From Occupations to Tasks: A New Perspective on Automatability Prediction Using BERT

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***Abstract*—As automation technologies continue to advance at an unprecedented rate, concerns about job displacement and the future of work have become increasingly prevalent. While existing research has primarily focused on the potential impact of automation at the occupation level, there has been a lack of investigation into the automatability of individual tasks. This paper addresses this gap by proposing a BERT-based classifier to predict the automatability of tasks in the forthcoming decade at a granular level leveraging the context and semantics information of tasks. We leverage three public datasets: O*NET Task Statements, ESCO Skills, and Australian Labour Market Insights Tasks, and perform expert annotation. Our BERT-based classifier, fine-tuned on our task statement data, demonstrates superior performance over traditional machine learning models, neural network architectures, and other transformer models. Our findings also indicate that approximately 25.1% of occupations within the O*NET database are at substantial risk of automation, with a diverse spectrum of automation vulnerability across sectors. This research provides a robust tool for assessing the future impact of automation on the labor market, offering valuable insights for policymakers, workers, and industry leaders in the face of rapid technological advancement.**

***Index Terms*—Task automatability prediction, Automated Occupation identification, BERT, Transfer learning**

I. Introduction

In the era of rapid technological advancement, the fear of large scale unemployment caused by automation technologies has become a significant concern. This concern is not unfounded; a growing body of research suggests that many occupations could be partially or fully automated in the coming years. According to the research conducted by [1], over 47% of current US employment is at high risk of being automated. Another similar study has been performed using job-level data and concluded a less alarming rate of 9% of employment is at risk [2]. However, these studies have largely focused on the potential for automation at the occupation level, leaving a significant gap in our understanding of how individual tasks within these occupations might be automated and multiple studies have shown the effectiveness of assessing the automatability on tasks level instead of occupations [3], [4].

The automatability of tasks is fundamentally a question of understanding the nature and requirements of the task and this information is often embedded in the contextual and semantic information of textual task statements [3]. For example, the task "Write a report" might be automatable, but "Write a creative story" might not be. And the word "run" means differently in "run a program" and "run a marathon" [2]. Therefore, our research is based on the assumption that the automatability of tasks can be apprehended through the extraction of contextual and semantic information embedded within textual task statements.

Due to this circumstance, our research employ the Bidirectional Encoder Representations from Transformers (BERT) model [5] to understand the context and semantics of words in a task statement allowing for a more sophisticated analysis of task descriptions, potentially leading to more accurate predictions of task automatability. We also utilize three task description datasets: O*NET Task statements [6], ESCO Skills [7], and Australian Labour Market Insights Tasks [8]. We annotate each task with one of three labels: "Substitution," "Complementarity," or "Negligibility," representing its automation susceptibility based on expert assessments. Using these annotations as ground truth, we apply a BERT-based classifier model [5] to predict task automatability, benefiting from BERT's context understanding and semantic capabilities.

We extend our analysis to occupation and industry levels, using aggregated task-level predictions to assess overall automation susceptibility. This comprehensive view can reveal trends not observable at the task level, providing additional automation impact insights. Our research holds significant implications for workers, businesses, and policymakers by offering clarity on automation-susceptible tasks and demonstrating BERT's utility in labor economics.

The contributions of our research to the domain of automation impact on the labor market can be summarized as follows:

- Presents a novel approach to predict the automatability at task level which provides a more detailed and nuanced understanding of the impact of automation.

- This work substantiates the hypothesis that task automatability can be discerned through mining the contextual and semantic information of textual task statements by leveraging BERT's contextual and semantic understanding capabilities.
- Fine-tuned the BERT-based classifier on task statement data, outperforms traditional machine learning and neural network models, offering a robust tool for assessing automation's future impact on the labor market.
- This research combine and annotates three public datasets: O*NET Task Statements, ESCO Skills, and Australian Labour Market Insights Tasks, creating a valuable resource that underscores the robustness of the BERT-based classifier across diverse data types.

II. Related Work

The body of literature on the automatability of occupations is vast and growing, with numerous studies focusing on predicting the susceptibility of entire occupations to automation. For instance, Frey and Osborne [1] pioneered the field with their seminal work, using a Gaussian process classifier to estimate the probability of computerisation for 702 detailed occupations and concluded that about 47% occupations in US is at high risk. Arntz [2] further expanded on this by considering the heterogeneity of jobs within occupations and obtained a less alarming rate of 9%, albeit their focus remained on the occupation level. These studies, while groundbreaking, have been critiqued for their broad-brush approach, which overlooks the granularity of tasks within occupations.

In parallel, there has been a surge of interest in the application of BERT-based models for sentence classification tasks. Devlin [5] introduced BERT, a transformer-based model that leverages context in both directions, making it highly effective for understanding the semantics of text. Since then, BERT has been widely used in various natural language processing tasks, including sentence classification [9], [10], and cross domain applications [11], [12] demonstrating its ability to capture contextual and semantic information effectively. However, this is limited research in automatability prediction leveraging sentences' contextual and semantic information and multiple studies have formulated hypothesis that the automatability of tasks is fundamentally a question of understanding the nature and requirements of the task which is often embedded in the contextual and semantic information of textual task statements [3], [4].

Our work bridges these two streams of literature. While we build upon the existing body of work on occupation automatability, we shift the focus from the occupation level to the task level. We argue that this provides a more nuanced and accurate picture of the potential impact of automation on the workforce. Furthermore, we leverage the power of BERT for sentence classification, applying it to the analysis of task descriptions to predict their automatability. This represents a novel application of BERT, extending its use beyond traditional natural language processing tasks. In doing so, we hope to contribute a new perspective to the ongoing discourse on the future of work in the age of automation.

III. Method

In this section, we outline the whole framework (Fig. 1) employed to predict task level automatability leveraging a BERT-based classifier. Our approach first harnesses the BERT architecture to generate task statement embeddings, then construct a BERT-based classifier with a softmax layer for categorizing automatabilities. The model undergoes fine-tuning, tailored to the downstream classification task, optimizing its performance on the specific domain.

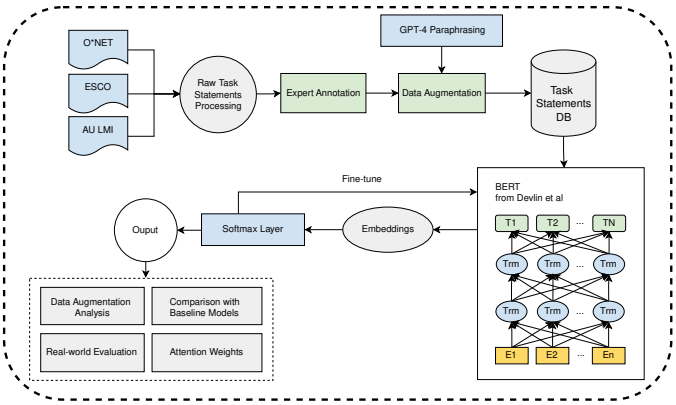

Fig. 1. The framework of the proposed method.

A. Dataset Creation

We used three public datasets: ONET Task Statements, ESCO skills, and AU Labor Market Insights Task statements. They provide a wide range of occupation-specific task statements with varying geographical and vocational coverage. We randomly sampled tasks: 5,060 from ONET, 4,783 from ESCO, and 3,356 from AU Labor Market Insights. This was done to ensure diversity across occupations, sectors, and regions for generalizable findings and to optimize computational resources and model training efficiency due to the high-dimensionality of text data and the large dataset sizes.

1) Expert Annotation: Our annotation process employs a voting mechanism involving five experts. For each task and each class, if a class receives more than three votes, it is designated as the final label for that task. This approach ensures a consensus among experts and enhances the reliability of the labels. Our expert annotation process labeled each task as "Substitution" (fully automatable), "Complementarity" (partial automation with human involvement), or "Negligibility" (unlikely to be automated). This provides a categorical understanding of task-level automation susceptibility. We base our process on the Skill-Biased Technological Change (SBTC) [13] and Routine-Biased Technological Change (RBTC) [14] hypotheses, which explain technological change's impact on labor markets. SBTC postulates that technology favors high-skill tasks and replaces lower-skilled routine jobs [15], while

RBTC asserts that technology replaces routine tasks, regardless of skill level [16]. We also incorporate six major automation bottlenecks : Complex Problem Solving, Social Interaction and Emotional Intelligence, Fine Motor Skills and Dexterity, Creative and Artistic Abilities, Contextual Understanding, and Ethical Decision Making [17], [18]. These bottlenecks highlight areas where humans still outperform machines.

2) Data Augmentation: The initial exploration of the labeled data revealed a class imbalance issue, a common problem in many real-world classification tasks [19]. This imbalance can lead to biased models, overfitting to the majority class and neglecting minority ones. Conventional data augmentation methods suitable for image data aren't applicable to text data due to its sequential and semantic nature [20]. Apart from class imbalance issue, effectively increasing the volume of training data is particularly beneficial for deep learning models like BERT that perform better with larger datasets.

We addressed this using GPT-4 [21] to paraphrase sentences, creating new task statements with identical meanings but different wording. GPT-4's ability to generate high-quality and varied paraphrases ensures the augmented data remains relevant and increases the classifier's robustness to different task expressions. Specifically, each statement was fed into GPT-4 for paraphrasing, followed by automated checks and expert reviews to validate the paraphrases for semantic similarity to the original statements:

Original Sentence:
Generate reports utilizing visual aids such as charts, graphs, and narratives by examining and documenting test data.
Paraphrased Sentence:
Create reports that *incorporate* visual *elements* like *diagrams*, *plots*, and descriptive narratives by *scrutinizing* and *recording* the results of tests.

B. BERT-based Classifier

BERT stands out with its multi-layer bidirectional Transformer encoder, which enables it to capture the deep contextual information embedded in text data [5]. Mathematically, this is achieved by applying the attention mechanism, where the output embeddings *E* for a given input token is a weighted sum of all input token embeddings:

$$E = \sum \textit{Attention\_Scores} \times \textit{Token\_Embeddings} \tag{1}$$

For our classification task, we fine-tuned a pre-trained BERT model on our task statement data. Each task statement was fed into BERT, which transformed the text into high-dimensional embeddings.

The embeddings were then passed through a softmax function to generate the final class probabilities. If we denote the output of our model before the softmax layer as z, the softmax function can be expressed as:

$$\textit{Softmax}(z_i) = \frac{e^{z_i}}{\sum e^{z_j}} \tag{2}$$

where z_i is the output corresponding to the i-th class and the sum in the denominator runs over all possible classes.

The training process involved adjusting the model's parameters to minimize the discrepancy between the predicted and actual class labels, typically quantified using the cross-entropy loss function:

$$L = -\sum \textit{y\_true} \times \log(\textit{y\_pred}) \tag{3}$$

where *y_true* is the true label and *y_pred* is the predicted probability.

C. Attention Mechanism

A fundamental feature of BERT's ability to capture deep contextual information is its use of the attention mechanism, specifically, the scaled dot-product attention as introduced in the original Transformer model [22]. This attention mechanism allows the model to weigh the importance of different words in a sentence, providing a powerful tool for understanding language semantics.

