

Insight Report

Towards a Reskilling Revolution

A Future of Jobs for All

In collaboration with The Boston Consulting Group

January 2018



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Preface

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Founder and Executive Chairman, World Economic Forum

As the types of skills needed in the labour market change rapidly, individual workers will have to engage in life-long learning if they are to remain not just employable but are to achieve fulfilling and rewarding careers that allow them to maximize their employment opportunities. For companies, reskilling and upskilling strategies will be critical if they are to find the talent they need and to contribute to socially responsible approaches to the future of work. For policy-makers, reskilling and retraining the existing workforce are essential levers to fuel future economic growth, enhance societal resilience in the face of technological change and pave the way for future-ready education systems for the next generation of workers.

In a complementary report—*Eight Futures of Work: Scenarios and Their Implications*—we have imagined various scenarios for what the future of work might look like by the year 2030 and what the key implications are for actions today. Unsurprisingly, the need to anticipate changes in the labour market, prepare for reskilling—that is, giving workers the skills and capabilities needed for the future workplace—and support job transitions all emerge as prominent priorities.

Yet while there has been much forecasting on transformations in labour markets, few practical approaches exist to identify reskilling and job transition opportunities. This report provides a valuable new tool that will help individual workers, companies, and governments to prioritize their actions and investments.

Towards a Reskilling Revolution: A Future of Jobs for All introduces a new approach to identifying reskilling and job transition opportunities, including those that might not be immediately apparent. Using big data analysis of online job postings, the methodology in this report demonstrates the power of a data-driven approach to discover reskilling pathways and job transition opportunities.

The methodology can be used to inform the actions of individual workers, policy-makers and companies. It can be applied to a variety of taxonomies of job requirements and sources of data.

In assessing reskilling pathways and job transition opportunities in such detail and at such scale, we aim to move the debate on the future of work to new—and practical—territory. This report is a beginning. In subsequent publications, the methodology will be extended to include additional perspectives and geographies and applied in collaboration with government and business stakeholders to support workers. We also hope it inspires similar efforts to think practically yet holistically about managing reskilling, upskilling and job transitions.

Towards a Reskilling Revolution: A Future of Jobs for All

Introduction

The path to a good life appears increasingly difficult to identify and attain for a growing number of people across our global community. Gender, inter-regional, generational and income inequalities are at risk of widening. A key factor driving these concerns is the changing nature of work and the extent to which opportunities for finding stable, meaningful work that provides a good income have increasingly become fractured and polarized, favouring those fortunate enough to be living in certain geographies and to be holding certain in-demand skills.¹ Economic value creation is increasingly based on the use of ever higher levels of specialized skills and knowledge, creating unprecedented new opportunities for some while threatening to leave behind a significant share of the workforce. In a recent survey of OECD countries, more than one in four adults reported a mismatch between their current skill sets and the qualifications required to do their jobs.²

Even among people formerly working good jobs, disruptive technological and socio-economic forces threaten to swiftly outdate the shelf life of people's skillsets and the relevance of what they thought they knew about the path to social mobility and rewarding employment.³ There is a sense that the rise of artificial intelligence, robotics and other digital developments is upending the primacy of human expertise in the economy. The individuals who will succeed in the economy of the future will be those who can complement the work done by mechanical or algorithmic technologies, and 'work with the machines'.⁴

Employers, too, are feeling the effects of these changes. ManpowerGroup's 2017 Talent Shortage Survey found that 40% of employers reported difficulties in finding skilled talent, while the number of employers filling these gaps by re-training and developing people internally has more than doubled since 2015, from just over one in five to more than half.⁵ Even so, the rate of change is threatening to outpace employers' positive efforts. The World Economic Forum's 2016 report, *The Future of Jobs*, found that, by 2020, across all types of occupations, on average, more than a third of the core skills needed to perform most jobs will be made up of skills currently not yet considered crucial to the job.⁶

The key question, then, for both individuals and employers facing these disruptions—and for governments and other stakeholders seeking to support them—is how to better anticipate and proactively manage the current realignments and transitions of the labour market to shape a future of work that expands economic growth and opportunities for all.

Towards a Reskilling Revolution, developed by the World Economic Forum in collaboration with The Boston Consulting Group and Burning Glass Technologies, aims to provide one key building block for workers looking to find their place in the future of work and for business leaders and governments looking to build more prosperous companies and productive economies and societies. Using the labour market of the United States as an example, the report introduces an innovative, big data approach built on conventional labour market information systems as well as online job postings. It demonstrates the power of data-driven approaches for finding solutions to job disruptions, including job transition pathways and reskilling opportunities that might not be immediately apparent.

The methodology introduced in this report can be used to inform the actions of individual workers, policy-makers and companies. Importantly, it is not limited to the geography or data presented here, and can be feasibly adapted to different jobs and skills taxonomies, divergent demand projections and broadly to new sources of data about the labour market. Our aim is to inspire similar efforts to think about reskilling and job transition opportunities among public and private actors globally. It is our hope that the report will become a valuable tool to move beyond the current impasse of polarized job prospects, help individuals uncover opportunities to build a good life and, above all, inspire confidence that lifelong learning and reskilling on a society-wide scale are truly possible.

This report is structured as follows: The next section introduces our data-driven approach to mapping job transition opportunities, providing a brief overview of the methodological building blocks and core elements of the approach. The following section explains how the methodology may be used by policy-makers, corporate strategic workforce planners and others, using

data for the United States as an example throughout. The third section then demonstrates the relevance of the approach to individuals, putting at their disposal a wide range of job transition pathways according to their own priority criteria. The final section concludes the report by briefly discussing the measures needed to support job transitions and reskilling at scale, and suggesting possible extensions of our work. For the interested reader, a methodological appendix provides a detailed, more technical discussion of our approach.

Mapping Job Transition Opportunities

Calls for stepping up workforce reskilling as a critical component of preparing labour markets for the Fourth Industrial Revolution have become ever more urgent. Until now, however, few practical approaches have existed to identify and systematically map out realistic job transition opportunities for workers facing declining job prospects, answering the question: “what kinds of jobs could affected workers actually reskill to?”. Accordingly, the aim of this report is to provide a valuable new tool that will help individual workers, companies, and governments to prioritize their actions, time and investments. In particular, the data-driven approach established in this publication can be used to inform policy-makers, corporate strategic workforce planners and individuals about possible pathways to meet the anticipated labour demands of the future. It maps out opportunities for job transitions for workers currently holding jobs that are highly likely to be disrupted by structural shifts in the labour market but also provides a method to anyone looking to upskill and improve their wage prospects and job satisfaction.

In this publication, we concentrate on job transitions for workers in the United States whose jobs are expected to disappear due to technological change in the medium-term.⁷ To do this, we use a range of data on US employment in 2016 from innovative data sources, as detailed below, as well as projections of expected employment change by 2026 from the US Bureau of Labor Statistics.⁸ It is important to note that we do not ourselves predict changes in demand for certain types of jobs in this publication. Rather, we utilize the US Bureau of Labor Statistics’ official forecast of employment in 2026 as an input to establish our overall approach. However, the methodology used in this publication can be readily adapted to other data sets, or to various scenarios that imagine higher or lower disruptions in the demand for certain types of jobs.

The purpose of the exercise is to uncover, in a systematic way, job transition opportunities that are both *viable* and *desirable* from the point of view of those workers affected by labour market disruptions. We develop a number of complementary approaches from the perspective of both an individual worker seeking guidance on high-quality, stable new job opportunities as well as from the perspective of a policy-maker or corporate planner seeking to optimize the collective outcomes for a wider range of individuals.

This section presents an overview of our data-driven approach to measuring the viability and establishing the desirability of various job transition options for workers affected

by the labour market disruptions of the Fourth Industrial Revolution. For a detailed, more technical description of our methodology, please refer to the publication’s Appendix A: Data and Methodology.

Is the job transition viable?

A conundrum often cited in the current debate on the future of work is the contention that “not every displaced coal miner will be able to become a software engineer”.⁹ Rhetoric aside, how might one actually go about assessing the practical viability of various theoretical job transition options?

From a methodological point of view, what is needed in order to do this is an ability to break down jobs into a series of relevant, measurable component parts in order to then systematically compare them and identify any gaps in knowledge, skills and experience. If we were able to do this, it would then become possible to calculate the ‘job-readiness’ or ‘job-fit’ of any one individual on the basis of objective criteria. Furthermore, we can think of jobs as a collection of tasks that need to be accomplished within a company.¹⁰ Viable future employees are those equipped to perform those tasks, individuals who possess the necessary knowledge, skills, and experience.

For the purposes of this publication we have assumed that those who currently hold jobs that require specific skills and knowledge typically possess the skills and knowledge in question.¹¹ Once we know the knowledge and skills requirements of a job, we can assume that employees transitioning out of that job will be able to bring those capacities into any new roles.

Therefore, the core of our data-driven approach to assessing the viability of a job transition consists of calculating the similarity between the requirements of two jobs in order to compute an objective ‘similarity score’ between them. Similarity scores express the overlap between the activities or tasks that need to be performed in a role as well as between primary indicators of job-fit such as knowledge, skills and abilities, and between secondary indicators of job-fit such as years of education and years of work experience (see **Table 1** for an overview of the components of jobs used in the calculation of similarity scores and the report’s Appendix A: Data and Methodology for a comprehensive technical description).¹²

To make this type of analysis possible in practice, data from two distinct sources inform our study: the US Bureau of Labor Statistics’ Occupational Information Network (O*NET) and Burning Glass Technologies. The Occupational Information Network (O*NET) database is the primary source of occupational information in the United States and contains information on required skills, knowledge, abilities, education, training, education and experience to perform a job; it groups individual jobs into clusters of related professions, or ‘job families’, and is continually updated by the US government by surveying a broad range of workers. Burning Glass Technologies is a big data labour market analysis provider that has compiled a unique data set aggregating insights from more than 50 million online job postings in the United States over a two-year period, between 2016 and 2017, ‘scraping’ data from approximately 40,000 unique online sources.¹³ The database developed by Burning Glass Technologies encompasses information on approximately 15,000

Table 1: Components of a job

Content	Aptitudes	Experience
<p>Work activities are the range of tasks that need to be accomplished within a job role</p>	<p>Knowledge is the body of facts, principles, theories and practices that acts as a foundation for skills</p> <p>Skills are used to apply knowledge to complete tasks</p> <p>Cross-functional skills are skills required by a variety of job roles which are transferrable to a broad range of job role</p> <p>Specialized skills are particular to an industry or a job role and are not easily transferable (e.g. skills related to the use, design, maintenance and repair of technology)</p> <p>Abilities are the range of physical and cognitive capabilities that are required to perform a job role</p>	<p>Time spent in education is the duration of time spent gaining knowledge and skills through a formal route of training</p> <p>Years of work experience are the time spent forming and improving skills to apply a given knowledge through on-the-job practice</p> <p>Years of job family experience are the share of work experience to date that has been spent within related professions which exhibit similarities in their required skills, knowledge and overall profile</p>

Note: Elaboration based on taxonomies by Burning Glass Technologies and Occupational Information Network (O*NET).

