructured data.

In addition, "perform general office duties, such as filing, answering telephones, and handling routine correspondence" has components falling within the human interfacing category; short phone calls and correspondence that are in highly predictable subject domains will likely be substitutable by NLP applications in the future scenario.

Many of the rest of bookkeepers' tasks require the handling of numeric data, such as "Perform financial calculations, such as amounts due, interest charges, balances, discounts, equity, and principal." While these tasks are not addressable by NLP, it's worth noting that many of these tasks may be substitutable by other forms of information and communications technologies (ICT), if they have not been already. NLP applications have the potential to accelerate any pre-existing impact of ICT on bookkeepers' jobs.

Table 10. Bookkeeping, Accounting, and Auditing Clerks' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Perform general office duties, such as filing, answering telephones, and handling routine correspondence.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Access computerized financial information to answer general questions as well as those related to specific accounts.	■■■■■ Document Creating & Human Interfacing	■■■■■ Document Creating & Human Interfacing
Operate 10-key calculators, typewriters, and copy machines to perform calculations and produce documents.	■■■■■ Document Creating	■■■■■ Document Creating
Classify, record, and summarize numerical and financial data to compile and keep financial records, using journals and ledgers or computers.	■■■■■ Document Creating	■■■■■ Document Creating
Operate computers programmed with accounting software to record, store, and analyze information.	■■■■■ Not Substitutable	■■■■■ Not Substitutable

Check figures, postings, and documents for correct entry, mathematical accuracy, and proper codes.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Comply with federal, state, and company policies, procedures, and regulations.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Receive, record, and bank cash, checks, and vouchers.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Code documents according to company procedures.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Perform financial calculations, such as amounts due, interest charges, balances, discounts, equity, and principal.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Reconcile or note and report discrepancies found in records.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Debit, credit, and total accounts on computer spreadsheets and databases, using specialized accounting software.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Match order forms with invoices, and record the necessary information.	■■■■■ Not Substitutable	■■■■■ Not Substitutable

Accountants (SOC 13-2011.01)

Present-Day Scenario: 13% Substitutability by NLP
Likely Future Scenario: 19% Substitutability by NLP
2016 Total Employment: 1,246,540⁶⁸

As with bookkeepers, only a small number of accountants’ tasks are addressable by NLP. Parts of “report to management regarding the finances of establishment” fall within the document creating category, such as instances where managers require only a short written summary of financial performance. Aspects of “prepare, examine, or analyze accounting records, financial statements, or other financial reports to assess accuracy, completeness, and conformance to reporting and procedural standards” fall within the document creating category. These tasks were evaluated to be slightly substitutable in the present-day scenario.

NLU capabilities in the likely future scenario will enable applications that can analyze financial documents for common compliance issues, allowing for greater substitution of the “prepare, examine, or analyze accounting records, financial statements, or other financial reports to assess accuracy, completeness, and conformance to reporting and procedural standards” tasks.

However, certain aspects of these tasks are not addressable by NLP. For example, as a part of reporting to management on finances, an accountant may be called upon to give strategic advice based on an analysis of financial data against other aspects of the business. Preparation of financial documents may also require strategic decision making that is beyond the scope of NLP. These factors limited the overall substitutability of accountants’ tasks.

Table 11. Accountants’ Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Report to management regarding the finances of establishment.	■■■■■ Document Creating	■■■■■ Document Creating

Prepare, examine, or analyze accounting records, financial statements, or other financial reports to assess accuracy, completeness, and conformance to reporting and procedural standards.	■ ■ ■ ■ Document Creating	■ ■ ■ ■ Document Creating
Establish tables of accounts and assign entries to proper accounts.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable
Develop, implement, modify, and document recordkeeping and accounting systems, making use of current computer technology.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable

Financial Analysts (SOC 13-2051.00)

Present-Day Scenario: 13% Substitutability Due to NLP

Likely Future Scenario: 20% Substitutability Due to NLP

2016 Total Employment: 281,610 ⁶⁹

A handful of financial analysts' tasks are addressable by NLP. In particular, both "Monitor fundamental economic, industrial, and corporate developments by analyzing information from financial publications and services, investment banking firms, government agencies, trade publications, company sources, or personal interviews" and "Monitor developments in the fields of industrial technology, business, finance, and economic theory" have heavy fact-finding components. These tasks were evaluated to be partially substitutable in the present-day scenario and mostly substitutable in the likely future scenario.

In addition, the task "present oral or written reports on general economic trends, individual corporations, and entire industries" has aspects that fall within the document creating category. Situations may arise where such written reports may only be short summaries of structured financial data, which NLP applications can already address in the present-day scenario.