Mathematically, the attention mechanism can be described as mapping a query and a set of key-value pairs to an output. Given a query (*Q*), keys (*K*), and values (*V*), the output (*O*) of the attention mechanism is calculated as a weighted sum of the values, where the weight assigned to each value is determined by the query's compatibility with the corresponding key:

$$\textit{Attention}(Q, K, V) = \textit{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V \tag{4}$$

where the denominator $\sqrt{d_k}$ is used for scaling, with d_k being the dimension of the key vectors. The softmax function ensures the attention scores are normalized to lie between 0 and 1, thus can be interpreted as probabilities. This results in words that are more important to the meaning of the sentence receiving a higher attention score, while less important words receive a lower score.

The use of attention weights allows us to visualize and interpret the model's decision-making process. By examining these weights, we can understand which parts of the input sentence are most influential in determining the output of the model.

IV. Experiment

A. Data

The datasets were partitioned into training, evaluation, and test subsets following an 8:1:1 ratio, providing a comprehensive and balanced basis for our experimental studies. And both the original and augmented datasets would be passed through the model to evaluate and quantify the influence of data augmentation.

The table I presented below provides a visual representation of both the initial and augmented datasets. Specifically, during the training phase using the original dataset, we observed that the AU LMI dataset exhibited superior performance compared to the other two datasets. Consequently, during the process of data augmentation, we prioritized augmenting the ONET and ESCO datasets to a greater extent, while applying relatively fewer augmentations to the AU LMI dataset. This decision was based on the recognition that ONET and ESCO present greater

challenges in terms of machine learning, warranting additional exposure to augmented instances for effective learning.

TABLE I
THE OVERVIEW OF DATASET

		O*NET	ESCO	AU LMI
Substitution	Original	1,594	1,435	998
	Augmented	**3,188**	**3,157**	**1,796**
Complementarity	Original	2,519	2,272	1,776
	Augmented	**3,023**	**3,181**	**1,776**
Negligibility	Original	947	1,076	582
	Augmented	**3,030**	**3,228**	**1,764**

B. Evaluation Metrics

We assessed our model and baselines using precision, recall, and F1 score. Precision evaluates the ratio of correct positive predictions to all positive predictions, indicating the model's false-positive avoidance. Recall measures the fraction of true positives from all actual positives, reflecting the model's ability to recognize all relevant instances. The F1 score, the harmonic mean of precision and recall, balances these aspects—a high F1 score indicates a model with high precision and recall, and vice versa.

In our multi-class problem, these metrics were computed for each class, considering the class in question as positive and the rest as negative. The average of per-class metrics provided a single performance measure across all classes.

C. Baselines

In our work, we make a comprehensive comparison of our proposed BERT-based model with a range of baseline models, encompassing both traditional machine learning approaches, neural network architectures, and other transformer models. These baselines span different approaches to text classification, allowing us to assess the relative merits of our approach in a broad context.

For traditional classifiers, we employ Logistic Regression [23], Random Forest [24], and Support Vector Machines (SVM) [25]. These models, with their varying theoretical underpinnings, provide a solid foundation against which to compare our more complex neural model. They represent different forms of linear and non-linear decision boundaries and incorporate different forms of regularization and ensemble learning.

In the realm of neural networks, we utilize Bi-directional Long Short-Term Memory (BiLSTM) [26], Gated Recurrent Units (GRU) [27], and one-dimensional Convolutional Neural Networks (Conv1D) [28]. These architectures demonstrate the potential of deep learning for text classification, and their comparison with our model allows us to quantify the value of pre-training and transformer architecture in this context.

Finally, we include three additional transformer models in our baselines: ALBERT [29], ELECTRA [30], and DistilBERT [31]. As close relatives of BERT, they provide a stringent test of the specific benefits of our BERT-based approach. By contrasting with these models, we can highlight the unique strengths of our chosen methodology.

D. Results

The table II summarizes the results for proposed BERT and other baseline models of different datasets. We evaluate them with precision, recall and F1-score.

As we can see from the results, the GRU model demonstrates the highest performance on the O*NET dataset, with Precision, Recall, and F1-Score at 0.7712, 0.7676, and 0.7712, respectively. BiLSTM exhibits superior performance on the ESCO dataset, with Precision, Recall, and F1-Score at 0.7973, 0.7898, and 0.7876, respectively. The same model outperforms others on the AU LMI dataset, with all three metrics around 0.8995.

When all datasets are combined, our proposed BERT-based classifier emerges as the most effective model. The precision, recall, and F1-score are 0.7981, 0.7955, and 0.7944, respectively, which are the highest among all models. These results indicate the robustness of BERT in handling diverse and large-scale datasets and its superiority over traditional, neural network, and other transformer models for this multi-class classification task. We will use BERT as the best performance model for follow-up experiments and analysis.

E. Data Augmentation Analysis

In this section, we examine the impact of different augmentation levels on our BERT model's performance. The data augmentation methods include no augmentation (Original), augmenting data to match the class with the largest instances (Balanced), and incremental augmentation of the original data by 1.5, 2, 2.5, 3, 4, and 5 times. The results are shown below as Fig. 2:

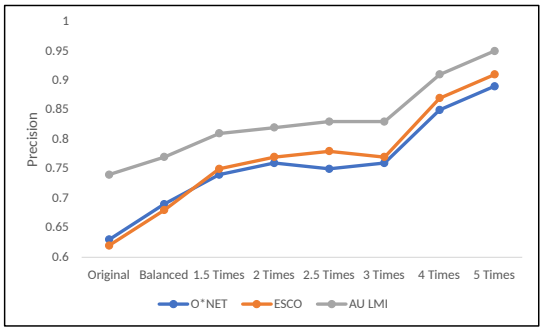

Fig. 2. The Comparison of different augmentation.

A careful review of the results indicates that augmentation improves the precision of the model across all three datasets (ONET, ESCO, and AU LMI). For the ONET and ESCO datasets, the precision increases modestly from "Balanced" to "2 Times" and then plateaus slightly at "2.5 Times". However, a dramatic rise is seen at "4 Times", implying potential over-augmentation, which could lead to an overfitted model.

Therefore, we choose to augment our data between "Balanced" and "2 Times" for the O*NET and ESCO datasets.

TABLE II
THE RESULTS OF PROPOSED MODEL AND BASELINES.

Model	O*NET			ESCO			AU LMI			O*NET + ESCO + AU LMI		
	Precision	**Recall**	**F1**	**Precision**	**Recall**	**F1**	**Precision**	**Recall**	**F1**	**Precision**	**Recall**	**F1**
LR	0.6091	0.61	0.609	0.5915	0.5915	0.5911	0.657	0.6602	0.6566	0.5902	0.5922	0.5908
SVM	0.6087	0.6072	0.6046	0.5738	0.5719	0.5707	0.6462	0.6473	0.6452	0.5837	0.5867	0.5811
RF	0.5922	0.593	0.5921	0.5657	0.5656	0.5652	0.6449	0.6483	0.6399	0.5889	0.5909	0.5891
BiLSTM	0.7487	0.7562	0.7532	**0.7973**	**0.7898**	**0.7876**	**0.8997**	**0.8994**	**0.8995**	0.7676	0.7701	0.7665
GRU	**0.7712**	**0.7676**	**0.7712**	0.7587	0.7612	0.7611	0.8677	0.8701	0.8664	0.7609	0.7624	0.7611
CONV1D	0.7695	0.7742	0.7778	0.7745	0.7812	0.7822	0.8424	0.8402	0.8468	0.7766	0.7798	0.7723
ALBERT	0.7703	0.6989	0.6988	0.7687	0.7723	0.7701	0.7997	0.8033	0.7946	0.7253	0.7114	0.6801
ELECTRA	0.7544	0.7621	0.7602	0.7384	0.7381	0.7285	0.8145	0.8093	0.8122	0.7459	0.7419	0.7425
BERT	0.7698	0.7643	0.7594	0.7701	0.7723	0.7698	0.8241	0.8225	0.8198	**0.7981**	**0.7955**	**0.7944**

As for the AU LMI dataset, which already shows good performance, we only balance the classes.

F. Model Robustness on Different Data Split

To ascertain the robustness of our proposed model for real-world applications, we conducted an experiment with varying training set sizes. The dataset was shuffled, and training sets were created with different proportions of the original dataset, namely 80%, 70%, 60%, 50%, 40%, 30%, and 20%. The remaining data in each scenario was used for performance evaluation. The results are presented at Fig. 3:

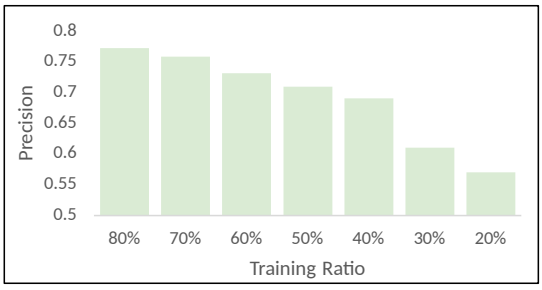

Fig. 3. The performance of model at different data split.

As can be observed, the proposed BERT model's performance is relatively stable, and it gets better performance with the increase of training data ratio. Besides, our model with only 20% training data can catch up with the baselines who use 80% data for training, which validates the effectiveness of BERT in the task of predicting the automatability at task level.

G. Attention Weights Visualization

For the visualization of the model's attention, we have employed the technique of Wordcloud. For class Substitution, the prominent terms include "using system", "machinery operate", "data record", "routine perform", and "trucks load". These tasks are generally routine and predictable, and hence, are more prone to automation. On the other hand, for class Complementarity and class Negligibility, the key terms hint at tasks that require a higher level of human judgment or interaction like "information provide", "educational program", "research conduct", "medical procedures", "human expertise", and "children care". These tasks correlate with recognized automation bottlenecks, corroborating the model's predictions. The results can be found at Fig. 4:

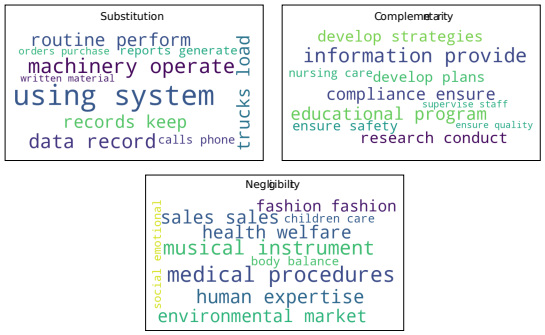

Fig. 4. The Wordclouds for different categories.