Table 2: Examples of high, medium and low similarity jobs

Starting job	'Job-fit' category	Similarity score	Target job
Office Clerks, General	High	0.92	Municipal Clerks
	Medium	0.87	First-Line Supervisors of Office and Administrative Support Workers
	Low	0.81	Aerospace Engineering and Operations Technicians
Cooks, Fast Food	High	0.93	Dining Room and Cafeteria Attendants and Bartender Helpers
	Medium	0.86	Butchers and Meat Cutters
	Low	0.82	Locksmiths and Safe Repairers
Electrical Engineering Technicians	High	0.91	Electrical and Electronics Repairers, Powerhouse, Substation and Relay
	Medium	0.86	Geothermal Technicians
	Low	0.81	First-Line Supervisors of Agricultural Crop and Horticultural Workers
Computer Programmers	High	0.92	Web Developers
	Medium	0.86	Computer and Information Systems Managers
	Low	0.82	Anthropologists

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

unique skills across approximately 550 unique skill clusters (categorized into baseline, specialized, and software skills).¹⁴

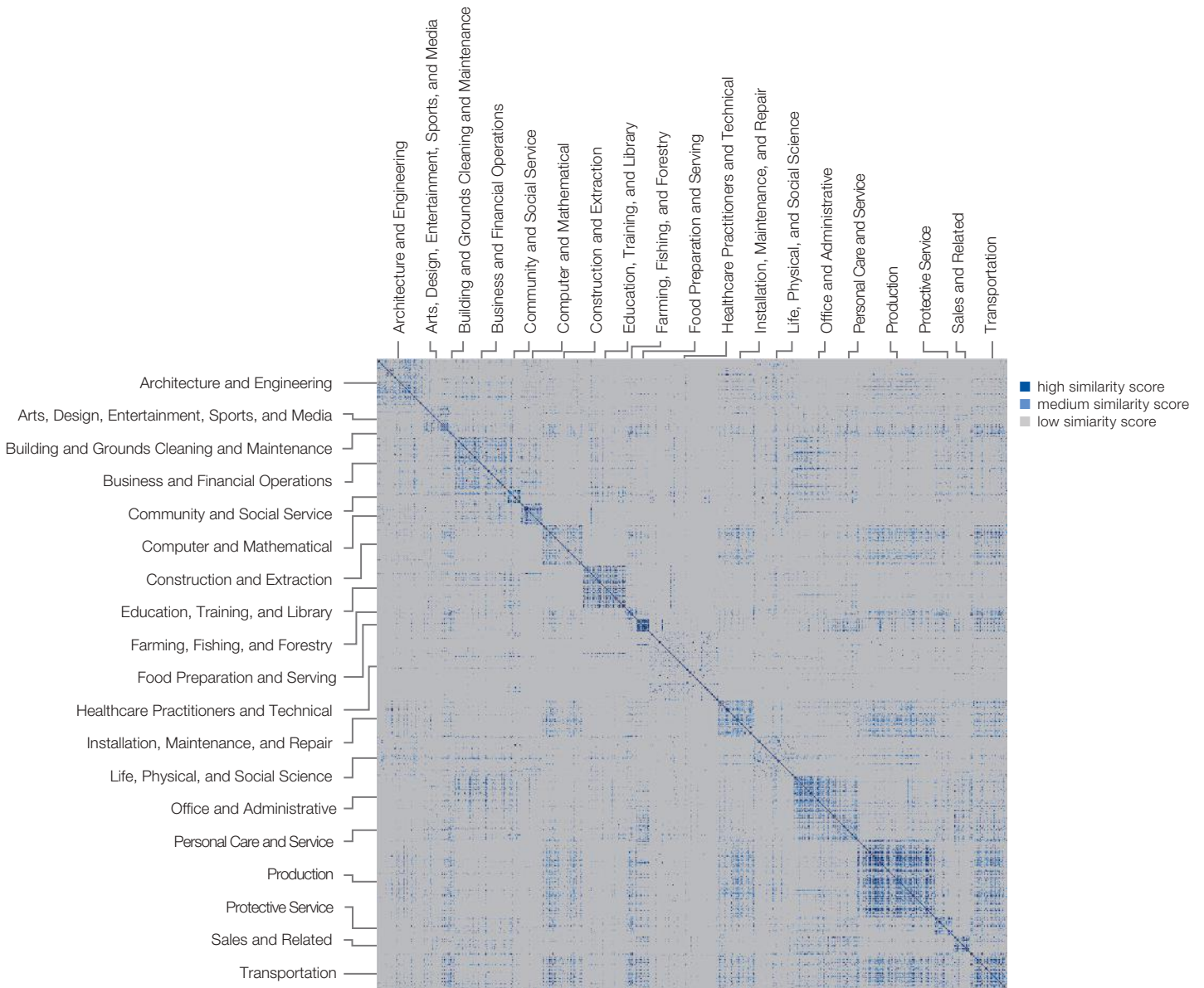
The combined data set used in our analysis consistently covers 958 unique types of jobs, as classified by the Occupational Information Network (O*NET),¹⁵ representing the large majority of the United States workforce, and provides reliable data points on the various components that define job-fit: work activities, skills, knowledge, abilities, years of experience and education. Following the method established by Burning Glass Technologies, our study aggregates these components of job-fit into an index of similarity, or 'similarity scores'.¹⁶ We use these similarity scores as a tool to objectively measure the similarity between each pair of our 958 unique job types and

create a schema (in essence, a matrix) to identify the job-fit between all 958 jobs in our dataset (see **Figure 1** on page 6).

The resulting similarity scores for each pair have a numeric value between 0 and 1. They can be seen as a proxy measure for the feasibility of transitioning between the two jobs. Job pairs that have a similarity score of 1 can be said to have a perfect fit, while job pairs with a similarity score of 0 have the most remote and imperfect fit. For example, a computer programmer and a web developer have a high job-fit with a similarity score of 0.92, while an office clerk and an aerospace engineering technician have a low job-fit with a similarity score of 0.81 (see **Table 2**).

We describe **high similarity** scores as scores of at least 0.9 or higher, **medium similarity** scores as those between 0.85 and 0.9, and **low similarity** scores as those below 0.85.¹⁷

Figure 1: Job transition matrix between 958 jobs in the United States



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Table 2 depicts examples of jobs that have high, medium and low levels of similarity. It indicates that a job pair is most likely to have a degree of job-fit that would enable a viable job transition if similarity scores are at least 0.85 or above. **Figure 1** depicts the overall job-fit matrix between all 958 types of jobs (categorized by job family) in the United States in our dataset. Where a zone is highlighted in dark blue, the corresponding row and column define two occupations with a combined profile that suggests a high degree of job-fit.

By themselves, similarity scores provide a useful tool for a systematic and comprehensive comparison of job-fit and for identifying viable job transition options. However, as with any composite index, the scores provide a highly aggregated summary view of the theoretical viability of any given job transition. Additional filter criteria are needed to ensure that the job-fit indicated by the aggregate similarity score stays realistic.

For example, prospective job movers are unlikely to be hired when their work experience and educational background are significantly divergent from the requirements of a job. The US Bureau of Labor Statistics' Occupational Information Network (O*NET) provides a reasonable measure of this profile, in the form of so-called 'job zones'. Job zones capture an occupation's expected level of education, related experience, and on-the-job training required to perform a job. They are measured on a 1-to-5 scale, where occupations in job zone 1 require little or no preparation (for example dish washers) and occupations in job zone 5 require extensive preparation (for example molecular and cellular biologists). By restricting job zone changes to no more than -1 or +1, our analysis allows us to control for unrealistic or unrewarding moves. The restriction also ensures consistency in the actual level of skills and knowledge use within any given occupation.

To summarize, in order to be able to say that a job transition opportunity represents a **viable job transition option**, we require a pairing of a starting job and target job that involves: (1) a medium or high level of job-fit and (2) realistic leaps in expected years of education or work experience.

Is the job transition desirable?

Within the full range of possible job transitions, there are a number of transitions that may be viable options—in the sense detailed in the previous section—but which are nevertheless unlikely to represent sustainable or attractive options for the individuals seeking to move jobs concerned. Two parameters capture these concerns: the long-term stability of the target job and its capacity to financially uphold (or improve) the standard of living to which the prospective job mover is currently accustomed.

Some theoretically viable job transitions are unsustainable and undesirable simply because the number of people projected to be employed in this job category is set to decline. In the medium term, a number of current occupations in the United States are forecast to shrink or fully disappear due to technological change.¹⁸ To identify job transitions that are undesirable due to declining target job numbers, we have used US employment figures for 2016 as well as projections of expected employment change by 2026 from the US Bureau of Labor Statistics.¹⁹ As mentioned previously, in this publication we defer to the US Bureau of Labor Statistics' official forecast of employment in 2026 as a baseline for our analysis. That is to say, we do not ourselves predict changes in demand for certain types of jobs in this publication.

Another type of theoretically viable job transition that is likely to appear less than attractive to prospective job movers despite a high job-fit involves target jobs whose remuneration fails to match the standard of living afforded by an individual's current job. Job transitions in which job movers experience a protracted fall in wages are unlikely to motivate further reskilling efforts or increases in productivity and job satisfaction by the individuals concerned. Wage-losing job transitions also present a less-than-optimal outcome for government efforts in the field of reskilling, as public returns on investment through income or consumption related taxes will fall with employee wages.²⁰

To summarize, in order to be able to say that a viable job transition opportunity represents a **desirable job transition option**, we require a pairing of a starting job and target job that involves: (1) stable long-term prospects, i.e. a job transition into an occupation with job numbers that are forecast not to decline; and (2) wage continuity (or increases), i.e. a level of employee remuneration for tasks performed in the new job that does not fall below a level that would allow the individuals concerned to maintain their current standard of living.

Finding Job Transition Pathways for All

Having established the parameters for viable and desirable job transition options, we now turn to demonstrating how our data-driven approach may be operationalized to map the opportunity space for job transitions and create a practical compendium of job transition options throughout the current—and future—labour market in the United States. We present two distinct but complementary lenses that utilize our principles of viable and desirable job transition options to speak to the concerns and priorities of a number of different stakeholder groups across the employment ecosystem:

- A **leadership lens** that provides policy-makers or corporate planners with a practical tool for maximizing productive re-deployment opportunities for workers affected by labour market disruptions and identifying priority job transition pathways among a number of viable and desirable options, with a view to optimizing the collective outcomes for a wide range of individuals.
- An **individual lens** that maps out viable and desirable job transition options from the perspective of a single role and measures the size of the opportunity space for affected workers contemplating their personal strategy for moving out of declining job types and navigating more securely the uncertainties of the future of work.