However, many tasks, such as "Recommend investments and investment timing to companies, investment firm staff, or the public" and "Prepare plans of action for investment, using financial analyses" most likely require a high degree of strategic thinking. Other tasks, like "Purchase investments for companies in accordance with company policy," are beyond the scope of NLP. These tasks limited the overall task substitutability of financial analysts due to NLP applications.

Table 12. Financial Analysts' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Monitor fundamental economic, industrial, and corporate developments by analyzing information from financial publications and services, investment banking firms, government agencies, trade publications, company sources, or personal interviews.	■ ■ ■ ■ Fact Finding	■ ■ ■ ■ Fact Finding
Monitor developments in the fields of industrial technology, business, finance, and economic theory.	■ ■ ■ ■ Fact Finding	■ ■ ■ ■ Fact Finding
Present oral or written reports on general economic trends, individual corporations, and entire industries.	■ ■ ■ ■ Document Creating	■ ■ ■ ■ Document Creating
Inform investment decisions by analyzing financial information to forecast business, industry, or economic conditions.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable

Prepare plans of action for investment, using financial analyses.	■■■■ Not Substitutable	■■■■ Not Substitutable
Evaluate and compare the relative quality of various securities in a given industry.	■■■■ Not Substitutable	■■■■ Not Substitutable
Recommend investments and investment timing to companies, investment firm staff, or the public.	■■■■ Not Substitutable	■■■■ Not Substitutable
Interpret data on price, yield, stability, future investment-risk trends, economic influences, and other factors affecting investment programs.	■■■■ Not Substitutable	■■■■ Not Substitutable
Purchase investments for companies in accordance with company policy.	■■■■ Not Substitutable	■■■■ Not Substitutable
Draw charts and graphs, using computer spreadsheets, to illustrate technical reports.	■■■■ Not Substitutable	■■■■ Not Substitutable

Tax Preparers (SOC 13-2082.00)

Present-Day Scenario: 11% Substitutability Due to NLP

Likely Future Scenario: 34% Substitutability Due to NLP

2016 Total Employment: 70,030⁷⁰

Over 50 percent of tax preparers' tasks are at least slightly substitutable by NLP. Of these, "Use all appropriate adjustments, deductions, and credits to keep clients' taxes to a minimum" does not fit neatly within one of the three main substitutable task categories. However, this task was evaluated to be slightly substitutable in the present-day scenario and partially substitutable in the likely future scenario. In certain situations, it is likely possible to determine adjustments, deductions, and credits a client should use based on a narrow range of objective factors. NLP applications can present users with pre-defined questions to collect information on these factors, and present a narrow range of recommendations. This task was evaluated to be partially substitutable by NLP in the likely future scenario. By the same reasoning, the task "prepare or assist in preparing simple to complex tax returns for individuals or small businesses" was also evaluated to be partially substitutable in the likely future scenario.

Two of tax preparers' tasks fall in the fact-finding category: "Review financial records such as income statements and documentation of expenditures to determine forms needed to prepare tax returns" and "consult tax law handbooks or bulletins to determine procedures for preparation of atypical returns." NLP applications' relatively weak abilities at verbal reasoning and in handling multiple texts in different formats limit the substitutability of these tasks in the present-day scenario. In the likely future scenario, leaps forward in NLU's abilities will enable applications that can mostly substitute for these tasks.

It will be difficult for NLP applications to completely substitute for the two tasks that fall outside the three main categories. Many tax situations will demand prior experience, knowledge, and strategic thinking to handle effectively. Other tasks, such as "Check data input or verify totals on forms prepared by others to detect errors in arithmetic, data entry, or procedures," are not addressable by NLP. However, improvements in NLP applications' fact finding abilities are likely to have a growing impact on tax preparers' tasks in the near future.

Table 13. Tax Preparers' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Explain federal and state tax laws to individuals and companies.	■■■■ Not Substitutable	■ ■ ■ ■ Fact Finding
Consult tax law handbooks or bulletins to determine procedures for preparation of atypical returns.	■ ■ ■ ■ Fact Finding	■ ■ ■ ■ Fact Finding
Review financial records such as income statements and documentation of expenditures to determine forms needed to prepare tax returns.	■■■■ Not Substitutable	■ ■ ■ ■ Fact Finding
Answer questions and provide future tax planning to clients.	■ ■ ■ ■ Human Interfacing	■ ■ ■ ■ Human Interfacing
Furnish taxpayers with sufficient information and advice to ensure correct tax form completion.	■■■■ Not Substitutable	■ ■ ■ ■ Human Interfacing
Compute taxes owed or overpaid, using adding machines or personal computers, and complete entries on forms, following tax form instructions and tax tables.	■ ■ ■ ■ Document Creating	■ ■ ■ ■ Document Creating
Use all appropriate adjustments, deductions, and credits to keep clients' taxes to a minimum.	■ ■ ■ ■ Other	■ ■ ■ ■ Other
Prepare or assist in preparing simple to complex tax returns for individuals or small businesses.	■ ■ ■ ■ Other	■ ■ ■ ■ Other
Interview clients to obtain additional information on taxable income and deductible expenses and allowances.	■■■■ Not Substitutable	■■■■ Not Substitutable
Check data input or verify totals on forms prepared by others to detect errors in arithmetic, data entry, or procedures.	■■■■ Not Substitutable	■■■■ Not Substitutable
Calculate form preparation fees according to return complexity and processing time required.	■■■■ Not Substitutable	■■■■ Not Substitutable