V. RESULTS AND DISCUSSION

Having established the optimal performance of our BERT model through a series of experiments, we moved to a practical application, leveraging the model for inference on real-world datasets. We selected O*NET task statements, a rich and diverse dataset that encapsulates a broad variety of professional tasks, totalling 19,530 individual tasks. The results showed that among the total tasks, 6664 tasks were labeled as "Substitution", 10,678 tasks were "Complementarity" and 2188 tasks were "Negligibility" which could be visualized as Fig. 5:

A. Assessment of Automatability at Occupation Level

We mapped individual task automatability measures to 974 distinct occupations using the O*NET task statement to occupation mapping. This allowed us to assess automatability at an occupation level by aggregating tasks and quantifying task type distributions. The results, summarized in Table 6, show the top 10 occupations with the highest substitution and

Fig. 5. The Distribution of O*NET Task Automatability.

negligibility, indicating the most and least likely automated occupations, respectively. As can be seen from the results,

TOP 10 OCCUPATIONS WITH HIGHEST AUTOMATABILITIES			
	SUBSTITUTION	COMPLEMENTARITY	NEGLIGIBILITY
Dishwashers	1	0	0
Fabric Menders, Except Garment	1	0	0
Packaging and Filling Machine Operators and Tenders	1	0	0
Pile-Driver Operators	1	0	0
Agricultural Equipment Operators	0.94	0	0.06
Packers and Packagers, Hand	0.92	0.08	0
Tire Builders	0.91	0.09	0
Word Processors and Typists	0.89	0.11	0
Data Entry Keyers	0.89	0.11	0
Roof Bolters, Mining	0.89	0.11	0
TOP 10 OCCUPATIONS WITH LOWEST AUTOMATABILITIES			
	SUBSTITUTION	COMPLEMENTARITY	NEGLIGIBILITY
Athletes and Sports Competitors	0.11	0	0.89
Sales Agents, Financial Services	0.13	0.12	0.75
Respiratory Therapists	0.32	0.05	0.63
Real Estate Brokers	0.26	0.16	0.58
Clergy	0	0.43	0.57
Choreographers	0.06	0.38	0.56
Chiropractors	0.18	0.27	0.55
Producers	0.08	0.38	0.54
Zoologists and Wildlife Biologists	0.27	0.2	0.53
Nuclear Equipment Operation Technicians	0.47	0	0.53

Fig. 6. Top 10 occupations that have highest and lowest automatabilities.

occupations with high automation susceptibility are primarily manual labor, repetitive tasks, or data-intensive roles, such as "Dishwashers" and "Packaging and Filling Machine Operators and Tenders". Conversely, roles requiring human interaction, creativity, specialized skills, or unpredictable environments, like "Athletes and Sports Competitors" and "Respiratory Therapists", showed lower automatability.

Our research findings indicate that out of 974 ONET occupations, 244 display a substitution score exceeding 50%. This suggests that approximately 25.1% of occupations within the ONET database are at substantial risk of automation. This outcome is aligned with the findings put forth in [32], thus adding robustness to our estimations. Furthermore, these results are nested between the estimations reported in [1] which places 47% of occupations at risk and [2] which estimates the figure at a comparatively lower 9%. Considering the limitations often associated with automated risk evaluations at the occupation and job level, the median value that our research arrives at seems reasonable. This is due to our methodology which leverages granular task statement data to predict occupation-level risks.

Additionally, our results indicate that a majority of occupations, specifically 603 out of 974 which is 61.8%, face a high risk of complementarities. Conversely, a relatively smaller fraction, constituting 128 occupations or 13.1%, appear to be comparatively safe from impending automation over the forthcoming decades. These conclusions underscore the nuanced complexities underpinning automation risks and the need for more granular data analysis in this domain.

B. Assessment of Automation Vulnerability Among Industries

Building on our earlier findings of automatability at the occupation level, we bridge the occupation-industry gap utilizing O*NET's detailed occupation-industry mapping. Our results shown as Fig. 7 indicate a diverse spectrum of automation vulnerability across sectors. On one end, industries such as "Accommodation and Food Services", "Administrative and Support Services", "Retail Trade", "Mining, Quarrying, and Oil and Gas Extraction", and "Manufacturing" emerge as the sectors most susceptible to automation. These industries comprise occupations with high automatability scores, revealing their high likelihood of experiencing significant changes due to automation.

On the other hand, industries such as "Educational Services", "Arts, Entertainment and Recreation", "Other Services (Except Public Administration)", "Real Estate and Rental and Leasing", and "Health Care and Social Assistance" stand on the less vulnerable end of the automation spectrum. Occupations within these sectors possess low automatability scores, indicating a lower likelihood of their roles being fully automated, largely due to the complexity of tasks or the high level of human judgment, interaction, and creativity required.

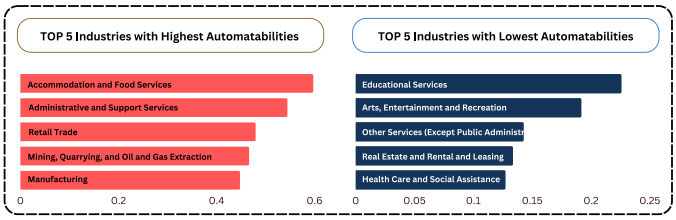

Fig. 7. Industries with highest and lowest automatabilities.

To validate the results, we leveraged the insights from the [33], and identified 4 sectors showing siginifican susceptibility to automation which are "Accommodation and Food Services", "Manufacturing", "Retail Trade", and "Transportation and Warehousing". These findings align well with our own results.

VI. Conclusion

This study presents a unique approach to predict task-level automatability with a BERT-based classifier, utilizing three diverse, public datasets and expert annotations. Rigorous experiments demonstrated our model's efficacy.

In practical application, we applied our model to real-world datasets, providing a comprehensive perspective of occupational automatability. Our findings indicate that approximately 25.1% of occupations within the O*NET database are at substantial risk of automation. Furthermore, our results reveal a diverse spectrum of automation vulnerability across sectors, with industries such as "Accommodation and Food Services", "Administrative and Support Services", "Retail Trade", "Mining, Quarrying, and Oil and Gas Extraction", and "Manufacturing" emerging as the sectors most susceptible to automation.

These findings have significant implications for workers and policymakers. For workers, understanding the susceptibility

of their tasks to automation can help them make informed decisions about their career paths and upskilling opportunities. For policymakers, these insights can guide the development of policies and initiatives aimed at managing the transition to an increasingly automated workforce. This could include strategies for retraining and reskilling workers, as well as measures to support industries and regions that are particularly vulnerable to automation.

In conclusion, our research provides a robust and effective approach to predicting task-level automatability, offering valuable insights for policymakers, educators, and workers. By understanding the potential impact of automation on different tasks, occupations, and industries, we can better prepare for the future of work.

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APPENDIX A
THE RESULTS OF OCCUPATIONS' AUTOMATABILITY

Occupation	Substitution	Complementarity	Negligibility
Attendants and Bartender Helpers	1	0	0
Dishwashers	1	0	0
Fabric Menders, Except Garment	1	0	0
Operators and Tenders	1	0	0
Pile-Driver Operators	1	0	0
Agricultural Equipment Operators	0.941176471	0	0.058823529
Packers and Packagers, Hand	0.916666667	0.083333333	0
Tire Builders	0.909090909	0.090909091	0
Material Movers, Hand	0.904761905	0.095238095	0
Fence Erectors	0.9	0.05	0.05
Word Processors and Typists	0.894736842	0.105263158	0
Data Entry Keyers	0.888888889	0.111111111	0
Roof Bolters, Mining	0.888888889	0.111111111	0
Prepress Technicians and Workers	0.875	0	0.125
Maids and Housekeeping Cleaners	0.869565217	0.130434783	0
Underground Mining	0.866666667	0.066666667	0.066666667
Operators, Except Postal Service	0.862068966	0.137931034	0
Statistical Assistants	0.857142857	0.071428571	0.071428571
Retail Sales	0.857142857	0.142857143	0
Hand	0.85	0.15	0
Medical Assistants	0.85	0.15	0
Foundry Mold and Coremakers	0.846153846	0.153846154	0
Tire Repairers and Changers	0.846153846	0.153846154	0
Parking Lot Attendants	0.833333333	0.111111111	0.055555556
Auditing Clerks	0.833333333	0.166666667	0
Credit Authorizers	0.833333333	0.166666667	0
and Tenders	0.823529412	0.117647059	0.058823529
Helpers--Production Workers	0.823529412	0.176470588	0
Pharmacy Aides	0.823529412	0.176470588	0
Cooks, Short Order	0.818181818	0.181818182	0
Operators	0.818181818	0.181818182	0
Applicators, Vegetation	0.8	0.2	0
Machine Setters, Operators, and Tenders	0.791666667	0.166666667	0.041666667
Cooks, Fast Food	0.789473684	0.105263158	0.105263158
Baristas	0.789473684	0.210526316	0
File Clerks	0.789473684	0.210526316	0
Food Servers, Nonrestaurant	0.785714286	0.071428571	0.142857143
Compacting Machine Setters, Operators, and Tenders	0.785714286	0.107142857	0.107142857
Locksmiths and Safe Repairers	0.785714286	0.214285714	0
Bakers	0.777777778	0.222222222	0

Marking Clerks	0.777777778	0.222222222	0
Technicians	0.777777778	0.222222222	0
Operators, and Tenders, Metal and Plastic	0.769230769	0.230769231	0
Machine Feeders and Offbearers	0.769230769	0.230769231	0
Signal and Track Switch Repairers	0.769230769	0.230769231	0
Statement Clerks	0.769230769	0.230769231	0
Equipment Assemblers	0.764705882	0.235294118	0
Precipitating, and Still Machine Setters, Operators, and Tenders	0.761904762	0.19047619	0.047619048
Service Attendants	0.75	0.25	0
Medical Secretaries	0.75	0.25	0
Pharmacy Technicians	0.75	0.25	0
Collectors	0.75	0.25	0
Solderers and Brazers	0.75	0.25	0
Stock Clerks, Sales Floor	0.75	0.25	0
Cashiers	0.740740741	0.222222222	0.037037037
Processors, and Processing Machine Operators	0.736842105	0.157894737	0.105263158
Highway Maintenance Workers	0.736842105	0.263157895	0
Payroll and Timekeeping Clerks	0.736842105	0.263157895	0
Answering Service	0.736842105	0.263157895	0
Technicians	0.733333333	0.2	0.066666667
Food Preparation Workers	0.733333333	0.233333333	0.033333333
Tree Trimmers and Pruners	0.730769231	0.230769231	0.038461538
Finishers	0.727272727	0.181818182	0.090909091
Pickling Equipment Operators and Tenders	0.727272727	0.272727273	0
and Samplers, Recordkeeping	0.727272727	0.272727273	0
Computer	0.722222222	0.166666667	0.111111111
Machine Setters, Operators, and Tenders, Metal and Plastic	0.71875	0.28125	0
Maids and Housekeeping Cleaners	0.714285714	0.285714286	0
Searchers	0.705882353	0.235294118	0.058823529
Equipment Operators	0.7	0.25	0.05
Baking, and Drying Machine Operators and Tenders	0.7	0.3	0
Postal Service Clerks	0.7	0.3	0
Installers and Repairers	0.7	0.3	0
Machine Setters, Operators, and Tenders, Metal and Plastic	0.696969697	0.303030303	0
Booth Cashiers	0.692307692	0.307692308	0
Mine Shuttle Car Operators	0.692307692	0.307692308	0