Throughout our empirical analysis of the United States labour market, we also highlight a range of thought-provoking examples of job transition opportunities uncovered by the analysis that might not be immediately apparent.

Leadership Lens

Intended as a practical planning tool for government and business decision-makers, the leadership lens perspective can be used to generate an economy-wide simulation of the ideal pathway of viable and desirable job transitions that would maximize the resulting job-fit with target jobs to ensure stable and good quality future employment for affected workers currently holding jobs that are set to become obsolete due to structural shifts in the labour market. Job transitions are simulated using a linear optimization algorithm.²¹

To operationalize this approach for the United States, we have used the official ten-year forecast of employment change produced biennially by the Bureau of Labor Statistics.²² There continues to be considerable debate about the degree of disruption to jobs that is likely to occur across global labour markets in the coming years. Our use of the 2026 Bureau of Labor Statistics data should not necessarily be considered an endorsement of these projections by the World Economic Forum. Indeed, the data-driven approach presented here could plausibly be executed using other forecasts, as long as sufficiently detailed data exists.

The Bureau of Labor Statistics projections predict that, over the period up to 2026, the US labour market will see a structural employment decline of 1.4 million redundant jobs, against structural employment growth of 12.4 million new jobs

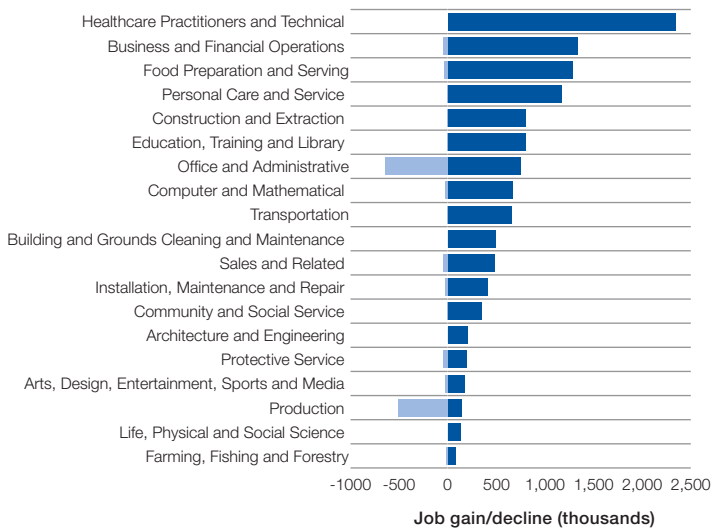
Table 3: Snapshot of projected US job changes by 2026

Job family	Gender breakdown in 2016 (%)		Employment (thousands)		Change in employment 2016–2026 (thousands)		
	Female	Male	2016	2026	Increasing jobs	Declining jobs	Net change
Office and Administrative	66	34	22,621	22,730	751	-642	109
Sales and Related	46	54	15,088	15,523	477	-41	436
Business and Financial Operations	51	49	13,578	14,865	1,334	-48	1,286
Food Preparation and Serving	52	48	13,436	14,688	1,286	-33	1,252
Healthcare Practitioners and Technical	66	34	12,917	15,246	2,339	-10	2,330
Transportation	16	84	10,266	10,907	650	-9	640
Production	25	75	8,926	8,558	142	-511	-368
Education, Training and Library	62	38	8,528	9,317	793	-4	789
Construction and Extraction	3	97	7,157	7,955	800	-1	799
Personal Care and Service	55	45	6,352	7,516	1,165	-1	1,164
Installation, Maintenance and Repair	5	95	5,729	6,111	411	-29	383
Building and Grounds Cleaning and Maintenance	24	76	5,619	6,109	490	0	490
Computer and Mathematical	29	71	4,765	5,402	660	-23	638
Protective Service	24	76	3,419	3,573	196	-42	154
Architecture and Engineering	16	84	2,689	2,886	197	0	197
Community and Social Service	61	39	2,523	2,866	346	-3	343
Arts, Design, Entertainment, Sports and Media	40	60	2,421	2,567	172	-26	146
Farming, Fishing and Forestry	20	80	2,045	2,113	81	-14	67
Life, Physical and Social Science	42	58	1,311	1,436	125	0	125
Total	37%	63%	149,389	160,368	12,416	-1,437	10,979

Source data: US Bureau of Labor Statistics.

Note: The figures above exclude 4% of US employment, due to differences in SOC and O*NET job categorization.

Figure 2: Projected structural changes in the US job market by 2026



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Note: The figures above exclude 4% of US employment, due to differences in SOC and O*NET job categorization.

(see **Table 3** and **Figure 2**). According to this forecast, only one job family—Production—will experience an overall net job decline. However, both Production and Office and Administrative roles are set to experience a significant employment decline. Unlike Production, however, the Office and Administrative job family is forecast to experience sufficient new job gains as well in roles like Billing, Cost and Rate Clerks, Receptionists and Information Clerks, and Customer Service Representatives to counter-balance the shrinking of other occupational categories, such as Data Entry Keyers, File Clerks, Mail Clerks, and Administrative Assistants.

The optimization algorithm used for our analysis maximizes job-fit between starting and target jobs, and therefore the actual feasibility of job transition options across all of the 958 job types in our data set, representing the large majority of the US workforce. Job transition options are filtered according to viability and desirability criteria. Transitions are excluded as unviable if they would require moving to a target job with a low similarity score or if they would require moving to a target job demanding vastly different levels of education and experience. Job transitions are only enacted towards target jobs that would be desirable, with total employment in the target job remaining stable or

Figure 3: Optimized viable and desirable job transitions across job families by 2026

Starting job family	Target job family																			Viable job transition options found	Gross job destruction by 2026	Disrupted jobs without viable transition options
	Architecture and Engineering	Arts, Design, Entertainment, Sports and Media	Building and Grounds Cleaning and Maintenance	Business and Financial Operations	Community and Social Service	Computer and Mathematical	Construction and Extraction	Education, Training and Library	Farming, Fishing and Forestry	Food Preparation and Serving	Healthcare Practitioners and Technical	Installation, Maintenance and Repair	Life, Physical and Social Science	Office and Administrative	Personal Care and Service	Production	Protective Service	Sales and Related	Transportation			
Architecture and Engineering																				N/A	0.0	0.0
Arts, Design, Entertainment, Sports, and Media	0.1	11.9		0.1	0.1		0.1	4.5	1.4			1.0		0.9		0.9				21.0	-26.2	5.2
Building and Grounds Cleaning and Maintenance																				N/A	0.0	0.0
Business and Financial Operations				36.9																36.9	-47.8	10.9
Community and Social Service																				0.0	-3.0	3.0
Computer and Mathematical						22.6														22.6	-22.6	0.0
Construction and Extraction	0.4	0.2					0.3					0.1					0.1		0.1	1.2	-1.2	0.0
Education, Training, and Library								3.9												3.9	-3.9	0.0
Farming, Fishing, and Forestry			1.0				3.5		0.1								9.2			13.8	-14.2	0.4
Food Preparation and Serving										30.2	3.1									33.3	-33.3	0.0
Healthcare Practitioners and Technical								1.7			6.1									7.8	-9.8	2.0
Installation, Maintenance, and Repair	2.9	1.4	4.5			0.9	0.6		0.0			13.7	1.4							25.4	-28.9	3.5
Life, Physical, and Social Science																				N/A	0.0	0.0
Office and Administrative	0.0	5.0		221.1	2.5	11.8	20.9	8.2	8.8	30.5	13.0	2.0		236.1	7.6	0.4	5.7	40.4	8.0	621.8	-642.0	20.2
Personal Care and Service		0.4		0.2																0.6	-0.6	0.0
Production	13.2	0.9	11.0	1.1		5.1	298.6	0.4	27.1	3.0	2.1	60.9	10.5	20.2	5.2	6.7	0.6	2.0	21.4	489.9	-510.7	20.8
Protective Service				0.3									2.4	0.7				34.8	3.5	41.7	-41.7	0.0
Sales and Related				4.7		0.6					29.5				2.7		0.5	3.2		41.2	-41.3	0.1
Transportation	0.2							0.2			5.5		1.5				0.4		0.6	8.4	-9.4	1.0
Optimal number of transitions to job family by 2026	16.7	19.8	16.5	264.4	2.6	41.0	324.1	14.3	40.5	100.1	24.3	80.6	13.6	256.3	16.4	7.1	52.2	45.6	33.5	1,369.4	-1,436.6	67.2
Gross job creation by 2026	197.2	172.3	489.6	1,333.9	346.1	660.2	799.9	793.3	81.4	1,285.5	2,339.3	411.4	124.8	751.3	1,164.9	142.4	195.6	476.9	649.7	12,415.7		

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Note: Units = 1,000s of people.

increasing through 2026 and the difference in wages between an individual's old and new jobs remaining neutral or positive.²³

Given the above conditions, the optimization algorithm used for our analysis is able to find 'good-fit' job transitions for the vast majority of workers currently holding jobs experiencing technological disruption—96%, or nearly 1.4 million individuals. **Figure 3** highlights suggested 'good-fit' job transitions between and across job families uncovered by our optimization algorithm. The light shades indicate situations in which there are only a small number of suggested 'good-fit' transition options between job families (or none at all) while the dark shades indicate larger numbers of transition options within job families. Interestingly, the majority of 'good-fit' job transition options—70%—will require the job mover to shift into a new, hitherto often unfamiliar cluster of roles, i.e. a new job family. Such job family shifts are the result of structural employment decline in particular starting job families, by the availability of 'better-fit' target jobs outside the starting job family, and by the occurrence of employment growth in job families other than the starting one. For example, for roles in the Production job family, such as Electromechanical Equipment Assemblers, opportunities can be found in the Architecture and Engineering job family in positions such as Robotics Technicians and Civil Engineering Technicians. A smaller number—30%—of workers holding jobs in structural decline have viable 'good-fit' job transition opportunities within their own current job family. For example, Data Entry Keyers whose jobs are being disrupted by technology can transition to becoming Medical Secretaries. Both roles are within the Office and Administrative job family.

According to the Bureau of Labor Statistics forecast, occupations in the Office and Administrative and Production job families will experience the highest rate of job disruption by 2026, accounting for a combined 1.15 million jobs lost to structural labour market change, or 80% of the total (see **Table 4**).

Within our leadership lens optimization model, 238,000 of the 642,000 total current workers within the Office and Administrative job family that require new opportunities may find well-fitting transition options within their own Office and Administrative job family. For those who will need to move to another job family to find a well-fitting job, the largest opportunity lies in the Business and Financial Operations job family, amounting to an additional 221,000 viable job transition options and featuring roles such as Human Resource Specialists and Real Estate and Property Managers. Smaller clusters of job transition opportunities also exist in the Sales and Related, Food Preparation and Serving Related and Construction and Extraction job families. Once all 'good-fit' job transition options within the Office and Administrative job family are taken into account, disrupted workers left without viable or well-fitting new opportunities amount to about 20,000 individuals—or around 3% of the current workforce in those roles.