Loan Officers (SOC 13-2072.00)

Present-Day Scenario: 6% Substitutability by NLP

Likely Future Scenario: 13% Substitutability by NLP

2016 Total Employment: 305,700⁷¹

A relatively small proportion of loan officers' tasks are addressable by NLP. Two of these tasks, "meet with applicants to obtain information for loan applications and to answer questions about the process" and "explain to customers the different types of loans and credit options that are available, as well as the terms of those services" have aspects that fall within the human interfacing category. Some of these interactions likely do not require the formation of a personal connection with applicants and have predictable subject matter; for these reasons, these tasks were evaluated to be slightly substitutable in the present-day scenario and mostly substitutable in the likely future scenario.

The task "Analyze applicants' financial status, credit, and property evaluations to determine feasibility of granting loans" has aspects falling within both the fact-finding and document creating categories. Due to advances in NLP capabilities in these categories, these tasks were evaluated to be partially substitutable in the likely future scenario.

However, loan officers will still be needed to supervise research and document creation tools as well as to synthesize their findings. In addition, many meetings and other interactions with customers in which only factual information is directly communicated nonetheless have a heavy social component. This limits the future substitutability of these tasks. Other tasks are not addressable by NLP.

Table 14. Loan Officers' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Analyze applicants' financial status, credit, and property evaluations to determine feasibility of granting loans.	■■■■ Not Substitutable	■■■■ Fact Finding & Document Creating
Explain to customers the different types of loans and credit options that are available, as well as the terms of those services.	■■■■ Human Interfacing	■■■■ Human Interfacing
Meet with applicants to obtain information for loan applications and to answer questions about the process.	■■■■ Human Interfacing	■■■■ Human Interfacing
Obtain and compile copies of loan applicants' credit histories, corporate financial statements, and other financial information.	■■■■ Document Creating	■■■■ Document Creating
Review loan agreements to ensure that they are complete and accurate according to policy.	■■■■ Not Substitutable	■■■■ Not Substitutable
Approve loans within specified limits, and refer loan applications outside those limits to management for approval.	■■■■ Not Substitutable	■■■■ Not Substitutable
Handle customer complaints and take appropriate action to resolve them.	■■■■ Not Substitutable	■■■■ Not Substitutable
Stay abreast of new types of loans and other financial services and products to better meet customers' needs.	■■■■ Not Substitutable	■■■■ Not Substitutable
Review and update credit and loan files.	■■■■ Not Substitutable	■■■■ Not Substitutable
Submit applications to credit analysts for verification and recommendation.	■■■■ Not Substitutable	■■■■ Not Substitutable
Compute payment schedules.	■■■■ Not Substitutable	■■■■ Not Substitutable
Analyze potential loan markets and develop referral networks to locate prospects for loans.	■■■■ Not Substitutable	■■■■ Not Substitutable

Paralegals and Legal Assistants (SOC 23-2011.00)

Present-Day Scenario: 8% Substitutability Due to NLP

Likely-Future Scenario: 25% Substitutability Due to NLP

2016 Total Employment: 277,310⁷²

A large proportion of paralegals' tasks have a significant language processing component. "Gather and analyze research data, such as statutes, decisions, and legal articles, codes, and documents" falls within the fact-finding category; in the likely future scenario, NLP applications that can accurately answer factual questions and synthesize responses into a research memo could mostly substitute for this task. The task "prepare legal documents, including briefs, pleadings, appeals, wills, contracts, and real estate closing statements" falls within the document creating category. Since many legal documents have extremely

consistent structure and straightforward content, this task was evaluated to be partially substitutable in the likely future scenario.

The task “meet with clients and other professionals to discuss details of case” falls within the human interfacing category. While client meetings often have the purpose of establishing trust, in some circumstances paralegals may sit in on these meetings only to record factual details and prepare summaries for attorneys to review later. NLP applications that can record and answer questions about factual information will be able to substitute for this function. For this reason, this task was evaluated to be slightly substitutable in the likely future scenario.

The task “prepare affidavits or other documents, such as legal correspondence, and organize and maintain documents in paper or electronic filing system,” while having a major language processing component, was evaluated to be not at all substitutable in the likely future scenario due to the highly variable length and content of affidavits and other legal correspondence. Some of paralegals’ tasks are not addressable by NLP. These include “prepare for trial by performing tasks such as organizing exhibits” and “file pleadings with court clerk.”