Roustabouts, Oil and Gas	0.692307692	0.307692308	0
Tapers	0.6875	0.125	0.1875
Equipment Installers and	0.684210526	0.263157895	0.052631579
Order Clerks	0.684210526	0.315789474	0
Endoscopy Technicians	0.666666667	0.083333333	0.25
Rock Splitters, Quarry	0.666666667	0.111111111	0.222222222
Equipment	0.666666667	0.19047619	0.142857143
Correspondence Clerks	0.666666667	0.238095238	0.095238095
Operators, Refinery Operators, and Gaugers	0.666666667	0.25	0.083333333
Cooks, Institution and Cafeteria	0.666666667	0.266666667	0.066666667
Semiconductor Processors	0.666666667	0.291666667	0.041666667
Sheet Metal Workers	0.666666667	0.291666667	0.041666667
Tool Operators, Metal and Plastic	0.666666667	0.296296296	0.037037037
Glaziers	0.666666667	0.296296296	0.037037037
Computer Operators	0.666666667	0.333333333	0
Cutters and Trimmers, Hand	0.666666667	0.333333333	0
Electro-Mechanical Technicians	0.666666667	0.333333333	0
and Tenders	0.666666667	0.333333333	0
Workers	0.666666667	0.333333333	0
Operators, and Tenders, Wood	0.666666667	0.333333333	0
Library Assistants, Clerical	0.65625	0.28125	0.0625
Freight and Cargo Inspectors	0.65	0.25	0.1
Fitters	0.65	0.3	0.05
Gaming Cage Workers	0.647058824	0.176470588	0.176470588
Food Concession, and Coffee Shop	0.647058824	0.352941176	0
Brickmasons and Blockmasons	0.642857143	0.285714286	0.071428571
Tellers	0.642857143	0.285714286	0.071428571
Waiters and Waitresses	0.64	0.36	0
Plasterers, and Stucco Masons	0.636363636	0.090909091	0.272727273
Hunters and Trappers	0.636363636	0.181818182	0.181818182
Crane and Tower Operators	0.636363636	0.272727273	0.090909091
Clerks	0.636363636	0.272727273	0.090909091
Cooks, Private Household	0.636363636	0.363636364	0
Insurance Claims Clerks	0.636363636	0.363636364	0
Operators, and Tenders, Metal and Plastic	0.633333333	0.366666667	0
Operators and Tenders	0.631578947	0.315789474	0.052631579
Setters, Operators, and Tenders	0.631578947	0.368421053	0
Parts Salespersons	0.631578947	0.368421053	0
Medical Equipment Preparers	0.625	0.25	0.125
Couriers and Messengers	0.625	0.3125	0.0625
Technologists	0.625	0.3125	0.0625

Dental Assistants	0.625	0.375	0
Assistants, Except Legal, Medical, and Executive	0.625	0.375	0
Telephone Operators	0.625	0.375	0
Treatment Plant and System	0.625	0.375	0
Machine Setters, Operators, and Tenders	0.620689655	0.137931034	0.24137931
Setters, Operators, and Tenders, Synthetic and Glass Fibers	0.619047619	0.333333333	0.047619048
Ticket Agents and Travel Clerks	0.619047619	0.333333333	0.047619048
Machine Operators	0.619047619	0.380952381	0
Library Technicians	0.617647059	0.323529412	0.058823529
Hoist and Winch Operators	0.615384615	0.230769231	0.153846154
Operators, and Tenders, Except Sawing	0.615384615	0.269230769	0.115384615
Workers	0.615384615	0.307692308	0.076923077
Legal Secretaries	0.615384615	0.384615385	0
Radio Mechanics	0.615384615	0.384615385	0
Manicurists and Pedicurists	0.611111111	0.388888889	0
Printing Press Operators	0.608695652	0.173913043	0.217391304
Dressing Room Attendants	0.608695652	0.391304348	0
Sailors and Marine Oilers	0.607142857	0.357142857	0.035714286
Bridge and Lock Tenders	0.6	0.2	0.2
Food Batchmakers	0.6	0.36	0.04
Locomotive Firers	0.6	0.4	0
Information Technicians	0.6	0.4	0
Paperhangers	0.6	0.4	0
Laundry and Dry-Cleaning Workers	0.59375	0.40625	0
Setters, Operators, and Tenders, Metal and Plastic	0.58974359	0.41025641	0
Ship Engineers	0.588235294	0.294117647	0.117647059
Baggage Porters and Bellhops	0.588235294	0.411764706	0
Billing, Cost, and Rate Clerks	0.588235294	0.411764706	0
Drawing Out Machine Setters, Operators, and Tenders	0.583333333	0.291666667	0.125
Operators	0.583333333	0.333333333	0.083333333
Retail Salespersons	0.583333333	0.333333333	0.083333333
Farm Products	0.583333333	0.416666667	0
News and Street Vendors, and Related Workers	0.583333333	0.416666667	0
Nursery Workers	0.583333333	0.416666667	0
Security Guards	0.583333333	0.416666667	0
Slot Supervisors	0.583333333	0.416666667	0

Procurement Clerks	0.578947368	0.368421053	0.052631579
Maintenance Equipment	0.576923077	0.423076923	0
Travel Agents	0.571428571	0.142857143	0.285714286
Helpers--Extraction Workers	0.571428571	0.214285714	0.214285714
Office Clerks, General	0.571428571	0.333333333	0.095238095
Photogrammetrists	0.571428571	0.357142857	0.071428571
Assemblers	0.571428571	0.357142857	0.071428571
License Clerks	0.571428571	0.380952381	0.047619048
Equipment and Systems Inspectors, Except Aviation	0.571428571	0.380952381	0.047619048
Farmworkers and Laborers, Crop	0.571428571	0.428571429	0
Damage	0.571428571	0.428571429	0
Postal Service Mail Carriers	0.571428571	0.428571429	0
Conveyor Operators and Tenders	0.565217391	0.434782609	0
Related Repairers	0.564102564	0.41025641	0.025641026
Counter and Rental Clerks	0.5625	0.375	0.0625
Insurance Policy Processing Clerks	0.5625	0.375	0.0625
Energy Brokers	0.5625	0.4375	0
Operators, and Tenders	0.555555556	0.277777778	0.166666667
Kettle Operators and Tenders	0.555555556	0.388888889	0.055555556
Database Architects	0.555555556	0.444444444	0
Loan Interviewers and Clerks	0.555555556	0.444444444	0
Court Reporters	0.545454545	0.454545455	0
Machine Operators and Tenders	0.541666667	0.416666667	0.041666667
Cargo and Freight Agents	0.541666667	0.458333333	0
Riggers	0.538461538	0.230769231	0.230769231
Workers	0.538461538	0.307692308	0.153846154
Agricultural Technicians	0.538461538	0.346153846	0.115384615
Specialists	0.538461538	0.423076923	0.038461538
Station Operators	0.538461538	0.461538462	0
Operators, and Tenders	0.533333333	0.333333333	0.133333333
Pest Control Workers	0.533333333	0.333333333	0.133333333
Equipment Repairers	0.533333333	0.4	0.066666667
New Accounts Clerks	0.533333333	0.466666667	0
Government Programs	0.529411765	0.470588235	0
Processing Machine Operators	0.527777778	0.444444444	0.027777778
and Finishers	0.526315789	0.263157895	0.210526316
Fallers	0.526315789	0.368421053	0.105263158
Clerks	0.526315789	0.368421053	0.105263158
Husbandry and Animal Care Workers	0.526315789	0.421052632	0.052631579
Commodities	0.526315789	0.421052632	0.052631579
Tenders	0.526315789	0.421052632	0.052631579

Attendants	0.526315789	0.473684211	0
Machine Servicers and Repairers	0.526315789	0.473684211	0
Tank Car, Truck, and Ship Loaders	0.526315789	0.473684211	0
Workers	0.523809524	0.333333333	0.142857143
Taxi Drivers and Chauffeurs	0.523809524	0.380952381	0.095238095
Motion Picture Projectionists	0.523809524	0.476190476	0
Parking Enforcement Workers	0.52173913	0.391304348	0.086956522
Mapping Technicians	0.52	0.4	0.08
Operators, and Hostlers	0.52	0.48	0
Workers	0.518518519	0.481481481	0
Drivers	0.516129032	0.451612903	0.032258065
Nursing Assistants	0.515151515	0.424242424	0.060606061
Farm Labor Contractors	0.5	0	0.5
and Dragline Operators	0.5	0.125	0.375
Inspectors	0.5	0.166666667	0.333333333
Assessors	0.5	0.2	0.3
Barbers	0.5	0.2	0.3
Ophthalmic Medical Technicians	0.5	0.25	0.25
Butchers and Meat Cutters	0.5	0.333333333	0.166666667
Operators, and Tenders, Metal and Plastic	0.5	0.35	0.15
Technicians	0.5	0.357142857	0.142857143
Flight Attendants	0.5	0.357142857	0.142857143
Accountants	0.5	0.375	0.125
Helpers--Roofers	0.5	0.388888889	0.111111111
and Runners	0.5	0.409090909	0.090909091
Meter Readers, Utilities	0.5	0.416666667	0.083333333
Telemarketers	0.5	0.416666667	0.083333333
Model Makers, Metal and Plastic	0.5	0.428571429	0.071428571
Multimedia Artists and Animators	0.5	0.428571429	0.071428571
Fabricators	0.5	0.4375	0.0625
Gaming Dealers	0.5	0.45	0.05
Machine Setters, Operators, and Tenders	0.5	0.45	0.05
Traders	0.5	0.454545455	0.045454545
Orderlies	0.5	0.458333333	0.041666667
Brokerage Clerks	0.5	0.5	0
Carpet Installers	0.5	0.5	0
Machine Setters, Operators, and Tenders	0.5	0.5	0
Dredge Operators	0.5	0.5	0
Driver/Sales Workers	0.5	0.5	0
Electronic Drafters	0.5	0.5	0

Setters, Operators, and Tenders, Metal and Plastic	0.5	0.5	0
Floor Sanders and Finishers	0.5	0.5	0
Products	0.5	0.5	0
Helpers--Electricians	0.5	0.5	0
Log Graders and Scalers	0.5	0.5	0
Maintenance Workers, Machinery	0.5	0.5	0
Patternmakers, Wood	0.5	0.5	0
Pourers and Casters, Metal	0.5	0.5	0
Radiation Therapists	0.5	0.5	0
Surgical Technologists	0.5	0.5	0
Repairers, Except Mechanical Door	0.487179487	0.487179487	0.025641026
Photographers	0.482758621	0.448275862	0.068965517
Office Machine Repairers	0.48	0.48	0.04
Technologists	0.47826087	0.47826087	0.043478261
Vocational Nurses	0.47826087	0.52173913	0
Radiologic Technicians	0.47826087	0.52173913	0
Animal Breeders	0.476190476	0.428571429	0.095238095
Forensic Science Technicians	0.476190476	0.523809524	0
Surveying Technicians	0.473684211	0.263157895	0.263157895
Gaming Managers	0.473684211	0.421052632	0.105263158
Gas Plant Operators	0.473684211	0.526315789	0
Graduate Teaching Assistants	0.473684211	0.526315789	0
Physical Therapist Aides	0.473684211	0.526315789	0
Software	0.473684211	0.526315789	0
Technicians	0.470588235	0	0.529411765
Interpreters and Translators	0.470588235	0.470588235	0.058823529
Operators and Tenders	0.470588235	0.529411765	0
Samplers, and Weighers	0.46875	0.40625	0.125
Technical Directors/Managers	0.466666667	0.266666667	0.266666667
Craft Artists	0.466666667	0.333333333	0.2
Survey Researchers	0.466666667	0.333333333	0.2
Technicians	0.466666667	0.4	0.133333333
Client	0.466666667	0.466666667	0.066666667
Food Science Technicians	0.466666667	0.466666667	0.066666667
Workers	0.466666667	0.5	0.033333333
Medical Transcriptionists	0.466666667	0.533333333	0
Roofers	0.464285714	0.428571429	0.107142857
Drywall and Ceiling Tile Installers	0.461538462	0.230769231	0.307692308
Sewing Machine Operators	0.461538462	0.461538462	0.076923077
Bus Drivers, Transit and Intercity and Ambulance	0.461538462	0.538461538	0