The Production job family is similarly expected to be heavily disrupted by the Fourth Industrial Revolution, with 511,000 jobs expected to be displaced. Unlike in the case of the Office and Administrative job family, however, the Production job family is not expected to create a significant number of viable or desirable intra-job family transition opportunities. The largest opportunities for displaced Production workers uncovered by our optimization model—amounting to approximately 299,000 'good-fit' transition

opportunities—are within the Construction and Extraction job family and involve target jobs such as Construction Laborers and Electricians. The next largest opportunity, amounting to about 60,000 well-fitting jobs, is in the Installation, Maintenance and Repair job family, followed by transition options in Farming, Forestry and Fishing, Transportation, and Office and Administrative roles. Once all 'good-fit' job transition options within the Production job family are taken into account, disrupted workers left without viable or well-fitting new opportunities amount to about 21,000 individuals—or around 4% of the current workforce in those roles.

Across other job families, growth in demand for Healthcare Practitioners and Technicians may absorb some of the structural decline within employment in Food Preparation and Serving Related roles with 'good-fit' new opportunities. Technological disruptions within the Computer and Mathematical job family may be balanced out by transition options within the same job family, while displaced workers in Business and Financial Operations may similarly find some 'good-fit' new opportunities within their own job family—but approximately 11,000 of the 48,000 displaced workers in Business and Financial Operations workers are left with no 'good-fit' viable transition options.

In all, our leadership lens optimization model uncovers that approximately 4.7% of all US workers projected to be displaced by structural labour market shifts by 2026—approximately 57,000 individuals—are left without immediately viable job transition options. Across all job families, the affected workers are heavily concentrated in three roles: Postal Service Mail Sorters (Office and Administrative job family), Processing Machine Operators (Production job family), and Sewing Machine Operators (Production job family), precisely the kind of occupations predicted to be heavily impacted by increasing workplace automation.

It should be noted that the difficulty of finding 'high-fit' job transition options depends on the strictness of the initial criteria used. For example, a slightly modified version of our optimization model relaxes the conditions for wage stability and prioritizes moving workers into new viable 'good-fit' jobs even at the price of accepting lower wages. Once we relax this criterion on the desirability of target jobs we are able to find opportunities for a wider range of workers. In the first model, which optimizes job transition options for viable and desirable conditions *including* wages, 4.7% of US workers who will need to change jobs due to future displacement cannot be placed in 'good-fit' new opportunities. If we optimize for wider labour market inclusion and accept that some workers can experience wage loss, that figure falls to 3.7%.

Under the more stringent requirement that our optimization pathways should maintain or grow workers' current level of wages, 'good-fit' job transition opportunities are likely, on average, to be located in target jobs that require approximately two years of additional education and two years of additional work experience. When relaxing the stable wage constraint, on average, this experience gap falls to one year of additional education required (see **Table 5**). While there are undoubtedly benefits to placing a larger number of individuals in new roles and finding transition opportunities that require more similar levels of education and work experience, our analysis finds that, under a

Table 4(a): ‘Good-fit’ job transition options for roles within the Office and Administrative and Production job families

Production

Starting job	Target job	'good-fit' transition opportunities
Assembly Line Workers	Construction Labourers	140,000
Electrical and Electronic Equipment Assemblers	Electricians	45,000
Inspectors, Testers, Sorters, Samplers and Weighers	Production, Planning and Expediting Clerks	18,000
Printing Press Operators	Farm and Ranch Managers	17,000
Inspectors, Testers, Sorters, Samplers and Weighers	First-Line Supervisors of Helpers, Labourers, and Material Movers, Hand	15,000
Molding, Coremaking and Casting Machine Setters, Operators and Tenders, Metal and Plastic	Industrial Machinery Mechanics	15,000
Extruding and Drawing Machine Setters, Operators and Tenders, Metal and Plastic	Roustabouts, Oil and Gas	11,000
Cutting, Punching and Press Machine Setters, Operators and Tenders, Metal and Plastic	Construction Labourers	11,000
Electromechanical Equipment Assemblers	Electricians	8,000
Grinding, Lapping, Polishing and Buffing Machine Tool Setters, Operators and Tenders, Metal and Plastic	Sheet Metal Workers	8,000
Structural Metal Fabricators and Fitters	Pipelayers	8,000
Aircraft Structure, Surfaces, Rigging and Systems Assemblers	Structural Iron and Steel Workers	7,000
Inspectors, Testers, Sorters, Samplers and Weighers	Quality Control Analysts	7,000
Prepress Technicians and Workers	Farm and Ranch Managers	7,000
Inspectors, Testers, Sorters, Samplers and Weighers	Civil Engineering Technicians	7,000
Engine and Other Machine Assemblers	Electricians	7,000
Cutting, Punching and Press Machine Setters, Operators and Tenders, Metal and Plastic	Tile and Marble Setters	6,000
Grinding and Polishing Workers, Hand	Automotive Body and Related Repairers	6,000
Tool and Die Makers	Industrial Machinery Mechanics	5,000
Photographic Process Workers and Processing Machine Operators	Computer User Support Specialists	5,000

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Table 4(b): 'Good-fit' job transition options for roles within the Office and Administrative and Production job families

Office and Administrative

Starting job	Target job	'good-fit' transition opportunities
Secretaries and Administrative Assistants, Except Legal, Medical and Executive	Billing, Cost and Rate Clerks	69,000
Secretaries and Administrative Assistants, Except Legal, Medical and Executive	First-Line Supervisors of Office and Administrative Support Workers	51,000
Executive Secretaries and Executive Administrative Assistants	Human Resources Specialists	39,000
Legal Secretaries	Paralegals and Legal Assistants	34,000
Executive Secretaries and Executive Administrative Assistants	Property, Real Estate and Community Association Managers	31,000
Office Clerks, General	Customer Service Representatives	31,000
Tellers	First-Line Supervisors of Food Preparation and Serving Workers	31,000
Executive Secretaries and Executive Administrative Assistants	Administrative Services Managers	28,000
Data Entry Keyers	Medical Secretaries	27,000
Bookkeeping, Accounting and Auditing Clerks	Accountants	24,000
Word Processors and Typists	Real Estate Sales Agents	22,000
Executive Secretaries and Executive Administrative Assistants	Training and Development Specialists	17,000
Computer Operators	Network and Computer Systems Administrators	12,000
Secretaries and Administrative Assistants, Except Legal, Medical and Executive	Meeting, Convention and Event Planners	12,000
Tellers	Opticians, Dispensing	11,000
Data Entry Keyers	Interviewers, Except Eligibility and Loan	10,000
Postal Service Mail Carriers	Brickmasons and Blockmasons	10,000
Office Machine Operators, Except Computer	First-Line Supervisors of Retail Sales Workers	9,000
File Clerks	Eligibility Interviewers, Government Programs	9,000
Secretaries and Administrative Assistants, Except Legal, Medical and Executive	Paralegals and Legal Assistants	8,000

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Table 5: Comparison of outcomes with different priority criteria

Outcomes	With stable wage requirement	With no wage restrictions
Job transitions with 'good-fit' options (millions/share of workers)	1.369 (95.3%)	1.383 (96.3%)
Job transitions without 'good-fit' options (millions/share of workers)	0.067 (4.7%)	0.053 (3.7%)
Share of workers needing to move to new jobs who are female	57%	57%
Share of job transitions that involve a change in job family	70%	71%
Share of job transitions with stable or increasing wages	100%	65%
For those increasing, average annual wage increase	\$15,200	\$19,000
Share of job transitions with reduction in wages	—	35%
For those decreasing, average annual wage decrease	—	\$8,600
Average additional years of work experience required	2.0	1.7
Average additional years of work education required	2.0	1.0

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

wage-agnostic model, wages tend to polarize: 65% of workers experience a sizable average wage increase of about US\$19,000, while a not-insignificant proportion of workers—35%—will need to accept an average pay cut of US\$8,600. Conversely, as shown in **Table 5**, in an optimization model that does not accept wage cuts, average wages increase by a more modest US\$15,200 for a solid proportion of individuals. Relaxing or restricting other conditions such as different requirements for work experience and education would also change the results in terms of job placement.

Finally, our systemic leadership lens view of job transitions enables us to consider additional dimensions of desirable job transition pathways, such as an integrated lens on gender parity. Among the workers affected by labour market disruptions, under both models, a larger share—57%—are projected to be female. In a model allowing wage cuts as well as increases, job transition options for displaced women are associated with increasing wages for 74% of all cases, while the equivalent figure for men is only 53%. This trend points to a potential convergence in women and men’s wages among the groups that make job transitions, partly addressing current wage inequality.

Individual lens

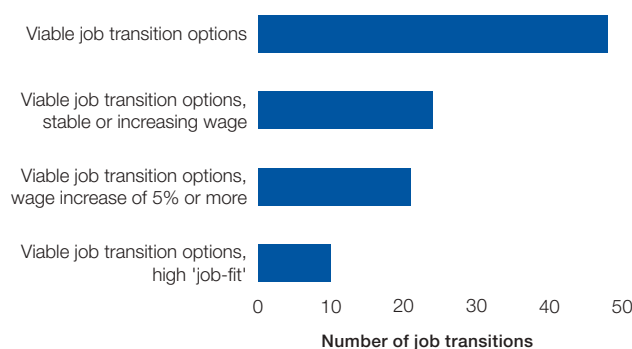
Intended as a practical guide to uncover the range of job transition opportunities for those threatened by job disruption, the report’s individual lens perspective aims to highlight viable and desirable job transition options from the point of view of individual workers. While the leadership lens presented a model in which we sought to maximize opportunities for everybody, the individual lens presents the perspective faced by workers in any given occupation which is set to experience job losses. To do this, we examine job transition opportunities for a number of selected jobs across various job families. Taken together, these examples illustrate the wide range of job transition opportunities for occupations which are set to experience near or medium-term disruption.

The average worker in the US economy has 48 viable job transitions, but that figure falls to half that amount if they are looking to maintain or increase their current wages. In

considering possible job transition options for at-risk roles, it is critical to consider the elasticity of opportunity under different conditions. **Figures 4(a) and 4(b)** present a summary overview of how the number of viable job transition options expands and contracts in relation to various desirability criteria. Initially, we only consider as a requirement that job demand should not fall but exclude the requirement that wages should remain stable or increase. We then, in turn, tighten different requirements to find better-fit opportunities, for example imposing two types of wage constraints and a constraint around job fit. The condition that constrains the number of job transitions the most is that workers should look to only move to jobs with high job similarity, suggesting that to uncover a larger set of opportunities, reskilling is key. If we look for good-fit jobs with high levels of similarity, 16% of roles have no opportunities for transition, and 41% have at most three other options.