Table 15. Paralegals and Legal Assistants’ Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Gather and analyze research data, such as statutes, decisions, and legal articles, codes, and documents.	■ ■ ■ ■ Fact Finding	■ ■ ■ ■ Fact Finding
Meet with clients and other professionals to discuss details of case.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Human Interfacing
Prepare legal documents, including briefs, pleadings, appeals, wills, contracts, and real estate closing statements.	■ ■ ■ ■ Document Creating	■ ■ ■ ■ Document Creating
Prepare affidavits or other documents, such as legal correspondence, and organize and maintain documents in paper or electronic filing system.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable
Prepare for trial by performing tasks such as organizing exhibits.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable
File pleadings with court clerk.	■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ Not Substitutable

Lawyers (SOC 23-1011.00)

Present-Day Scenario: 4% Substitutability by NLP
Likely Future Scenario: 14% Substitutability by NLP
2016 Total Employment: 619,530⁷³

Many of lawyers’ tasks demand reading, writing, speaking, and listening. In fact, these could be understood as lawyers’ core functions. NLP applications can be applied to some of these tasks.

The tasks "study Constitution, statutes, decisions, regulations, and ordinances of quasi-judicial bodies to determine ramifications for cases" and "search for and examine public and other legal records to write opinions or establish ownership" have aspects that fall within the fact-finding category and will at least slightly substitutable in the likely future scenario. In addition, tasks like "prepare, draft, and review legal documents, such as wills, deeds, patent applications, mortgages, leases, and contracts" fall within the document creating category and will likely be mostly substitutable in the likely future scenario.

However, many of tasks require natural language functions more complex than the understanding or conveyance of objective, factual information. For example, "prepare legal briefs and opinions, and file appeals in state and federal courts of appeal" demands knowledge of the context of a case, strategic thinking, creativity, and persuasive abilities. Core activities to lawyers' job performance, such as courtroom and client service activities, are beyond the scope of NLP.

Table 16. Lawyers' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Study Constitution, statutes, decisions, regulations, and ordinances of quasi-judicial bodies to determine ramifications for cases.	■■■■■ Not Substitutable	■ ■ ■ ■ ■ Fact Finding
Search for and examine public and other legal records to write opinions or establish ownership.	■ ■ ■ ■ ■ Fact Finding	■ ■ ■ ■ ■ Fact Finding
Gather evidence to formulate defense or to initiate legal actions, by such means as interviewing clients and witnesses to ascertain the facts of a case.	■■■■■ Not Substitutable	■ ■ ■ ■ ■ Human Interfacing
Examine legal data to determine advisability of defending or prosecuting lawsuit.	■ ■ ■ ■ ■ Document Creating	■ ■ ■ ■ ■ Document Creating
Prepare, draft, and review legal documents, such as wills, deeds, patent applications, mortgages, leases, and contracts.	■ ■ ■ ■ ■ Document Creating	■ ■ ■ ■ ■ Document Creating
Analyze the probable outcomes of cases, using knowledge of legal precedents.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Advise clients concerning business transactions, claim liability, advisability of prosecuting or defending lawsuits, or legal rights and obligations.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Select jurors, argue motions, meet with judges, and question witnesses during the course of a trial.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Interpret laws, rulings and regulations for individuals and businesses.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Present evidence to defend clients or prosecute defendants in criminal or civil litigation.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Represent clients in court or before government agencies.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Present and summarize cases to judges and juries.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Negotiate settlements of civil disputes.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Supervise legal assistants.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Evaluate findings and develop strategies and arguments in preparation for presentation of cases.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Prepare legal briefs and opinions, and file appeals in state and federal courts of appeal.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Confer with colleagues with specialties in appropriate areas of legal issue to establish and verify bases for legal proceedings.	■■■■■ Not Substitutable	■■■■■ Not Substitutable
Perform administrative and management functions related to the practice of law.	■■■■■ Not Substitutable	■■■■■ Not Substitutable

Legal Secretaries (SOC 46-6012)

Present-Day Scenario: 17% of Tasks Substitutable by NLP

Likely Future Scenario: 25% of Tasks Substitutable by NLP

2016 Total Employment: 191,200⁷⁴

Only a few of legal secretaries' tasks are addressable by NLP. However, the natural language functions of these tasks demand the conveyance and understanding of factual information in highly predictable contexts. In particular, "schedule and make appointments" falls within the human interfacing category and is already completely substitutable by NLP in the present-day scenario.

The two remaining NLP-addressable tasks, "prepare and process legal documents and papers, such as summonses, subpoenas, complaints, appeals, motions, and pretrial agreements" and "complete various forms, such as accident reports, trial and courtroom requests, and applications for clients," fall within the document creating category. They were evaluated to be partially and mostly substitutable in the likely future scenario.