and Trimmers	0.461538462	0.538461538	0
Technicians	0.461538462	0.538461538	0
Automotive Master Mechanics	0.458333333	0.416666667	0.125
Nurse Anesthetists	0.458333333	0.458333333	0.083333333
Construction Laborers	0.454545455	0.393939394	0.151515152
Sewers	0.454545455	0.5	0.045454545
Aquacultural Animals	0.454545455	0.545454545	0
Warehouse, or Storage Yard	0.454545455	0.545454545	0
Technicians	0.451612903	0.451612903	0.096774194
Jewelers	0.45	0.35	0.2
Carpenters	0.45	0.45	0.1
Cooks, Restaurant	0.45	0.45	0.1
Clerks	0.45	0.55	0
Rail Car Repairers	0.45	0.55	0
Construction Equipment Operators	0.448275862	0.413793103	0.137931034
Repairers	0.444444444	0.407407407	0.148148148
Desktop Publishers	0.444444444	0.5	0.055555556
Online Merchants	0.441176471	0.529411765	0.029411765
Repairers	0.44	0.52	0.04
Technicians	0.44	0.52	0.04
Mechanical Door Repairers	0.44	0.52	0.04
Equipment	0.44	0.56	0
Teacher Assistants	0.4375	0.375	0.1875
Biomass Plant Technicians	0.4375	0.5	0.0625
and Analysts	0.434782609	0.347826087	0.217391304
Technologists	0.434782609	0.565217391	0
Assistants	0.434782609	0.565217391	0
Traffic Technicians	0.434782609	0.565217391	0
Cytogenetic Technologists	0.433333333	0.433333333	0.133333333
Earth Drillers, Except Oil and Gas	0.433333333	0.5	0.066666667
Food Service Managers	0.428571429	0.285714286	0.285714286
Forest and Conservation Workers	0.428571429	0.476190476	0.095238095
Nonfarm Animal Caretakers	0.428571429	0.476190476	0.095238095
Drivers	0.428571429	0.5	0.071428571
Model Makers, Wood	0.428571429	0.5	0.071428571
Serving Workers, Including Fast Food	0.428571429	0.523809524	0.047619048
Setters, Operators, and Tenders	0.428571429	0.535714286	0.035714286
Credit Checkers	0.428571429	0.571428571	0
Wood, and Hard Tiles	0.428571429	0.571428571	0
Insurance Underwriters	0.428571429	0.571428571	0
Layout Workers, Metal and Plastic	0.428571429	0.571428571	0
Molding and Casting Workers	0.428571429	0.571428571	0

Officers	0.428571429	0.571428571	0
Workers	0.428571429	0.571428571	0
Medical Equipment Repairers	0.421052632	0.473684211	0.105263158
Biomedical Engineers	0.421052632	0.526315789	0.052631579
Biofuels Processing Technicians	0.421052632	0.578947368	0
Agricultural Crop and Horticultural Workers	0.416666667	0.375	0.208333333
Geographers	0.416666667	0.416666667	0.166666667
Subway and Streetcar Operators	0.416666667	0.416666667	0.166666667
Laborers, and Material Movers, Hand	0.416666667	0.458333333	0.125
Flight Attendants	0.416666667	0.458333333	0.125
Promoters	0.416666667	0.541666667	0.041666667
Paralegals and Legal Assistants	0.416666667	0.583333333	0
Phlebotomists	0.416666667	0.583333333	0
Ship and Boat Captains	0.416666667	0.583333333	0
Technicians	0.413793103	0.448275862	0.137931034
Industrial Engineering Technicians	0.411764706	0.470588235	0.117647059
Dental Laboratory Technicians	0.411764706	0.529411765	0.058823529
Psychiatric Aides	0.411764706	0.529411765	0.058823529
Setters, Operators, and Tenders, Metal and Plastic	0.411764706	0.588235294	0
Motorboat Operators	0.411764706	0.588235294	0
Upholsterers	0.409090909	0.272727273	0.318181818
Gas	0.409090909	0.5	0.090909091
Pipe Cleaners	0.409090909	0.590909091	0
Laboratory Animal Caretakers	0.407407407	0.518518519	0.074074074
Precious Metal Workers	0.40625	0.59375	0
Diesel Engine Specialists	0.4	0.44	0.16
Bartenders	0.4	0.45	0.15
Diagnostic Medical Sonographers	0.4	0.45	0.15
Machine Tool Programmers, Metal and Plastic	0.4	0.466666667	0.133333333
Industrial Machinery Mechanics	0.4	0.466666667	0.133333333
Hearing Aid Specialists	0.4	0.5	0.1
and Wall	0.4	0.5	0.1
Pipe Fitters and Steamfitters	0.4	0.5	0.1
Setters, Operators, and Tenders, Metal and Plastic	0.4	0.533333333	0.066666667
Auditors	0.4	0.55	0.05
Operators	0.4	0.56	0.04
Web Administrators	0.4	0.571428571	0.028571429
Concierges	0.4	0.6	0

Medical Appliance Technicians	0.4	0.6	0
Occupational Therapy Aides	0.4	0.6	0
Slaughterers and Meat Packers	0.4	0.6	0
Software Developers, Applications	0.4	0.6	0
Tile and Marble Setters	0.4	0.6	0
and Tenders	0.391304348	0.434782609	0.173913043
Ticket Takers	0.391304348	0.47826087	0.130434783
Specialists	0.391304348	0.565217391	0.043478261
Municipal Clerks	0.391304348	0.565217391	0.043478261
Buffing Machine Tool Setters, Operators, and Tenders, Metal	0.388888889	0.444444444	0.166666667
Librarians	0.388888889	0.444444444	0.166666667
Retail Sales Workers	0.388888889	0.5	0.111111111
Technicians	0.388888889	0.5	0.111111111
Collections Specialists	0.388888889	0.555555556	0.055555556
Helpers--Carpenters	0.388888889	0.611111111	0
Except Payroll and Timekeeping	0.388888889	0.611111111	0
Home Appliance Repairers	0.387096774	0.580645161	0.032258065
Fabric and Apparel Patternmakers	0.384615385	0.461538462	0.153846154
Food Scientists and Technologists	0.384615385	0.461538462	0.153846154
Tuners	0.384615385	0.512820513	0.102564103
Funeral Attendants	0.384615385	0.538461538	0.076923077
Wellhead Pumpers	0.384615385	0.538461538	0.076923077
Wind Turbine Service Technicians	0.384615385	0.538461538	0.076923077
Chefs and Head Cooks	0.380952381	0.428571429	0.19047619
Technologists	0.380952381	0.428571429	0.19047619
Device Specialists	0.380952381	0.428571429	0.19047619
Electricians	0.380952381	0.476190476	0.142857143
Sales Workers	0.380952381	0.523809524	0.095238095
Broadcast Technicians	0.379310345	0.517241379	0.103448276
Appraisers, Real Estate	0.375	0.5625	0.0625
Aquacultural Workers	0.375	0.5625	0.0625
Geodetic Surveyors	0.375	0.5625	0.0625
Installers and Repairers, Except Line Installers	0.375	0.575	0.05
Floral Designers	0.375	0.625	0
Proofreaders and Copy Markers	0.375	0.625	0
Related Materials	0.37037037	0.592592593	0.037037037
Actors	0.368421053	0.315789474	0.315789474
Animal Trainers	0.368421053	0.421052632	0.210526316
Wholesale, Retail, and Farm	0.368421053	0.473684211	0.157894737
Maintenance	0.368421053	0.526315789	0.105263158
Technicians	0.368421053	0.578947368	0.052631579

Pathologists	0.368421053	0.578947368	0.052631579
Technicians	0.368421053	0.631578947	0
Assistants	0.363636364	0.454545455	0.181818182
Operations Technicians	0.363636364	0.545454545	0.090909091
Lounge, and Coffee Shop	0.363636364	0.636363636	0
Yardmasters	0.363636364	0.636363636	0
Tax Preparers	0.363636364	0.636363636	0
Transit and Railroad Police	0.363636364	0.636363636	0
Embalmers	0.36	0.36	0.28
Human Resources Specialists	0.36	0.56	0.08
Sound Engineering Technicians	0.357142857	0.428571429	0.214285714
Urologists	0.357142857	0.5	0.142857143
Mechanical Drafters	0.357142857	0.571428571	0.071428571
Pipelayers	0.357142857	0.571428571	0.071428571
Pumpers	0.357142857	0.571428571	0.071428571
Watch Repairers	0.357142857	0.571428571	0.071428571
Administrative Services Managers	0.357142857	0.642857143	0
Biofuels Production Managers	0.357142857	0.642857143	0
Logistics Analysts	0.35483871	0.516129032	0.129032258
Police Detectives	0.35483871	0.64516129	0
Investigators	0.352941176	0.470588235	0.176470588
General and Operations Managers	0.352941176	0.647058824	0
Tool and Die Makers	0.352941176	0.647058824	0
Potters, Manufacturing	0.35	0.5	0.15
Except Farm Products	0.35	0.5	0.15
Fashion Designers	0.35	0.6	0.05
Administrators	0.35	0.6	0.05
Pharmacists	0.35	0.65	0
Court Clerks	0.347826087	0.260869565	0.391304348
and Repairers	0.347826087	0.52173913	0.130434783
Technologists	0.347826087	0.565217391	0.086956522
Transportation Security Screeners	0.346153846	0.461538462	0.192307692
Childcare Workers	0.346153846	0.538461538	0.115384615
Housekeeping and Janitorial	0.346153846	0.576923077	0.076923077
Automotive Specialty Technicians	0.346153846	0.615384615	0.038461538
Video, and Motion Picture	0.346153846	0.615384615	0.038461538
Specialists	0.346153846	0.615384615	0.038461538
Solar Photovoltaic Installers	0.346153846	0.653846154	0
Revenue Agents	0.346153846	0.653846154	0
Critical Care Nurses	0.344827586	0.413793103	0.24137931
Handling Experts, and Blasters	0.344827586	0.586206897	0.068965517
Customer Service Representatives	0.333333333	0.266666667	0.4
Home Health Aides	0.333333333	0.266666667	0.4