Of the 1.4 million jobs, which are projected by the US Bureau of Labor Statistics to become disrupted between now and 2026, the majority – 57% – belong to women. Reflecting gender gaps analyzed in the World Economic Forum’s *Global Gender Gap Report 2017*, the roles that men and women perform in organizations remain out of balance. In today’s US economy, some professions predominantly employ female workers, others predominantly male workers. Female workers

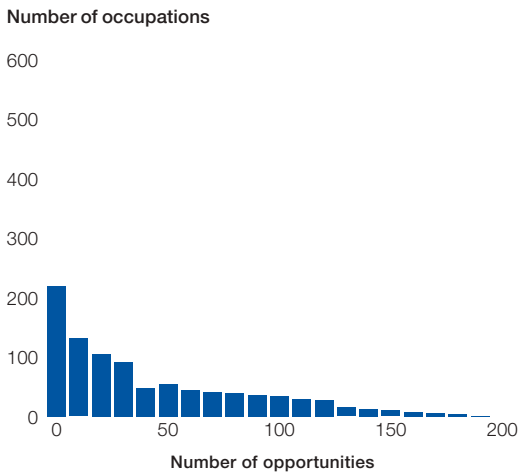
Figure 4(a): Average number of job transition options under different conditions



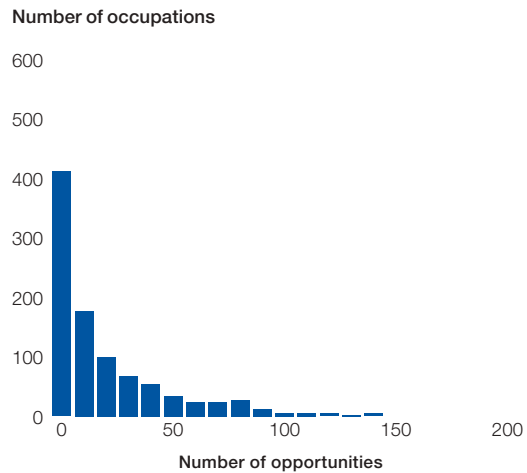
Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure 4(b): Distribution of job transition options fulfilling stated criteria (all occupations)

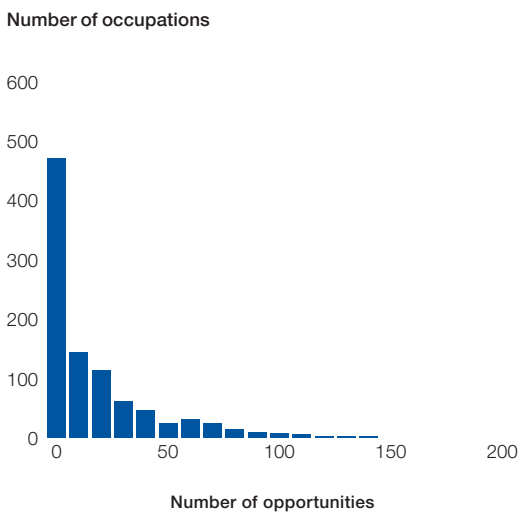
Viable job transition options



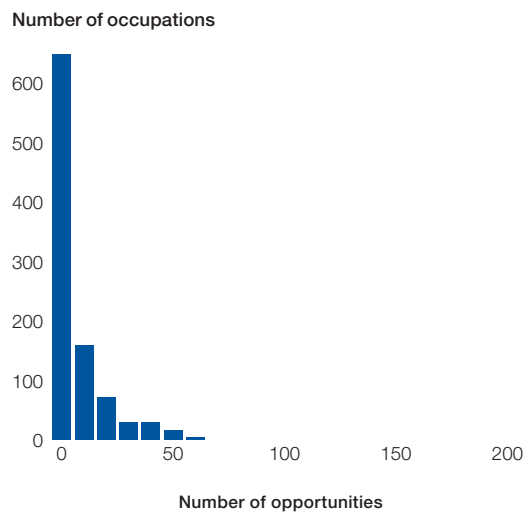
Viable job transition options, stable or increasing wage



Viable job transition options, wage increase of 5% or more



Viable job transition options, high 'job-fit'



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

dominate secretarial and administrative assistant roles. In the US economy 164,000 female workers in those roles are at risk. Some occupations such as assembly line workers predominantly employ male workers, and in the United States over 90,000 workers employed there are at risk. Without reskilling, on average, professions that are predominantly female and at risk of disruption have only 12 job transition options while at-risk male-dominated professions have 22 options. On the other hand, with reskilling, women have 49 options while predominantly male professions at risk of disruption have 80 options. In other words, reskilling can narrow the options gap between women and men. More broadly, when considering pathways in an already disrupted future of jobs, an opportunity presents itself to close persistent gender wage gaps.

Our analysis of opportunities across an individual worker's full profile of available job transition options reveals the distinctive trade-offs which are likely to be experienced by employees seeking transition opportunities from the vantage point of any given starting job. In considering possible job transition

options for at-risk roles, it is critical to consider the elasticity of opportunity under different conditions.

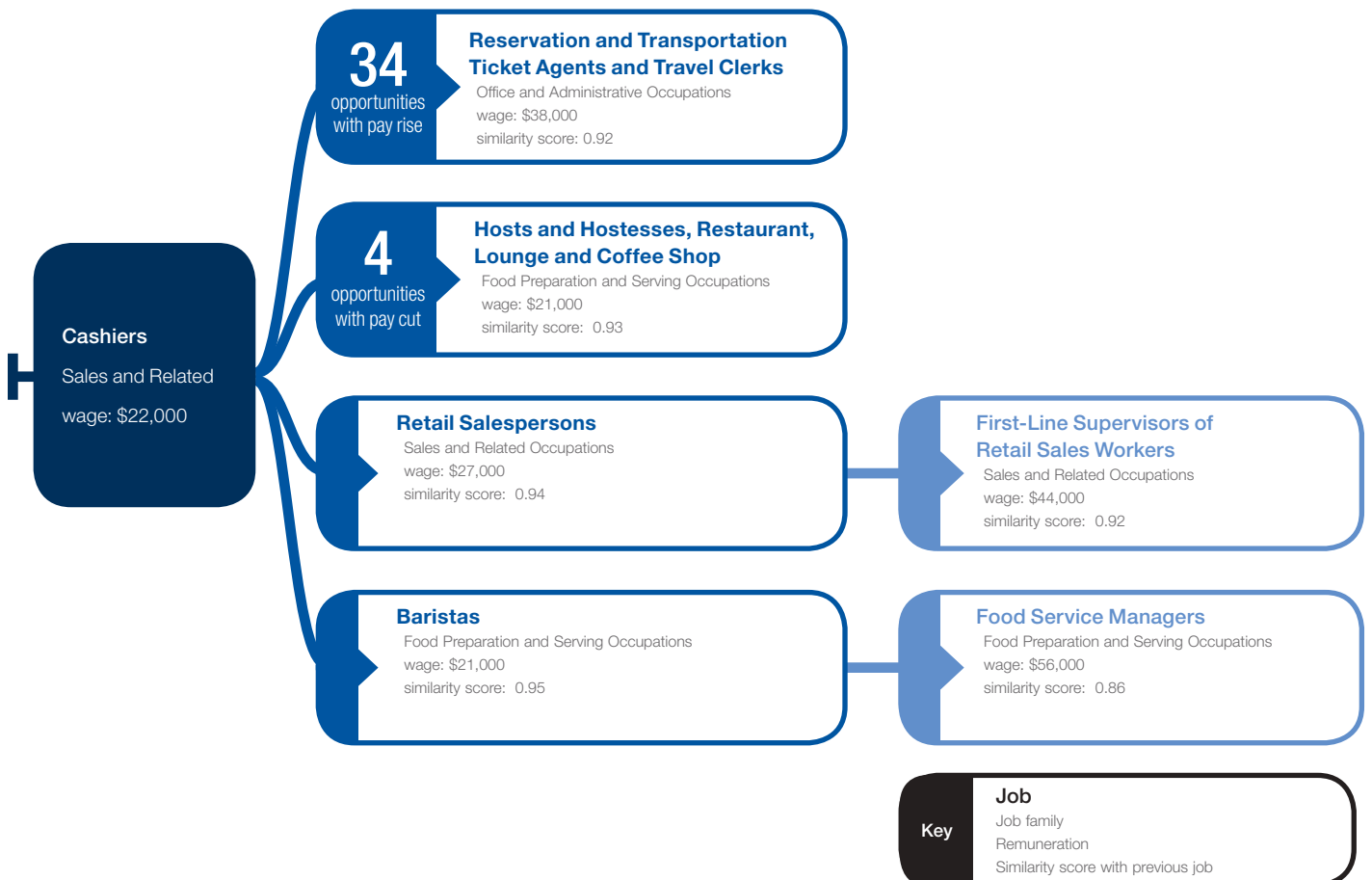
We know that workers facing job disruption are likely to want to or have to move jobs or even change careers. However, this method is also intended as a long-term planning tool for individuals that hope to take charge of improving their long-term career prospects through continuous acquisition of new skills and relevant experience. As the notion of a job for life increasingly no longer exists, the application of our data-driven approach can uncover the opportunities and options available to any individual for lifelong learning and periodic job transitions.