Other tasks of legal secretaries include "Organize and maintain law libraries, documents, and case files" and "assist attorneys in collecting information such as employment, medical, and other records." These and other organizational and administrative duties are not addressable by NLP.

Table 17. Legal Secretaries' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Schedule and make appointments.	■■■■■ Human Interfacing	■■■■■ Human Interfacing
Prepare and process legal documents and papers, such as summonses, subpoenas, complaints, appeals, motions, and pretrial agreements.	■ ■ ■ ■ ■ Document Creating	■ ■ ■ ■ ■ Document Creating
Complete various forms, such as accident reports, trial and courtroom requests, and applications for clients.	■ ■ ■ ■ ■ Document Creating	■ ■ ■ ■ ■ Document Creating
Mail, fax, or arrange for delivery of legal correspondence to clients, witnesses, and court officials.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Receive and place telephone calls.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Organize and maintain law libraries, documents, and case files.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Make photocopies of correspondence, documents, and other printed matter.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Assist attorneys in collecting information such as employment, medical, and other records.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable
Draft and type office memos.	■ ■ ■ ■ ■ Not Substitutable	■ ■ ■ ■ ■ Not Substitutable

Management Analysts (SOC 13-1111.00)

Present-Day Scenario: 5% Substitutability by NLP
Likely-Future Scenario: 10% Substitutability by NLP
2016 Total Employment: 637,690⁷⁵

Management analysts, commonly known as management consultants, had the fewest tasks that were even addressable by NLP of all occupations profiled in this report. "Interview personnel and conduct on-site observation to ascertain unit functions, work performed, and methods, equipment, and personnel used" may in some cases require management analysts to conduct a large number of interviews that are strictly for the purpose of gathering straightforward, factual information and have consistent content. In these cases, an NLP application could substitute for a worker. NLP applications could likewise substitute for any portion of "analyze data gathered and develop solutions or alternative methods of proceeding" that requires management analysts to develop short written summaries of highly structured data. These two tasks were evaluated to be slightly substitutable by NLP in the present-day scenario.

"Document findings of study and prepare recommendations for implementation of new systems, procedures, or organizational changes" has aspects falling in the document creating category and was evaluated to be slightly substitutable by NLP in the likely future scenario. This was based on the projection that in the likely future scenario NLP applications will be able to synthesize structured and some unstructured data into summary narratives. Applications using this capability could assist management analysts in tying together their research into text snippets that are easily understood by clients.

Finally, "gather and organize information on problems or procedures" has aspects falling in the fact-finding category and was also evaluated to be slightly substitutable in the likely future scenario. This was based on the projection that in the likely future scenario NLP applications will be able to report objective information contained in written content across a variety of visual formats and at a high level of verbal complexity. Applications using this ability could perform initial analyses of company documentation and procedure manuals to inform management analysts' research.

However, the above four tasks will likely be the extent of NLP's substitution of management analysts' tasks. NLP will likely have only a marginal impact on management analysts' work. Many tasks, such as "plan study of work problems and procedures, such as organizational change, communications, information flow, integrated production methods, inventory control, or cost analysis," involve a high level of strategic thinking and collaboration that NLP does not address.

Table 18. Management Analysts' Task Substitutability

Task Detail	Present-Day Substitutability	Likely Future Substitutability
Gather and organize information on problems or procedures.	 Not Substitutable	 Fact Finding
Interview personnel and conduct on-site observation to ascertain unit functions, work performed, and methods, equipment, and personnel used.	 Human Interfacing	 Human Interfacing
Analyze data gathered and develop solutions or alternative methods of proceeding.	 Document Creating	 Document Creating

Document findings of study and prepare recommendations for implementation of new systems, procedures, or organizational changes.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Document Creating</p>
Plan study of work problems and procedures, such as organizational change, communications, information flow, integrated production methods, inventory control, or cost analysis.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>
Confer with personnel concerned to ensure successful functioning of newly implemented systems or procedures.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>
Prepare manuals and train workers in use of new forms, reports, procedures or equipment, according to organizational policy.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>
Review forms and reports and confer with management and users about format, distribution, and purpose, identifying problems and improvements.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>
Develop and implement records management program for filing, protection, and retrieval of records, and assure compliance with program.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>
Design, evaluate, recommend, and approve changes of forms and reports.	<p>■ ■ ■ ■ Not Substitutable</p>	<p>■ ■ ■ ■ Not Substitutable</p>

Discussion

Even assuming substantial improvement from present-day capabilities, NLP does not come close to matching humans in reading, writing, speaking, and listening abilities. NLP applications will be able to substitute for human labor in many tasks that involved fact-finding, interfacing with humans, or creating documents. Humans will still be needed to apply strategic thinking, creativity, and social and emotional intelligence to many natural language tasks. This implication aligns with the conclusions of many prior analyses of automation's impact, such as those performed by Osborne and Frey and the McKinsey Global Institute. An average of 23 percent of the tasks of the sample occupations were evaluated to be substitutable by NLP in the likely future scenario – an overall modest, but significant impact.