Municipal Firefighters	0.333333333	0.407407407	0.259259259
Assemblers	0.333333333	0.416666667	0.25
Installers	0.333333333	0.476190476	0.19047619
and Repairers, Motor Vehicles	0.333333333	0.5	0.166666667
Clinical Data Managers	0.333333333	0.523809524	0.142857143
Opticians, Dispensing	0.333333333	0.523809524	0.142857143
Radio and Television Announcers	0.333333333	0.523809524	0.142857143
Bill and Account Collectors	0.333333333	0.533333333	0.133333333
Civil Drafters	0.333333333	0.533333333	0.133333333
Power Plant Operators	0.333333333	0.541666667	0.125
Logging Equipment Operators	0.333333333	0.555555556	0.111111111
Funeral Directors	0.333333333	0.571428571	0.095238095
Technicians	0.333333333	0.571428571	0.095238095
City and Regional Planning Aides	0.333333333	0.583333333	0.083333333
Information Security Analysts	0.333333333	0.583333333	0.083333333
Lodging Managers	0.333333333	0.583333333	0.083333333
General	0.333333333	0.6	0.066666667
Dispatchers	0.333333333	0.6	0.066666667
Radio Operators	0.333333333	0.6	0.066666667
Rough Carpenters	0.333333333	0.6	0.066666667
Soil and Water Conservationists	0.333333333	0.606060606	0.060606061
Loss Prevention Managers	0.333333333	0.62962963	0.037037037
Bicycle Repairers	0.333333333	0.666666667	0
Costume Attendants	0.333333333	0.666666667	0
Blockmasons, Stonemasons, and Tile and Marble Setters	0.333333333	0.666666667	0
System Operators	0.333333333	0.666666667	0
Plasterers and Stucco Masons	0.333333333	0.666666667	0
Superintendents	0.333333333	0.666666667	0
Spa Managers	0.333333333	0.666666667	0
Managers	0.333333333	0.666666667	0
Sharpeners	0.333333333	0.666666667	0
Freight Forwarders	0.322580645	0.612903226	0.064516129
Conservators	0.32	0.44	0.24
Window Trimmers	0.32	0.6	0.08
Protection Technicians, Including Health	0.32	0.68	0
Respiratory Therapists	0.318181818	0.045454545	0.636363636
Transportation and Material-Moving Machine and Vehicle	0.318181818	0.454545455	0.227272727
Cosmetologists	0.318181818	0.5	0.181818182
Remote Sensing Technicians	0.318181818	0.590909091	0.090909091
Audiologists	0.318181818	0.636363636	0.045454545

Executive Administrative	0.318181818	0.636363636	0.045454545
Furniture Finishers	0.318181818	0.681818182	0
Production and Operating Workers	0.315789474	0.210526316	0.473684211
Technicians	0.315789474	0.578947368	0.105263158
Nuclear Monitoring Technicians	0.315789474	0.631578947	0.052631579
Operators	0.315789474	0.684210526	0
Chemical Technicians	0.3125	0.5	0.1875
Repairers, Powerhouse, Substation, and Relay	0.3125	0.5	0.1875
Installers	0.3125	0.5625	0.125
Etchers and Engravers	0.3125	0.65625	0.03125
Biological Technicians	0.3125	0.6875	0
Casualty Insurance	0.3125	0.6875	0
Maintenance, and Repair Workers	0.3125	0.6875	0
Chemists	0.307692308	0.461538462	0.230769231
Epidemiologists	0.307692308	0.461538462	0.230769231
Terrazzo Workers and Finishers	0.307692308	0.576923077	0.115384615
Assessors	0.307692308	0.615384615	0.076923077
Commercial Pilots	0.307692308	0.653846154	0.038461538
Archivists	0.307692308	0.692307692	0
Loan Officers	0.304347826	0.565217391	0.130434783
Radiologic Technologists	0.304347826	0.608695652	0.086956522
Recycling Coordinators	0.304347826	0.652173913	0.043478261
Coroners	0.3	0.4	0.3
Materials Engineers	0.3	0.55	0.15
Advertising Sales Agents	0.3	0.6	0.1
Naturopathic Physicians	0.3	0.6	0.1
Rigging, and Systems Assemblers	0.3	0.7	0
Credit Analysts	0.3	0.7	0
and Manufacturing, Except Technical and Scientific Products	0.3	0.7	0
Graphic Designers	0.294117647	0.411764706	0.294117647
Expediting Clerks	0.294117647	0.588235294	0.117647059
Business Intelligence Analysts	0.294117647	0.647058824	0.058823529
Systems Managers	0.294117647	0.647058824	0.058823529
Dental Hygienists	0.294117647	0.647058824	0.058823529
Technologists	0.294117647	0.647058824	0.058823529
Architectural Drafters	0.294117647	0.705882353	0
Civil Engineers	0.294117647	0.705882353	0
Financial Examiners	0.294117647	0.705882353	0
Service Workers	0.294117647	0.705882353	0
System Technicians	0.294117647	0.705882353	0
Travel Guides	0.294117647	0.705882353	0

Geneticists	0.291666667	0.541666667	0.166666667
Technicians	0.289473684	0.710526316	0
Gaming Supervisors	0.285714286	0.19047619	0.523809524
Energy Auditors	0.285714286	0.285714286	0.428571429
Energy Engineers	0.285714286	0.428571429	0.285714286
Loan Counselors	0.285714286	0.5	0.214285714
Prevention Supervisors	0.285714286	0.535714286	0.178571429
Geophysical Data Technicians	0.285714286	0.571428571	0.142857143
Registered Nurses	0.285714286	0.607142857	0.107142857
Agricultural Engineers	0.285714286	0.642857143	0.071428571
Prevention Specialists	0.285714286	0.642857143	0.071428571
Other Small Engine Mechanics	0.285714286	0.642857143	0.071428571
Hydroelectric Plant Technicians	0.285714286	0.666666667	0.047619048
Engineers and Testers	0.285714286	0.678571429	0.035714286
Mobile Home Installers	0.285714286	0.714285714	0
Patternmakers, Metal and Plastic	0.285714286	0.714285714	0
Postsecondary	0.28	0.4	0.32
Construction Managers	0.28	0.56	0.16
Sales Engineers	0.28	0.6	0.12
and Manufacturing, Technical and Scientific Products	0.277777778	0.527777778	0.194444444
Mining and Geological Engineers, Including Mining Safety Engineers	0.277777778	0.611111111	0.111111111
Dispatchers	0.277777778	0.611111111	0.111111111
Preschool	0.277777778	0.611111111	0.111111111
Computer Hardware Engineers	0.277777778	0.666666667	0.055555556
Physical Therapist Assistants	0.277777778	0.666666667	0.055555556
Acupuncturists	0.277777778	0.722222222	0
Ophthalmic Medical Technologists	0.275862069	0.620689655	0.103448276
Team Assemblers	0.272727273	0.545454545	0.181818182
Music Composers and Arrangers	0.272727273	0.590909091	0.136363636
Computer	0.272727273	0.681818182	0.045454545
Mechanics, Installers, and	0.272727273	0.727272727	0
Inspectors	0.272727273	0.727272727	0
Management Analysts	0.272727273	0.727272727	0
Mates- Ship, Boat, and Barge	0.272727273	0.727272727	0
Technicians	0.269230769	0.615384615	0.115384615
Correctional Officers and Jailers	0.269230769	0.653846154	0.076923077
Preparation and Serving Workers	0.269230769	0.653846154	0.076923077
Engineers	0.269230769	0.692307692	0.038461538
Finishers	0.269230769	0.692307692	0.038461538
Inspectors	0.269230769	0.692307692	0.038461538
Zoologists and Wildlife Biologists	0.266666667	0.2	0.533333333

Installers and Repairers, Transportation Equipment	0.266666667	0.4	0.333333333
Recreational Protective Service Workers	0.266666667	0.4	0.333333333
Orthotists and Prosthetists	0.266666667	0.533333333	0.2
Locomotive Engineers	0.266666667	0.6	0.133333333
Computer Programmers	0.266666667	0.666666667	0.066666667
Setters, Operators, and Tenders, Metal and Plastic	0.266666667	0.666666667	0.066666667
Pipefitters, and Steamfitters	0.266666667	0.733333333	0
Photonics Technicians	0.266666667	0.733333333	0
Sports Officials	0.266666667	0.733333333	0
Real Estate Brokers	0.263157895	0.157894737	0.578947368
Tour Guides and Escorts	0.263157895	0.421052632	0.315789474
Aquacultural Managers	0.263157895	0.473684211	0.263157895
Bioinformatics Technicians	0.263157895	0.578947368	0.157894737
Judicial Law Clerks	0.263157895	0.684210526	0.052631579
and Mining	0.263157895	0.684210526	0.052631579
Plumbers	0.260869565	0.391304348	0.347826087
Fitness and Wellness Coordinators	0.260869565	0.565217391	0.173913043
Precision Agriculture Technicians	0.260869565	0.608695652	0.130434783
Marine Engineers	0.260869565	0.652173913	0.086956522
Mechatronics Engineers	0.260869565	0.652173913	0.086956522
Distance Learning Coordinators	0.260869565	0.695652174	0.043478261
Credit Counselors	0.260869565	0.739130435	0
Farm and Ranch Managers	0.259259259	0.62962963	0.111111111
Business Teachers, Postsecondary	0.25	0.25	0.5
Park Naturalists	0.25	0.25	0.5
Manufacturing	0.25	0.25	0.5
Teachers, Postsecondary	0.25	0.375	0.375
Managers	0.25	0.4	0.35
Teachers, Postsecondary	0.25	0.416666667	0.333333333
Postsecondary	0.25	0.416666667	0.333333333
Physics Teachers, Postsecondary	0.25	0.458333333	0.291666667
Broadcast News Analysts	0.25	0.5	0.25
Shampooers	0.25	0.5	0.25
Managers	0.25	0.5	0.25
Elevator Installers and Repairers	0.25	0.55	0.2
Archeologists	0.25	0.5625	0.1875
Crossing Guards	0.25	0.583333333	0.166666667
Real Estate Sales Agents	0.25	0.59375	0.15625
Landscaping, Lawn Service, and Groundskeeping Workers	0.25	0.607142857	0.142857143

Mechanical Engineers	0.25	0.607142857	0.142857143
Technologists	0.25	0.625	0.125
Repairers, Commercial and Industrial Equipment	0.25	0.65	0.1
Police Patrol Officers	0.25	0.65	0.1
Fundraisers	0.25	0.678571429	0.071428571
Animal Control Workers	0.25	0.6875	0.0625
Specialists	0.25	0.6875	0.0625
Loan	0.25	0.6875	0.0625
Robotics Engineers	0.25	0.708333333	0.041666667
Technicians	0.25	0.75	0
Operators	0.25	0.75	0
Except Brickmasons	0.25	0.75	0
Web Developers	0.243243243	0.702702703	0.054054054
Clinical Research Coordinators	0.242424242	0.696969697	0.060606061
History Teachers, Postsecondary	0.24	0.44	0.32
Postsecondary	0.24	0.52	0.24
Commercial Divers	0.24	0.72	0.04
Exercise Physiologists	0.24	0.72	0.04
Department	0.238095238	0.714285714	0.047619048
Planners	0.238095238	0.761904762	0
Boilermakers	0.235294118	0.411764706	0.352941176
Purchasing Managers	0.235294118	0.588235294	0.176470588
Technicians	0.235294118	0.588235294	0.176470588
Nuclear Medicine Technologists	0.235294118	0.705882353	0.058823529
Occupational Therapists	0.235294118	0.705882353	0.058823529
Special Education	0.235294118	0.764705882	0
Residential Advisors	0.233333333	0.7	0.066666667
Sewers, Hand	0.230769231	0.769230769	0
Special and Career/Technical Education	0.228571429	0.742857143	0.028571429
Postsecondary	0.227272727	0.363636364	0.409090909
Postsecondary	0.227272727	0.409090909	0.363636364
Enforcement Teachers,	0.227272727	0.409090909	0.363636364
Postsecondary	0.227272727	0.409090909	0.363636364
Gem and Diamond Workers	0.227272727	0.409090909	0.363636364
Postsecondary	0.227272727	0.409090909	0.363636364
Postsecondary	0.227272727	0.409090909	0.363636364
Occupational Therapy Assistants	0.227272727	0.409090909	0.363636364
Postsecondary	0.227272727	0.409090909	0.363636364
Forest Firefighters	0.227272727	0.681818182	0.090909091
Agents	0.227272727	0.772727273	0
Transportation Planners	0.227272727	0.772727273	0