Methodologically, our data-driven analysis of individual job transitions between a pair of starting and target jobs can be extended, and repeated regularly, to cover a full chain of job transition pathways. Job transition pathways illustrate potential long-term reskilling trajectories where a second job transition occurs after an initial job transition. Job transition pathways allow the discovery of unexpected high-return career trajectories and reveal that while some job transition options may initially be

Figure 5(a): Examples of Pathways for Secretaries and Administrative Assistants



Figure 5(b): Examples of Pathways for Cashiers



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure 5(c): Examples of Pathways for Bookkeeping, Accounting & Auditing Clerks

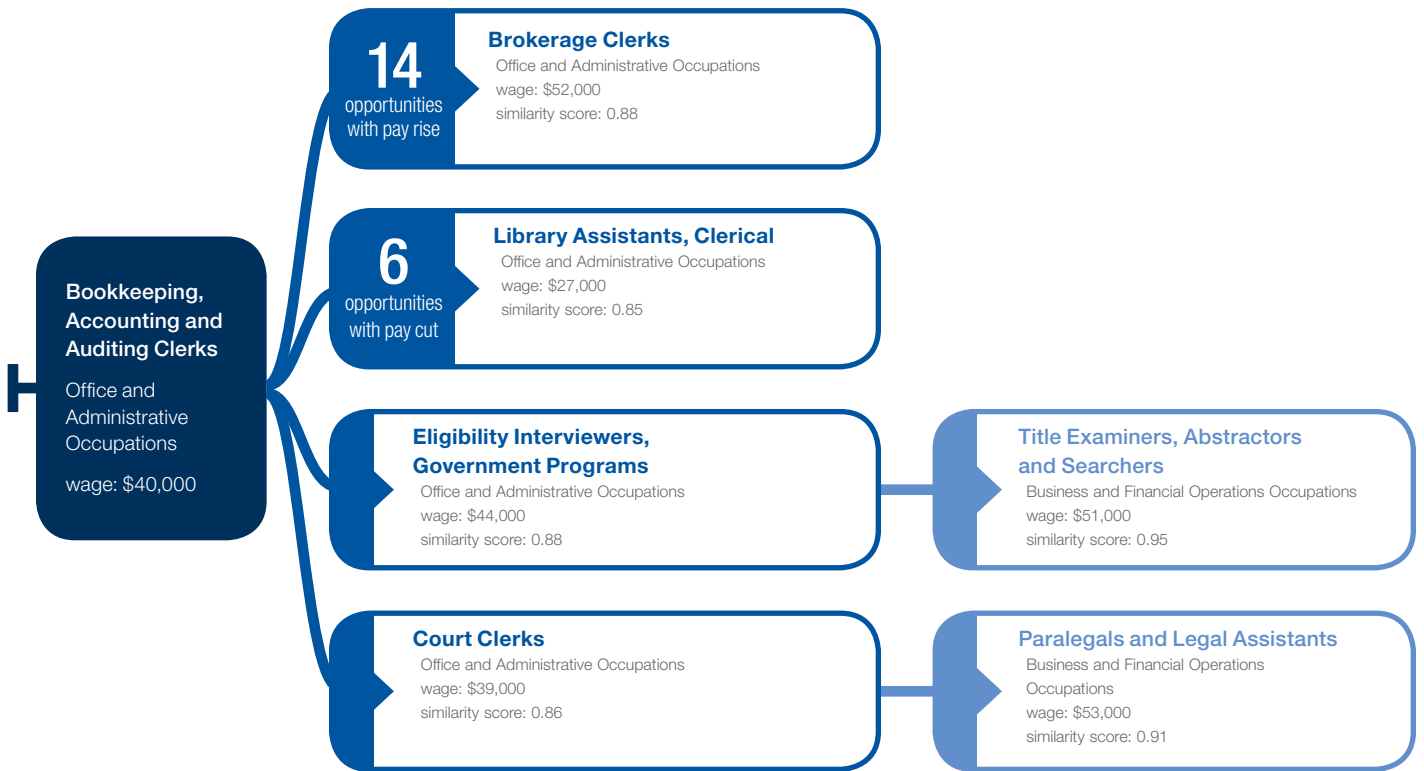
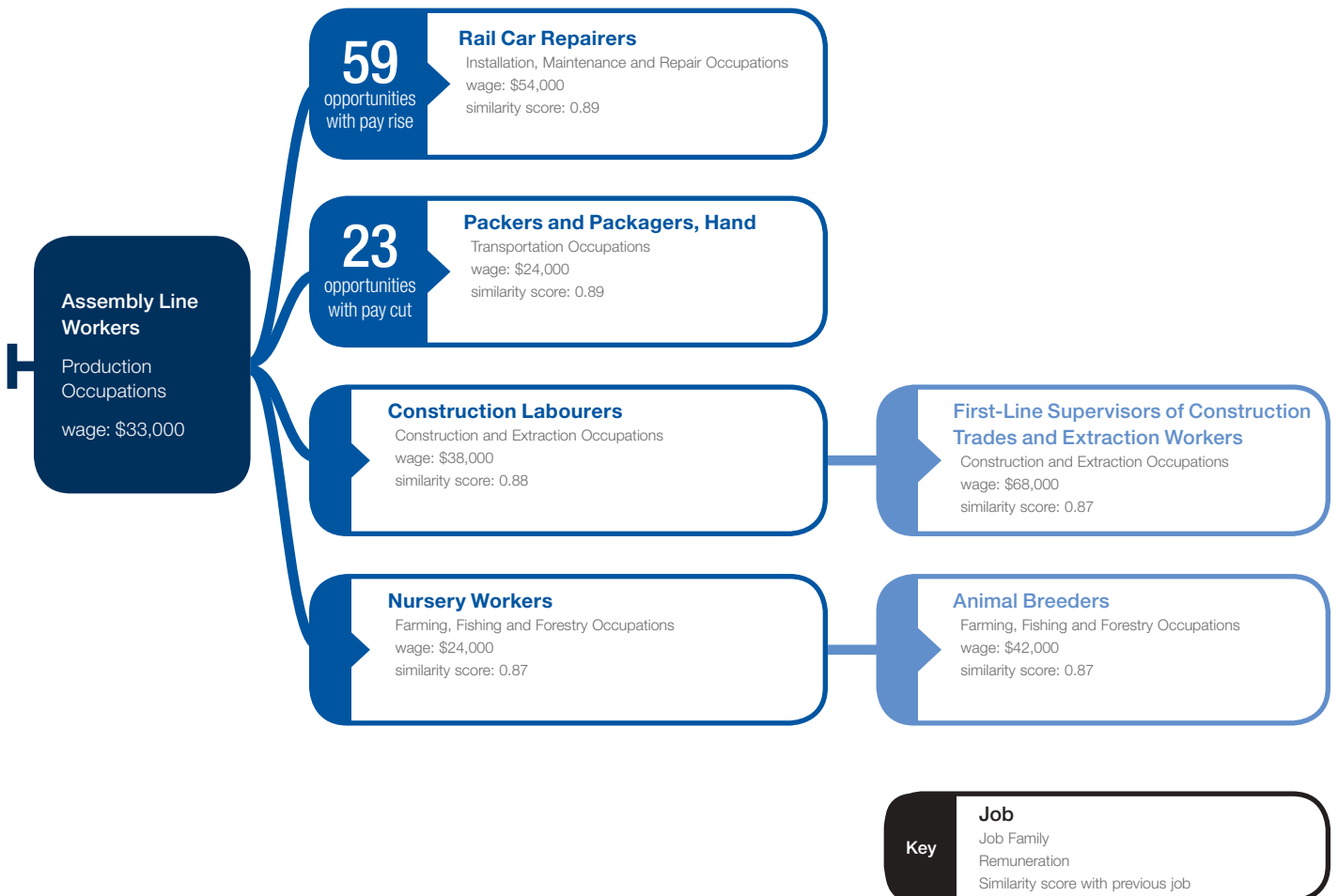


Figure 5(d): Examples of Pathways for Assembly Line Workers



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

associated with pay cuts, those initial job transition decisions might pave the way to rewarding careers later on. Facing a variable horizon of opportunities, aiming for long-term gains after short-term displacement becomes one additional route for workers with few desirable short term job transition options.

Figures 5(a) to 5(d) illustrate selected job transition pathways for a range of jobs at risk from technological disruption. For each job, we have defined four profiles (or ‘archetypes’), to reflect the range of opportunities—as well as the attitudes and mindsets with which individuals are likely to approach career planning and the lifelong learning and reskilling challenge in the Fourth Industrial Revolution.

A first archetype consists of a simple single transition with a rising wage. A second archetype consists of a single transition with a declining wage. A third consists of a steady rise in two steps. A fourth consists of an initial decline in the first step followed by an increase.

Secretaries and Administrative Assistants is an occupation for which the United States will see a fall in demand amounting to 165,000 workers by 2026 according to the Bureau of Labor Statistics. The range of opportunities available to those displaced workers are illustrated in **Figure 5(a)**. Despite the magnitude of projected losses, Secretaries and Administrative Assistants have 44 viable job transition opportunities which will see them retain their current wage or gain in wages, opportunities such as roles as Insurance Claims Clerks or Production, Planning and Expediting Clerks. In the long term, those transitions can serve as stepping stones to even more lucrative opportunities, such as roles in Logistics.

Secretaries and Administrative Assistants have a variety of opportunities, so it is unlikely that individuals working in those roles will need to revert to lower paying roles such as Clerical Library Assistants, however, other declining professions have a more constrained horizon. Bookkeeping, Accounting and Auditing Clerks have only 14 viable opportunities with stable or rising wages. A wide range of factors such as the uneven distribution of opportunities geographically mean that workers in those roles might need to consider roles with decreasing wages. This will expand their opportunities with good job-fit to 20. Taking on a role with lesser salary might mean they become Clerical Library Assistants or Court Clerks. Yet those roles can serve as a stepping stone to roles that exceed their initial wages—such as Paralegal and Legal Assistants.

Conclusion

Current discussions of the future of work have often emphasized the urgency of reskilling and life-long learning. Yet, few approaches exist to help identify productive ways of planning job transitions that can minimize strain on companies’ workforce strategies, public finances and social safety nets, as well as the affected individuals themselves. The purpose of this report has been to introduce such an approach to mapping out job transition pathways and reskilling opportunities, using the power of digital data to help guide workers, companies, and governments to prioritize their actions, time and investments on focusing reskilling efforts efficiently and effectively.

Given the impending job displacement and rapid changes already underway in the types of skills demanded by the labour markets of the Fourth Industrial Revolution, the arguments for taking action now are compelling for individuals, employers and policy-makers:

- For **individuals**, particularly those under risk of displacement, simply to remain employed will require engaging in lifelong learning and regular reskilling. Additionally, for all workers, continuous learning will not only be key to securing employment but also to building stable, fulfilling careers and seizing rewarding job transition opportunities.
- For **employers**, relying solely on new workers entering the labour market with the right ready-made skills will no longer be sufficient. And while predicting the exact nature of the demand for skills is impossible, recent research from the World Economic Forum reveals that across a wide range of scenarios, investment in workforce reskilling and human capital development is a ‘no-regret action’—that is, it will be a beneficial investment even in the absence of skills shortages.²⁴
- For **policy-makers**, fostering continuous reskilling and lifelong learning across the economy will be critical in order to maintain a labour force with the tools needed to fuel inclusive economic growth and to ensure that companies can find workers with the skills needed to help them succeed and contribute their full potential to the economy and society.²⁵

In assessing reskilling pathways and job transition opportunities with detail and scale, we aim to move the debate on the future of work to new—and practical—territory. This report is a beginning. In subsequent publications, the methodology will be extended to include additional perspectives and geographies and applied in collaboration with government and business stakeholders to support workers.