It will be technically feasible for NLP to substitute for tasks disproportionately among occupations whose workers occupy more junior positions within their workplace hierarchies. Due to this substitution effect, the number of workers employed in these occupations will likely decline at an undetermined point in the future. Many individual workers will be able to adapt as their jobs change. In addition, this change is not likely to be sudden, as adoption of state of the art technology by firms can stretch out over many years.

However, this change will displace some workers, and reduce opportunities for people entering the workforce. Policy makers should consider measures that ensure workers of all ages can attain the foundational and specific skills they'll need to thrive in the future.

Implications for Workers and Workplaces

In examining the case study results, a pattern emerges: workers that occupy most junior positions within their organizations spend a proportionately large amount of time interacting with objective, factual information in natural language, from reading text, communicating with humans, or composing memos. Meanwhile, a core part of the job of their seniors is to use this information to inform their strategic and creative thought processes. Table 19 summarizes the case study findings.

There are a variety of ways that individual workers can adapt to task substitution. However, to the extent that lower level information processing can be performed by NLP-powered applications, the ratio of lower level occupations relative to upper level occupations will likely decline.

Senior Decision Makers

Many tasks required of lawyers, management analysts, and financial analysts require a high degree of creativity, strategic thinking and/or social and emotional intelligence. NLP applications in the future could substitute for some of tasks required of these occupations that are performed by humans today, but these occupations were evaluated to have a relatively low level of task substitutability. Workers in these occupations will likely use time saved from using NLP applications to deliver better outcomes on their more difficult responsibilities. In this way, NLP will serve to augment, rather than replace, human labor in these and similar occupations.

Table 19. Summary of present-day and likely future task substitutability for sample occupations

Occupation	Present-Day Substitutability	Likely Future Substitutability
Customer Service Representatives	38%	44%
Receptionists and Information Clerks	30%	39%
Tax Preparers	11%	34%
Legal Secretaries	17%	25%
Administrative Assistants	15%	25%
Paralegals and Legal Assistants	8%	25%
Financial Analysts	13%	20%
Accountants	13%	19%
Bookkeeping, Accounting, and Auditing Clerks	12%	17%
Loan Officers	6%	13%
Lawyers	4%	14%
Management Analysts	5%	10%
Median	12%	23%

Number-Heavy Financial Professionals

Other occupations also had a relatively low level of substitutability, such as loan officers, bookkeepers, and accountants/auditors. These occupations are comprised of tasks that require little reading, writing, speaking, or listening, and were not addressable by NLP. Compared to lawyers, management analysts, and financial analysts, these occupations do not have many tasks that require creativity, strategic thinking, or social and emotional intelligence. Instead, many tasks required the processing of numerical data. Many of these tasks may be substitutable by other forms of information and communications technologies (ICT) in the near future, if they have not been already. NLP applications have the potential to accelerate any pre-existing impact of ICT on these and other applications in the professional services sector that are heavily comprised of numeric tasks.

Information Processors

For the remaining six sample occupations (administrative assistants, receptionists, tax preparers, paralegals, legal secretaries, and customer service representatives), a quarter or more of their tasks were evaluated to be substitutable by NLP in the likely future scenario.

If faced with replacement of such a large proportion of their job by NLP, workers could adapt in one of two ways. First, a worker's job may shift to include more time spent on tasks that require creativity, strategic thinking, or social and emotional intelligence. For example, administrative assistants may use time saved from having to give out an establishment's address over the phone to manage more projects. Alternatively, tasks could evolve to require more strategic, creative, and social skills. For example, over 40 percent of customer service representatives' tasks were evaluated to be substitutable by NLP in the likely future scenario, because many customer interactions are short and highly predictable. But time saved from answering routine questions could be spent driving faster resolution on more complicated issues. A customer service representative may

spend the same amount of time on this task as they did before NLP applications substituted for much of their labor.

However, some workers in these six occupations will not find ways to reallocate time saved from the use of NLP applications to activities requiring creativity, strategic thinking, or social/emotional intelligence. In these circumstances, firms may not replace such a worker if he or she departs, or hire fewer such workers per business unit when expanding. In aggregate, it's likely that employment levels per business unit of each of these six occupations will decrease as NLP applications are adopted. It's also likely that many other occupations in the professional services sector with similar task profiles will see similar declines.