Middle School	0.225	0.725	0.05
Skincare Specialists	0.222222222	0.388888889	0.388888889
Postsecondary	0.222222222	0.518518519	0.259259259
Attendants, Except Emergency Medical Technicians	0.222222222	0.666666667	0.111111111
Pilots, Ship	0.222222222	0.666666667	0.111111111
Acute Care Nurses	0.222222222	0.703703704	0.074074074
Financial Analysts	0.222222222	0.722222222	0.055555556
Intelligence Analysts	0.222222222	0.777777778	0
Community Association Managers	0.222222222	0.777777778	0
Statisticians	0.222222222	0.777777778	0
Except Special and Career/Technical Education	0.21875	0.71875	0.0625
Postsecondary	0.217391304	0.391304348	0.391304348
Teachers, Postsecondary	0.217391304	0.434782609	0.347826087
Postsecondary	0.217391304	0.434782609	0.347826087
Postsecondary	0.217391304	0.434782609	0.347826087
Postsecondary	0.217391304	0.434782609	0.347826087
Postsecondary	0.217391304	0.434782609	0.347826087
Sociology Teachers, Postsecondary	0.217391304	0.434782609	0.347826087
Law Teachers, Postsecondary	0.217391304	0.47826087	0.304347826
Veterinarians	0.217391304	0.52173913	0.260869565
Robotics Technicians	0.217391304	0.608695652	0.173913043
Film and Video Editors	0.217391304	0.652173913	0.130434783
Air Traffic Controllers	0.217391304	0.739130435	0.043478261
Customs Brokers	0.217391304	0.739130435	0.043478261
Surveyors	0.217391304	0.782608696	0
Industrial Production Managers	0.214285714	0.571428571	0.214285714
Environmental Engineers	0.214285714	0.607142857	0.178571429
Service Technicians	0.214285714	0.785714286	0
Insurance Sales Agents	0.210526316	0.631578947	0.157894737
Operators, and Tenders, Metal and Plastic	0.210526316	0.631578947	0.157894737
Internists, General	0.210526316	0.736842105	0.052631579
Postsecondary	0.208333333	0.5	0.291666667
Postsecondary	0.208333333	0.5	0.291666667
Manufacturing Engineers	0.208333333	0.583333333	0.208333333
Security Management Specialists	0.208333333	0.625	0.166666667
Nurses	0.208333333	0.708333333	0.083333333
Geothermal Technicians	0.208333333	0.75	0.041666667
and Administrative Support Workers	0.206896552	0.551724138	0.24137931
Machinists	0.206896552	0.724137931	0.068965517

Radiologists	0.206896552	0.793103448	0
Construction Trades and Extraction Workers	0.2	0.266666667	0.533333333
Midwives	0.2	0.4	0.4
Teachers, Postsecondary	0.2	0.466666667	0.333333333
Managers	0.2	0.48	0.32
Teachers, Postsecondary	0.2	0.48	0.32
Aviation Inspectors	0.2	0.533333333	0.266666667
Technical Writers	0.2	0.533333333	0.266666667
Derrick Operators, Oil and Gas	0.2	0.6	0.2
Nurse Midwives	0.2	0.6	0.2
Hydrologists	0.2	0.64	0.16
and Paramedics	0.2	0.666666667	0.133333333
and Detectives	0.2	0.7	0.1
Investment Fund Managers	0.2	0.7	0.1
Specialists	0.2	0.7	0.1
Family and General Practitioners	0.2	0.733333333	0.066666667
Materials Scientists	0.2	0.733333333	0.066666667
Physicists	0.2	0.733333333	0.066666667
Teachers	0.2	0.733333333	0.066666667
Managers	0.2	0.733333333	0.066666667
Nuclear Power Reactor Operators	0.2	0.75	0.05
Secondary School	0.2	0.75	0.05
Art Therapists	0.2	0.8	0
Gaming Investigators	0.2	0.8	0
Industrial Engineers	0.2	0.8	0
Sheriffs and Deputy Sheriffs	0.2	0.8	0
Teachers, Middle School	0.193548387	0.741935484	0.064516129
Technicians	0.192307692	0.346153846	0.461538462
Space Sciences Teachers, Postsecondary	0.192307692	0.461538462	0.346153846
Postsecondary	0.192307692	0.538461538	0.269230769
Mechanics and Installers	0.192307692	0.730769231	0.076923077
Performance	0.19047619	0.476190476	0.333333333
Business Continuity Planners	0.19047619	0.571428571	0.238095238
Financial Quantitative Analysts	0.19047619	0.619047619	0.19047619
Personal Financial Advisors	0.19047619	0.666666667	0.142857143
Retail Loss Prevention Specialists	0.19047619	0.714285714	0.095238095
Logisticians	0.19047619	0.80952381	0
Allergists and Immunologists	0.1875	0.5625	0.25
Anesthesiologist Assistants	0.1875	0.5625	0.25
Regulatory Affairs Specialists	0.1875	0.59375	0.21875
Electrical Drafters	0.1875	0.6875	0.125

Neurodiagnostic Technologists	0.1875	0.6875	0.125
Specialists	0.1875	0.75	0.0625
Pediatricians, General	0.1875	0.75	0.0625
Health Educators	0.1875	0.8125	0
Quality Control Systems Managers	0.185185185	0.703703704	0.111111111
Reporters and Correspondents	0.185185185	0.777777778	0.037037037
Except Special Education	0.184210526	0.736842105	0.078947368
Chiropractors	0.181818182	0.272727273	0.545454545
Mathematicians	0.181818182	0.363636364	0.454545455
Athletic Trainers	0.181818182	0.590909091	0.227272727
Equipment Installers and Repairers	0.181818182	0.636363636	0.181818182
Teachers, Secondary School	0.181818182	0.727272727	0.090909091
Funeral Service Managers	0.181818182	0.727272727	0.090909091
Podiatrists	0.181818182	0.727272727	0.090909091
Speech-Language Pathologists	0.181818182	0.772727273	0.045454545
Personal Care Aides	0.181818182	0.818181818	0
Prosthodontists	0.181818182	0.818181818	0
Treasurers and Controllers	0.181818182	0.818181818	0
Education and Literacy Teachers and Instructors	0.179487179	0.743589744	0.076923077
Surgical Assistants	0.178571429	0.535714286	0.285714286
Postsecondary	0.178571429	0.571428571	0.25
Preschool and Childcare Center/Program	0.176470588	0.529411765	0.294117647
Models	0.176470588	0.529411765	0.294117647
Technologists	0.176470588	0.705882353	0.117647059
Technicians	0.176470588	0.705882353	0.117647059
Sales Managers	0.176470588	0.764705882	0.058823529
Kindergarten and Elementary	0.175	0.725	0.1
Teachers, Postsecondary	0.173913043	0.434782609	0.391304348
Fitters	0.173913043	0.695652174	0.130434783
Millwrights	0.173913043	0.782608696	0.043478261
Program Directors	0.173913043	0.782608696	0.043478261
Petroleum Engineers	0.173913043	0.826086957	0
Technologists	0.172413793	0.551724138	0.275862069
Product Safety Engineers	0.166666667	0.5	0.333333333
Risk Management Specialists	0.166666667	0.5	0.333333333
Fire Inspectors	0.166666667	0.583333333	0.25
Airfield Operations Specialists	0.166666667	0.666666667	0.166666667
Compliance Managers	0.166666667	0.666666667	0.166666667
Mathematical Technicians	0.166666667	0.666666667	0.166666667
Nannies	0.166666667	0.666666667	0.166666667

Physician Assistants	0.166666667	0.666666667	0.166666667
Assistants	0.166666667	0.666666667	0.166666667
Chief Sustainability Officers	0.166666667	0.722222222	0.111111111
Technicians	0.166666667	0.722222222	0.111111111
Managers	0.166666667	0.722222222	0.111111111
Electrical Engineering Technicians	0.166666667	0.75	0.083333333
Repairers	0.166666667	0.777777778	0.055555556
Logistics Managers	0.166666667	0.8	0.033333333
Search Marketing Strategists	0.166666667	0.805555556	0.027777778
Anesthesiologists	0.166666667	0.833333333	0
Biomass Power Plant Managers	0.166666667	0.833333333	0
Database Administrators	0.166666667	0.833333333	0
and Investigators	0.166666667	0.833333333	0
Logistics Engineers	0.166666667	0.833333333	0
Political Scientists	0.166666667	0.833333333	0
Special Education	0.162162162	0.810810811	0.027027027
Biostatisticians	0.16	0.72	0.12
Inspectors	0.157894737	0.631578947	0.210526316
Specialists	0.157894737	0.736842105	0.105263158
Representatives and Officers	0.157894737	0.736842105	0.105263158
Investment Underwriters	0.157894737	0.736842105	0.105263158
School Psychologists	0.157894737	0.736842105	0.105263158
Tutors	0.157894737	0.789473684	0.052631579
Patient Representatives	0.153846154	0.384615385	0.461538462
Surgeons	0.153846154	0.384615385	0.461538462
Civil Engineering Technicians	0.153846154	0.461538462	0.384615385
Postsecondary	0.153846154	0.538461538	0.307692308
Sculptors, and Illustrators	0.153846154	0.538461538	0.307692308
Hospitalists	0.153846154	0.538461538	0.307692308
Cost Estimators	0.153846154	0.615384615	0.230769231
Workers	0.153846154	0.615384615	0.230769231
Insulation Workers, Mechanical	0.153846154	0.615384615	0.230769231
Avionics Technicians	0.153846154	0.692307692	0.153846154
Fire Investigators	0.153846154	0.692307692	0.153846154
Nuclear Medicine Physicians	0.153846154	0.730769231	0.115384615
Agents and Business Managers of Artists, Performers, and Athletes	0.153846154	0.769230769	0.076923077
Bailiffs	0.153846154	0.769230769	0.076923077
Mental Health Counselors	0.153846154	0.769230769	0.076923077
Photonics Engineers	0.153846154	0.769230769	0.076923077
Prevention Supervisors	0.153846154	0.807692308	0.038461538
Human Resources Managers	0.153846154	0.807692308	0.038461538
and Investigators	0.153846154	0.846153846	0