The report points to a number of directions for the efforts that will be needed to support and scale job transitions and reskilling efforts,

Planning, delivering and financing reskilling and job transitions

The main limiting factor on opening up a world of job transition opportunities is the willingness to make a reasonable investment in reskilling that will bridge workers onto new jobs. While the need for equipping the world’s workforce with the skills for the future of work and emerging job types is clear, the question is what policies and strategies may be used to drive and deliver lifelong learning and reskilling at scale. As individuals may need to take temporary time out from work while re-training and exploring job transition options, public as well as private financial support will be needed. Translating reskilling into viable and desirable jobs will require new thinking around workforce planning. As redeploying workers across jobs will become the norm, there will also be a need for agile social protection and insurance mechanisms that avoid destabilizing income while prioritizing rapid workforce re-integration. Wide-spread adoption of micro-credentials and new methods of education and training delivery that combine online and offline models will be necessary for creating new

opportunities for workers. As detailed in two recent World Economic Forum White Papers, *Accelerating Workforce Reskilling for the Fourth Industrial Revolution* and *Realizing Human Potential in the Fourth Industrial Revolution*, countries such as Denmark and have already seen success experimenting with policy measures that may support the scale of the efforts that will be required.²⁶ By helping to quantify the gains in aggregate income of an economy that will result from redeploying workers to emerging positions that otherwise might have gone unfilled, the data-driven approach described in this publication is helpful in highlighting the viability of this new vision and in building the economic and business case for planning, delivering and financing reskilling and job transitions.

Individuals' mindset and efforts will be key

To even begin thinking about large-scale job transition planning and economy-wide reskilling, the role of individuals will be absolutely critical. Some reskilling will require time off work, some will require gaining additional formal qualifications, perhaps after decades out of the classroom. These efforts will not be easy, and individuals will need to be adequately supported and incentivized and will need to be able to see the eventual benefits of continuous reskilling in the form of rewarding job transition pathways. Here, too, the data-driven approach advocated in this publication may help to create greater transparency and choice for workers. Nevertheless, what will be required is nothing less than a societal mindset shift for people to become creative, curious, agile lifelong learners, comfortable with continuous change.

No single actor can solve the job transition and reskilling puzzle alone

To make reskilling real, and prepare for accelerated structural change of the labour market, a wide range of stakeholders—governments, employers, individuals, educational institutions and labour unions, among others—will need to learn to come together, collaborate and pool their resources more than ever before. For businesses, working together across traditional industry boundaries and, sometimes, with their competitors, in order to ensure they have the talent for tomorrow they need, will hold significant benefits but require new ways of thinking and working as well.²⁷ Governments too will need more rapid learning from each other and consider a range of experiments for discovering the most effective approaches. Education and training businesses and non-profits will find they are in high demand and will need to collaborate with each other—and with other stakeholders to determine how they can be most effective.

Extending the data-driven approach

Data-driven approaches can bring speed and additional value to reskilling and job transitions. The World Economic Forum will undertake some of this work in subsequent publications—and we actively encourage others to follow suit. A non-exhaustive list of extensions could look to:

- **Geographic expansion:** The report's methodology can be extended both to additional geographies outside the United States and to cover local geographies—such as the state-level perspective—to help address the needs of local markets and consider the impact of mobility within and between geographies when workers move to new jobs.
- **The quantification of reskilling efforts:** The methodology can be used to assess the amount of time required to make job transitions, based on the difficulty of acquiring new skills. It can also assess the costs associated with reskilling, such as the actual cost of training and associated opportunity costs to determine motivations and incentives.
- **Nuanced evaluation of economic benefits:** The methodology can be used to assess the gains in aggregate income of an economy that result from job transitions into emerging roles that otherwise would have gone unfilled as well as determine the cost-benefit analysis around government payments and safety nets (e.g. unemployment benefits).
- **Different scenarios of changing demand for jobs:** The methodology can be used to create job transition models as they apply in different scenarios of growth/decline in jobs (e.g., a job transition model that proposes that a larger number of jobs will be lost as a result of automation).
- **Gender perspectives on job transitions:** The methodology can be used to promote gender-inclusive proactive workforce planning, by uncovering job transition models that promote gender equality (as relevant to corporate and policy decision-makers).

It is our hope that *Towards a Reskilling Revolution* will become a valuable tool to move beyond the current impasse of polarized job prospects, help individuals uncover opportunities to build a good life and, above all, inspire confidence that taking a focused, proactive approach to large-scale reskilling and lifelong learning is truly possible. We also hope it inspires similar efforts to think practically yet holistically about managing reskilling, upskilling and job transitions.

Endnotes

- 1 Autor, David, *The Polarization of Job Opportunities in the U.S. Labor Market: Implications for Employment and Earnings*, Center for American Progress and The Hamilton Projects, 2010.
- 2 McGowan, Müge Adalet and Dan Andrews, *Skill Mismatch and Public Policy in OECD Countries*, (OECD Economics Department Working Paper No. 1210), OECD, 2015.
- 3 Bessen, James, "Toil and Technology: Innovative technology is displacing workers to new jobs rather than replacing them entirely", *IMF Finance and Development Magazine*, March 2015.
- 4 Deming, David, *The Growing Importance of Social Skills in the Labor Market*, NBER Working Paper 21473, National Bureau of Economic Research, 2015.
- 5 ManpowerGroup, *2016-2017 Talent Shortage Survey*, 2017.
- 6 World Economic Forum, *The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*, 2016.
- 7 There are a range of such predictions. See, for example, Frey, Carl Benedikt and Michael A. Osborne, *The future of employment: How susceptible are jobs to computerisation?*, Oxford Martin School, University of Oxford, September 2013. However, for the purpose of this study, we use official projections from the US Bureau of Labor Statistics. The proposed model, however, can be applied to any range of predictions with appropriate data.

- 8 See US Bureau of Labor Statistics, *2016–26 Employment Projections and Occupational Outlook Handbook*, <https://www.bls.gov/emp/> (released on 24 October 2017).
- 9 See, for example, Smiley, Lauren, “Can you Teach a Coal Miner to Code?”, *WIRED*, 18 November 2015, <https://www.wired.com/2015/11/can-you-teach-a-coal-miner-to-code/>; and Field, Anne, “Turning Coal Miners Into Coders—And Preventing A Brain Drain”, *Forbes*, 30 January 2017, <https://www.forbes.com/sites/annefield/2017/01/30/turning-coal-miners-into-coders-and-preventing-a-brain-drain/>.
- 10 Autor, David, “The ‘Task Approach’ to Labor Markets: An Overview”, (NBER Working Paper No. 18711), National Bureau of Economic Research, 2013, <http://www.nber.org/papers/w18711>.
- 11 A second, perhaps less obvious, assumption is that skill demands for a particular type of job are the same across different firms; see: Deming, David, and Lisa B. Kahn “Skill Requirements across Firms and Labor Markets: Evidence from Job Postings for Professionals”, *Journal of Labor Economics*, vol. 36, no. S1, 2018, pp. S337-S369.
- 12 Theoretically, task requirements, knowledge, skills and abilities are sufficient elements to uniquely define ‘job-fit’ between any two jobs, however, as these components are hard to measure with high levels of precision in practice, our calculation of ‘similarity scores’ also includes three secondary dimensions that are more commonly used signals or proxies: time spent in education; years of work experience; and years of experience within the concerned job family.
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- 14 See Appendix A: Data and Methodology for a detailed description of the report’s methodology, data and data sources.
- 15 Job types are categorized in accordance with O*NET-SOC 2010 codes for which sufficient information was available from both Occupational Information Network (O*NET) and Burning Glass Technologies; <https://www.onetcenter.org/taxonomy.html>.
- 16 While both the underlying components and exact method of calculating similarity scores for this publication are the result of discussions between Burning Glass Technologies, World Economic Forum and Boston Consulting Group, the approach taken is adaptable and generalizable to other datasets and occupational classifications, and may be updated if additional new or improved data on jobs becomes available.
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- 22 See US Bureau of Labor Statistics, 2017.
- 23 For a detailed, more technical overview of our methodology, please refer to the report’s Appendix A: Data and Methodology.
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Appendix A: Data and Methodology

The analysis that forms the basis of this report is based on the concept of ‘viable job transitions’, which is comprised of four criteria and explained in more detail below. The concept is created from a variety of source data. In addition to establishing the overall viability of job transitions, we conduct further specific analysis on various sub-components of this data.

The majority of our analysis has been conducted using data from three distinct data sources, as referenced in **Figure A1** and explained in detail below. All of the analysis has been conducted on data from the United States. Each source provides a different type of job data, allowing us to create an overall combined data set and refine our analysis.

Data Sources

Occupational Information Network (O*NET)

The Occupational Information Network (O*NET) database is the primary source of occupational information in the United States, developed under the sponsorship of the US Department of Labor/Employment and Training Administration. The database groups individual jobs into clusters of related professions, or ‘job families’, and is continually updated by surveying a broad range of workers from each job. Its use in our work is providing both a standardized list of almost one thousand job types, covering the entire US economy, and job-specific descriptors (e.g. required skills and knowledge) on these jobs.

Burning Glass Technologies (BGT)

The data set compiled by Burning Glass Technologies (BGT) for this report is based on online job postings. This information is sourced by ‘scraping’ detailed data for a job from various online sources (e.g. job boards, employer sites). The data set encompasses detailed information on 958 jobs within the United States. Jobs in the data set are based on standardized job codes and job titles from O*NET. The data set is based on approximately 50 million job postings over a two-year period from 2016 to 2017, covering approximately 40,000 unique data sources in the United States.

Figure A1: Conditions of viable job transitions

Viable job transitions	
Condition	Main source data
1. Similarity scores between jobs are sufficiently high	BGT, O*NET
2. Transition does not require huge leaps in education and experience	BGT, O*NET
Desirable job transitions	
Condition	Main source data
3. Transition involves moving to jobs where numbers are forecast not to decline	BLS, O*NET
4. Transition leads to a level of wage continuity that allows individuals to maintain their standard of living	BGT

The BGT analysis of each job posting results in an accumulation of detailed information on required skills in each job. This information is categorized into approximately 15,000 individual skills within approximately 550 skill clusters (categorized into baseline, specialized, and software skills). Information is also captured on the education and experience required for a job as well as average wages. Additionally, the BGT data set includes supplementary information on the employment gender distribution of each job covered from the American Community Survey (ACS).

US Bureau of Labor Statistics (BLS)

The 2016–2026 National Industry-Occupation Employment Matrix is developed by the US Bureau of Labor Statistics in the course of its ongoing Employment Projections program. The 2016 matrix was developed primarily from the Occupational Employment Statistics (OES) survey, the Current Employment Statistics (CES) survey, and the Current Population Survey (CPS). The 2016–26 National Employment Matrix encompasses data for approximately 800 jobs in the US and contains information on employment in 2016, as well as projections for expected employment in 2026 on an individual job basis.