Uncertain Impact on Aggregate Employment Levels

It's worth noting that decline in per-business unit employment does not necessarily portend decline in economy-wide employment levels for a given occupation, as was demonstrated in an analysis of bank tellers and ATMs by James Bessen in 2016.⁷⁶ When the number of tellers needed to fully staff a commercial bank branch fell from an average of 21 to 13 between 2000 and 2014, it decreased the cost of expansion for banks.⁷⁷ In response, banks opened many new branches across the US in that time period, and the total number of tellers employed in the US increased by 10 percent.⁷⁸

However, it's unlikely that decline in per-business unit employment of highly substitutable occupations will always coincide with rapid compensatory expansion in their respective businesses and industries. Instead, it's probable that overall employment levels of at least some of highly substitutable occupations will decline. While adoption of state of the art technologies that cause substitution will not happen suddenly, this would ultimately cause displacement for some workers. Over time, it would also diminish the pool of relatively low-skill, well-paid employment opportunities available to people entering the workforce. The next section will discuss areas policymakers could focus on to address these challenges.

Paths Forward for Policy

Governments must design policies to ensure that current and future workers have foundational creative, strategic, and social skills. These skills are critical to interacting with clients, managing projects, writing persuasive documents, making strategic recommendations, and performing administrative duties. These skills increase the likelihood that workers in high-substitutability occupations will be able to adapt in place or move into higher positions in their organizations. They will also enable more young people to enter the workforce at more senior positions. Policies must also ensure that current workers are able to develop the specific skills they need as jobs and workplaces change. These policies could include targeted interventions aimed at displaced and at-risk workers. They could also include reforms aimed at all workers that enable continuous skills evolution to address dynamic workplace demands. Governments can pursue these goals through changes in public education, tax policy, workforce development, and other policy areas.

Education

High school and college learning environments could better emphasize the creative, strategic, and social skills students will need in the coming decades. Learning activities that foster these skills could be emphasized at a higher rate. For example, students could each be required to lead group projects or class discussions more often than they currently are today. Incorporating project management, administration, presentation, and other workplace activities that are unlikely to be substituted for in the likely future scenario more explicitly into curricula design and student evaluation would better align students' academic goals with professional services workplace needs.

Tax Incentives

Business tax incentives currently favor investment in capital equipment; policy makers could use **tax policy to better incent businesses** to invest in workers. One possibility is the worker training tax credit, which would allow businesses to write off a significant proportion of their training expenses. With a worker training tax credit realigning incentives, more managers may be inclined towards helping their more junior employees develop skills they'll need to advance in the professional services sector. Policy makers could explore other strategies as well, such as tax credits for the employment of workers in occupations most likely to face displacement.

Workforce Development

Policy makers could collaborate with industries within the professional services sector to create **microcredential programs**. These standardized training programs would certify workers in industry-relevant skill areas that do not require years of classroom learning. For example, short programs could be developed to train receptionists on how to use spreadsheet software for data analysis, deliver persuasive presentations, or become a CRM administrator. These credentials could be "stackable," or organized into career pathways, and would be focused on instilling digital literacy skills that are constantly evolving in today's workplaces.

As ICT continuously changes workplaces, continuous skills development must become a part of the fabric of working life. This will require a change in cultural outlook on the part of both workers and employers, but policy makers can help. For example, every six years workers in Belgium are given a **government voucher for a few hours of career counseling**. Such a policy could help workers stay informed of technological changes and the kinds of skills that would be most useful to develop.

Other Policy Areas

Policy makers could also explore ways of **experimenting with a four-day workweek**, with the extra day designated for career learning and skills development. Such a major change in workers' habits should be experimented with heavily before being instituted at scale; however, it's worth considering as one way of managing the substitution of workplace tasks by ICT.

For workers that are suddenly out of their jobs, unemployment benefits may not be sufficient to help them find new careers. These workers may need more direct and immediate assistance to stay in the workforce. Policy makers could explore providing **training subsidies** to displaced workers. Policy makers would need to carefully consider how these subsidies should be targeted, perhaps addressing certain at-risk industries or occupational categories. For displaced workers that are later in their careers, policy makers could explore **early retirement programs**.

For training programs to be effective, there must be consistent dialogue between employers and educators on the skills required for workplace success. **Collaboration among institutions at the local level** can help ensure that workers are receiving the training they really need. At a higher level, public/private data sharing initiatives to support a **real-time, continuously-updating repository of information on what skills employees need and what training programs can teach** could increase the chances of workers learning the right skills, and of employers finding the right applicants. Government at all levels could play a role in expanding on many existing, smaller-scale initiatives, or spearheading new ones.

Recommendations for Further Research: Platform Disruption

Task substitutability analysis may underestimate ICT's impact on employment. Sometimes, tasks are automated one at a time, when technology firms design tools to substitute for labor in a particular workplace or occupational category. The impact on workers' jobs varies, as described in the previous section. Task substitutability analysis can help researchers understand the potential for this kind of automation.