Massage Therapists	0.153846154	0.846153846	0
Solar Energy Systems Engineers	0.153846154	0.846153846	0
Structural Iron and Steel Workers	0.15	0.55	0.3
Conciliators	0.15	0.65	0.2
Dentists, General	0.15	0.65	0.2
Nuclear Engineers	0.15	0.65	0.2
Mechanics, Except Engines	0.15	0.8	0.05
Editors	0.15	0.85	0
Postsecondary	0.15	0.85	0
Postsecondary	0.148148148	0.481481481	0.37037037
Water/Wastewater Engineers	0.148148148	0.851851852	0
Astronomers	0.142857143	0.571428571	0.285714286
Molecular and Cellular Biologists	0.142857143	0.571428571	0.285714286
Cytotechnologists	0.142857143	0.642857143	0.214285714
Announcers	0.142857143	0.642857143	0.214285714
Actuaries	0.142857143	0.714285714	0.142857143
Microbiologists	0.142857143	0.714285714	0.142857143
Operations Research Analysts	0.142857143	0.714285714	0.142857143
Sustainability Specialists	0.142857143	0.714285714	0.142857143
Biochemical Engineers	0.142857143	0.771428571	0.085714286
Engineers/Architects	0.142857143	0.857142857	0
Marine Architects	0.142857143	0.857142857	0
Community Health Workers	0.137931034	0.827586207	0.034482759
Construction Carpenters	0.136363636	0.590909091	0.272727273
Instructors	0.136363636	0.590909091	0.272727273
Biologists	0.136363636	0.681818182	0.181818182
Validation Engineers	0.136363636	0.818181818	0.045454545
Recreation Workers	0.136363636	0.863636364	0
Curators	0.133333333	0.466666667	0.4
Security Managers	0.133333333	0.566666667	0.3
Epidemiologists	0.133333333	0.733333333	0.133333333
Legislators	0.133333333	0.8	0.066666667
Supply Chain Managers	0.133333333	0.8	0.066666667
Workers	0.130434783	0.739130435	0.130434783
Dietitians and Nutritionists	0.130434783	0.782608696	0.086956522
Sales Agents, Financial Services	0.125	0.125	0.75
Managers	0.125	0.583333333	0.291666667
Atmospheric and Space Scientists	0.125	0.666666667	0.208333333
Art Directors	0.125	0.75	0.125
Analysis Specialists	0.125	0.791666667	0.083333333
Healthcare Social Workers	0.125	0.8125	0.0625
Green Marketers	0.125	0.875	0
Rehabilitation Counselors	0.125	0.875	0

Computer Network Architects	0.121212121	0.757575758	0.121212121
Automotive Engineers	0.12	0.84	0.04
Foresters	0.12	0.84	0.04
Adjusters	0.117647059	0.529411765	0.352941176
Stonemasons	0.117647059	0.882352941	0
Transportation Engineers	0.115384615	0.769230769	0.115384615
Quality Control Analysts	0.115384615	0.846153846	0.038461538
Ergonomists	0.115384615	0.884615385	0
Athletes and Sports Competitors	0.111111111	0	0.888888889
Technicians	0.111111111	0.666666667	0.222222222
Ophthalmologists	0.111111111	0.666666667	0.222222222
Nurse Practitioners	0.111111111	0.703703704	0.185185185
Sports Medicine Physicians	0.111111111	0.851851852	0.037037037
Anthropologists	0.107142857	0.607142857	0.285714286
Transportation Managers	0.107142857	0.714285714	0.178571429
Labor Relations Specialists	0.107142857	0.75	0.142857143
Postsecondary	0.107142857	0.892857143	0
Dermatologists	0.105263158	0.473684211	0.421052632
Managers	0.105263158	0.736842105	0.157894737
Managers	0.105263158	0.736842105	0.157894737
Respiratory Therapy Technicians	0.105263158	0.789473684	0.105263158
Urban and Regional Planners	0.105263158	0.789473684	0.105263158
Genetic Counselors	0.105263158	0.842105263	0.052631579
Optometrists	0.1	0.5	0.4
Bioinformatics Scientists	0.1	0.65	0.25
Music Therapists	0.1	0.8	0.1
Specialists	0.1	0.8	0.1
and Mobility Specialists, and Vision Rehabilitation Therapists	0.1	0.9	0
Historians	0.095238095	0.523809524	0.380952381
Water Resource Specialists	0.095238095	0.666666667	0.238095238
Computer Systems Analysts	0.095238095	0.761904762	0.142857143
Clinical Psychologists	0.095238095	0.904761905	0
Engineers	0.095238095	0.904761905	0
Correctional Officers	0.090909091	0.681818182	0.227272727
Agricultural Inspectors	0.090909091	0.909090909	0
Interior Designers	0.090909091	0.909090909	0
and Vocational Counselors	0.088235294	0.764705882	0.147058824
Biochemists and Biophysicists	0.086956522	0.782608696	0.130434783
Producers	0.083333333	0.375	0.541666667
Fish and Game Wardens	0.083333333	0.625	0.291666667
Dietetic Technicians	0.083333333	0.666666667	0.25
Economists	0.083333333	0.75	0.166666667

Psychiatrists	0.083333333	0.75	0.166666667
Video Game Designers	0.083333333	0.75	0.166666667
and Technologists	0.083333333	0.833333333	0.083333333
Motorcycle Mechanics	0.083333333	0.833333333	0.083333333
Segmental Pavers	0.083333333	0.833333333	0.083333333
Naval	0.083333333	0.916666667	0
Chemical Engineers	0.083333333	0.916666667	0
Managers	0.083333333	0.916666667	0
Marketing Specialists	0.076923077	0.461538462	0.461538462
Fuel Cell Engineers	0.076923077	0.769230769	0.153846154
Budget Analysts	0.076923077	0.846153846	0.076923077
Counseling Psychologists	0.076923077	0.846153846	0.076923077
Adjudicators, and Hearing Officers	0.076923077	0.923076923	0
Engineers	0.076923077	0.923076923	0
Abuse Social Workers	0.076923077	0.923076923	0
Talent Directors	0.076923077	0.923076923	0
Set and Exhibit Designers	0.074074074	0.888888889	0.037037037
Oral and Maxillofacial Surgeons	0.071428571	0.857142857	0.071428571
Advisors	0.066666667	0.533333333	0.4
Research Scientists	0.066666667	0.733333333	0.2
Musicians, Instrumental	0.066666667	0.733333333	0.2
Preventive Medicine Physicians	0.066666667	0.8	0.133333333
Obstetricians and Gynecologists	0.066666667	0.866666667	0.066666667
Rehabilitation Physicians	0.066666667	0.933333333	0
Microsystems Engineers	0.064516129	0.677419355	0.258064516
Orthoptists	0.0625	0.4375	0.5
Psychiatric Technicians	0.0625	0.5	0.4375
Wind Energy Engineers	0.0625	0.75	0.1875
Managers	0.0625	0.8125	0.125
Fuel Cell Technicians	0.0625	0.9375	0
Marriage and Family Therapists	0.0625	0.9375	0
Geothermal Production Managers	0.058823529	0.647058824	0.294117647
Informatics Nurse Specialists	0.058823529	0.647058824	0.294117647
Choreographers	0.055555556	0.388888889	0.555555556
Public Relations Specialists	0.055555556	0.722222222	0.222222222
Music Directors	0.055555556	0.777777778	0.166666667
Neuropsychologists	0.055555556	0.833333333	0.111111111
Aerospace Engineers	0.055555556	0.944444444	0
Education	0.052631579	0.421052632	0.526315789
Environmental Economists	0.052631579	0.736842105	0.210526316
Instructional Coordinators	0.052631579	0.842105263	0.105263158
Landscape Architects	0.052631579	0.947368421	0
Technologists	0.05	0.9	0.05

Marketing Managers	0.05	0.9	0.05
Correctional Treatment Specialists	0.047619048	0.571428571	0.380952381
Managers	0.047619048	0.80952381	0.142857143
Electrical Engineers	0.045454545	0.681818182	0.272727273
Specialists and Site Managers	0.045454545	0.954545455	0
Specialists, Including Health	0.045454545	0.954545455	0
Disorder Counselors	0.043478261	0.52173913	0.434782609
Neurologists	0.041666667	0.625	0.333333333
Physical Therapists	0.041666667	0.708333333	0.25
Television, and Radio	0.04	0.72	0.24
Psychologists	0.04	0.84	0.12
Soil and Plant Scientists	0.037037037	0.962962963	0
Coaches and Scouts	0.035714286	0.785714286	0.178571429
Clinical Nurse Specialists	0.034482759	0.896551724	0.068965517
Chief Executives	0.032258065	0.612903226	0.35483871
Elementary and Secondary School	0.032258065	0.709677419	0.258064516
and Geographers	0.032258065	0.935483871	0.032258065
Clergy	0	0.428571429	0.571428571
Dancers	0	0.538461538	0.461538462
Sociologists	0	0.583333333	0.416666667
Designers	0	0.588235294	0.411764706
Singers	0	0.615384615	0.384615385
Writers	0	0.625	0.375
Managers	0	0.714285714	0.285714286
Directors	0	0.739130435	0.260869565
Lawyers	0	0.772727273	0.227272727
Supervisors	0	0.8	0.2
Magistrates	0	0.8	0.2
Nanosystems Engineers	0	0.8	0.2
Orthodontists	0	0.8	0.2
Natural Sciences Managers	0	0.8125	0.1875
Range Managers	0	0.875	0.125
Animal Scientists	0	0.888888889	0.111111111
Biofuels/Biodiesel Technology and Product Development Managers	0	0.947368421	0.052631579
Climate Change Analysts	0	1	0
Copy Writers	0	1	0
Data Warehousing Specialists	0	1	0
Planners	0	1	0
Industrial Ecologists	0	1	0
Technologists	0	1	0
Recreational Therapists	0	1	0
Regulatory Affairs Managers	0	1	0

Wind Energy Project Managers	0	1	0

APPENDIX B

THE RESULTS OF INDUSTRIES' AUTOMATABILITY

Industries	Substitution	Complementarity	Negligibility
Educational Services	0.230367742	0.543841067	0.225791191
Arts, Entertainment and Recreation	0.273589262	0.534721882	0.191688856
Other Services (Except Public Administratio	0.334531855	0.522794247	0.142673898
Real Estate and Rental and Leasing	0.332822567	0.533638338	0.133539095
Health Care and Social Assistance	0.282281819	0.590504851	0.12721333
Government	0.284248443	0.60369429	0.112057267
Professional, Scientific and Technical Servic	0.239996052	0.650227068	0.10977688
Agriculture, Forestry, Fishing and Hunting	0.415514488	0.4798687	0.104616812
Construction	0.402369766	0.499573624	0.09805661
Management of Companies and Enterprises	0.219898769	0.688056181	0.09204505
Information	0.337971671	0.575005684	0.087022645
Manufacturing	0.447618473	0.467541898	0.084839629
Utilities	0.34821794	0.570123881	0.081658179
Mining, Quarrying, and Oil and Gas Extracti	0.466154889	0.452643383	0.081201727
Finance and Insurance	0.369701562	0.554126927	0.07617151
Administrative and Support Services	0.544294248	0.386182565	0.069523187
Wholesale Trade	0.402604274	0.535910322	0.061485404
Retail Trade	0.479448168	0.459071623	0.061480209
Transportation and Warehousing	0.442244448	0.49711725	0.060638302
Accommodation and Food Services	0.597011386	0.348796044	0.05419257