However, technology can also impact employment via disruption, where instead of replacing labor one task at a time, platform companies – firms built on algorithms applied to enormous cloud databases, which often have relatively low employment concentration – replace older firms whose business models rely more on human labor. The employment impact of automation can be fast and dramatic.

An example of how platform disruption can affect employment is the impact of online booking platforms on travel agents. Since 1999, companies like Expedia have used cloud databases and algorithms to provide travel booking services faster and more cheaply than travel agents. Likely as a result of this competition from platforms, travel agents' employment declined by 40% between 1999 and 2016.⁷⁹ Task substitutability analysis does not measure the potential for this kind of technology-induced employment impact; it's possible that certain professional service occupations with relatively modest task substitutability may yet be vulnerable to platform disruption. To better estimate the future impact of technology on professional services jobs, future research should examine the impact of platform disruption on employment. Specific areas could include the relationship between an occupation's task substitutability and susceptibility to disruption and the speed of disruption's employment impact relative to one-at-a-time task substitution.

If automation-by-disruption is shown by research to be a demonstrable trend with steeper employment disruption impact than task substitutability analysis projects, researchers should investigate more inventive policy responses. Such efforts could focus on redesigning early education with creativity as the core curricular objective, enabling and encouraging entrepreneurial risk taking, and reimagining the safety net around the needs of people in work arrangements that we call "alternative" today but may be the norm in the future. In addition, policy makers could consider measures that directly address the concentration of market power and wealth among platforms. These companies are the primary disruptors and may become dominant orchestrators of economic transactions in future decades. Policy makers may need to design mechanisms that account for these companies' singular impact on the ability of people to earn a stable living.

Conclusion

This report sought to contribute to the ongoing discussion on the impact of information and communications technologies (ICT), including artificial intelligence on jobs by adopting a granular focus. Instead of modeling the impact of all forms of ICT on all jobs, this report evaluated the potential for computers that can read, write, speak, and listen, commonly known as natural language processing (NLP), to achieve technical feasibility of substituting for human performance of tasks in twelve occupations in the professional services sector. In doing so, this report aimed to generate estimates of future task substitutability that were transparent, studied, and trustworthy. Along with measured discussions of the labor market impact of task substitutability, these estimates will hopefully form a solid foundation for policy research and discussion.

By analyzing multiple objective and subjective measurements, this report ascertained that progress in NLP in recent years has been impressive. NLP applications are currently capable of reading, writing, listening, and speaking across a variety of business contexts. In the near future, NLP applications will likely be able to read and accurately answer questions about the factual content of almost any document. They will also likely be able to handle most interactions with humans in which the only purpose is the exchange of straightforward,

objective information, and compose many documents that have consistent form and structure. However, natural language activities that require creativity, strategic thinking, or social intelligence will remain beyond the scope of NLP applications.

Based on these capabilities and limitations, an average of 23 percent of tasks of the twelve occupations analyzed in this report were estimated to be substitutable by NLP in a likely future scenario – overall, a modest, but significant impact. Task substitutability was not distributed evenly across all occupations: occupations that typically constitute more senior positions in their professional contexts had very low substitutability due to NLP. In addition, certain lower-level occupations whose tasks primarily required the processing of numeric information also had relatively low substitutability due to NLP. It was occupations that both require heavy use of language for task performance and occupy relatively low positions in their professional hierarchies that were estimated to be much more highly substitutable by NLP.

Due to the multitude of factors at play that were beyond the scope of this report, it was not possible to assess with the same degree of confidence what the overall labor market impact of this task substitutability could be. However, it was determined that all other things being equal, it is likely that a moderate but significant amount of labor displacement in the professional services sector will occur as a result.

To mitigate this displacement, this report recommended several areas that policy makers could consider, including secondary and post-secondary education, tax incentives, and innovations in workforce development. This report further recommended that leaders consider other areas for potential policy development, such as training subsidies, shortening the work week, directly subsidizing training for displaced workers, and using government's reach and scale to invest in programs that do a better job of matching workers, skills, and job openings. Finally, this report cautions that task substitutability analysis alone is insufficient for assessing the impact of ICT on labor, and recommends possible strategies for researching the impact of disruption by platforms built around cloud databases and algorithms on employment. Displacement that is larger or more dramatic than currently anticipated may require measures that are more inventive than what can be found in the current policy repertoire, and leaders must be prepared to address fundamental economic shifts with policies to match.

Advances in ICT will have a profound impact on how people earn a living in the coming decades. It is critical that researchers, policy makers, business leaders, and citizens understand as much as possible how this impact will unfold. In assessing how natural language processing may substitute for human labor in office jobs in the near future, it is hoped that this report will provide a valuable contribution to that understanding for all concerned.

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