The information on jobs in the 2016–2026 National Industry-Occupation Employment Matrix is based on Standard Occupational Classification (SOC) codes. The data set of 958 jobs used in this study captures about 96% of total employment in the 2016–2026 National Industry-Occupation Employment Matrix. Projections of employment per job were developed in a series of six interrelated steps, each based on a different procedure or model and related assumptions: labour force, aggregate economy, final demand (GDP) by consuming sector and product, industry output, employment by industry, and employment by occupation. The results produced by each step are key inputs to following steps, and the sequence may be repeated multiple times to allow feedback and to ensure consistency.

Viable and Desirable Job Transitions: Methodology

Condition 1: Similarity scores between jobs are sufficiently high

Assessing viable job transition opportunities requires an understanding of the requirements necessary to perform a given job and an ability to compare these requirements to the requirements of another job. The requirements of a job fall into a number of categories:

- **Work activities:** The range of tasks that need to be accomplished within a job role.
- **Knowledge:** Knowledge is the body of facts, principles, theories, and practices that acts as a foundation for skills.
- **Skills:** Skills are used to apply knowledge to complete tasks.
 - » **Cross-functional skills:** Common, non-specialized skills required by job applicants to be considered for a role (applicable to broad categories of jobs).
 - » **Specialized skills:** Skills particular to an industry or a job that are not easily transferable. For the purpose of refining the requirements of a job in the calculations used in this report, we separate out **software skills** (the use, design, maintenance and repair of different types of software).
- **Abilities:** The range of physical and cognitive capabilities that are required to perform a job role.
- **Education:** Education is a formal mechanism for acquiring skills and knowledge.
- **Work and Job Family Experience:** Experience plays a crucial role in forming and improving skills to apply a given knowledge.

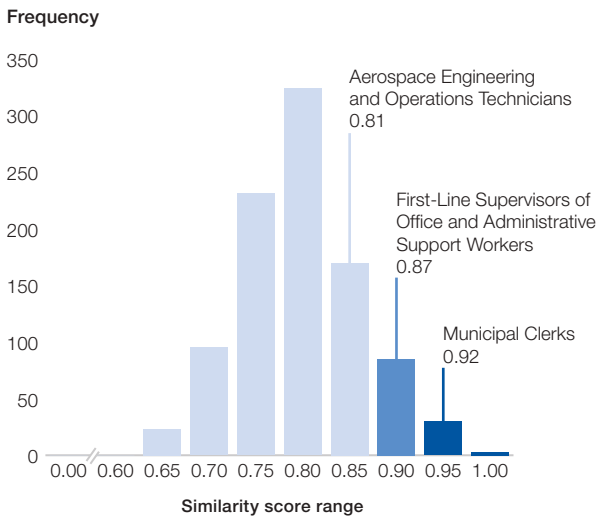
Table A1: Examples of calibration of similarity scores for high, medium and low similarity jobs

Starting job	Job-fit' category	Similarity score	Target job
Office Clerks, General	High	0.92	Municipal Clerks
	Medium	0.87	First-Line Supervisors of Office and Administrative Support Workers
	Low	0.81	Aerospace Engineering and Operations Technicians
Cooks, Fast Food	High	0.93	Dining Room and Cafeteria Attendants and Bartender Helpers
	Medium	0.86	Butchers and Meat Cutters
	Low	0.82	Locksmiths and Safe Repairers
Electrical Engineering Technicians	High	0.91	Electrical and Electronics Repairers, Powerhouse, Substation and Relay
	Medium	0.86	Geothermal Technicians
	Low	0.81	First-Line Supervisors of Agricultural Crop and Horticultural Workers
Computer Programmers	High	0.92	Web Developers
	Medium	0.86	Computer and Information Systems Managers
	Low	0.82	Anthropologists

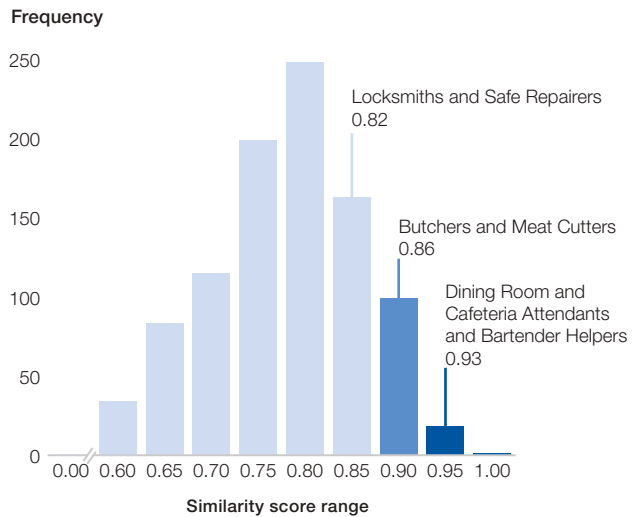
Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure A2: Frequency of similarity scores (selected examples)

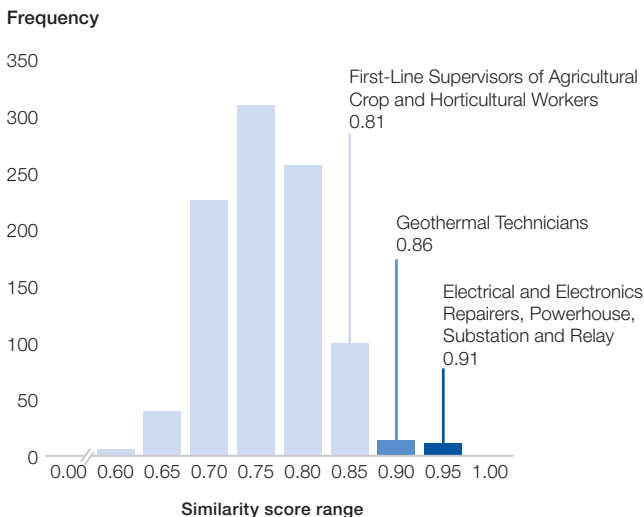
Office Clerks, General



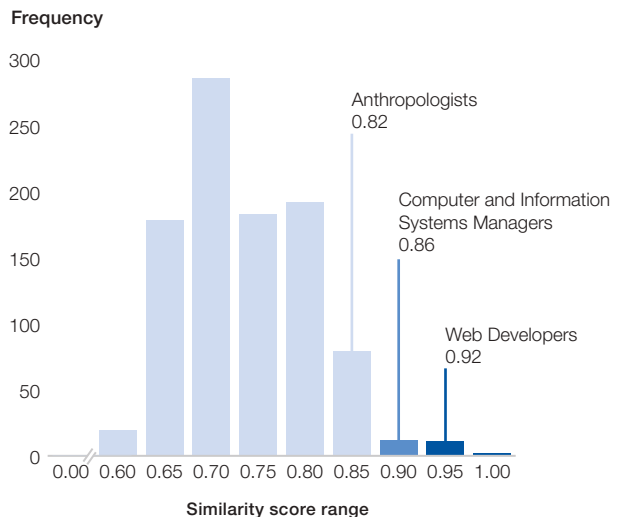
Cooks, Fast Food



Electrical Engineering Technicians



Computer Programmers



■ High similarity score ■ Medium similarity score ■ Low similarity score

Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Note: Similarity score ranges below 0.60 are excluded, given they are not significant values (frequency of 1).

To assess the similarity between the requirements of two jobs, this report introduces the concept of ‘similarity scores’. Similarity scores express the overlap between requirements such as education, experience, training, skills and knowledge, as a numeric value between 0 and 1. They can be seen as a proxy for the feasibility of transitioning between two jobs (or ‘job pair’).

Job pairs that have a similarity score of 1 share the exact same requirements, while job pairs with a similarity score of 0 have no requirements in common. For example, a computer programmer and a web developer have a similarity score of 0.92, while a computer programmer and an anthropologist only have a similarity score of 0.82. For ease of analysis, we have categorized similarity scores into high (scores of at least 0.9), medium (scores between 0.9 and 0.85) and low (scores below 0.85). Categorization of similarity scores was based on a calibration

process across a wide range of examples (see **Table A1** and **Figure A2**).

For the purpose of identifying viable job transitions options, we exclude job transitions that are characterized by low similarity scores (below 0.85).

To arrive at the concept of a numerical similarity score, Burning Glass Technologies contributes a distinctive approach to calculating these scores. This methodology combines data from both BGT job posting results and from O*NET’s database of job-specific descriptors. In a first step, for each of these two data sources, individual similarity scores are calculated (‘Burning Glass Technologies similarity scores’ and ‘O*NET similarity scores’). This is necessary to harness the advantages of both standardized job descriptors as well as actual up-to-date job requirements (that also provide additional detail—for example, the ‘software skill’ category as mentioned above). In a second step, results are

Table A2: Detailed information on scaling and weighting of inputs for calculation of similarity scores

	Input	Definition	Type of information for scaling	Scaling	Weighting for similarity score	
O*NET data	KSA measure	Knowledge	Skills learned through education/training/experience	Level	0–7	1 (equal weighting of knowledge, skills and abilities within KSA measure)
		Skills	Learning acquired through practice and experience, practice used to facilitate knowledge acquisition	Level	0–7	
		Abilities	Similar job activities and behaviors which underlie the work functions	Level	0–7	
	Work Activities	Tasks required to perform the role	Level	0–7	1	
	Education, Training and Experience	Requirements for each occupation by education and work experience ¹	Distribution	0–100	1	
BGT data	Skills measure	Baseline skills	Common, non-specialized skills required by job applicants to be considered for the role (applicable to broad categories of jobs)	Percent of job postings containing skill name	0–100	1 (equal weighting of baseline, specialized and software skills within skills measure)
		Specialized skills	Skills particular to industry or occupation, not easily transferable	Percent of job postings containing skill name	0–100	
		Software skills	Skills related to the use, design, maintenance and repair of software	Percent of job postings containing skill name	0–100	
	Education x Experience	Experience	Year of experience required for the role	Percent of job postings containing experience requirement	0–100	1
		Education	Years of education (and type: AA, BA, MA, PhD) required for the role	Percent of job postings containing educational requirement	0–100	

Source: Burning Glass Technologies.

Note: Categories of work experience are measured in time ranges and include: On-Site of In-Plant Training, On-the-Job Training, Related Work Experience and Required Level of Education. Required Level of Education is measured in types of educational qualifications, including high school diploma, associate’s degree, bachelor’s degree and others. The final measure here indicates the occupation’s distribution across joint time and education/experience requirements for each occupation by either educational requirement-type (for example, Required Level of Education-Bachelor’s Degree) or work experience type-time requirement (for example, On-the-Job Training-over 6 months, up to and including 1 year).

combined into a joint similarity score by calculating a weighted average between BGT and O*NET similarity scores.

Individual similarity scores for Burning Glass Technologies job postings data and data from O*NET are computed by calculating the similarity of requirement profiles for each separate pair of jobs. This is done by using a technique known as cosine similarity.¹

The features of every job can be expressed in the form of a vector, which consists of the skill demand frequency, education, and experience requirements.² Two jobs can then be compared by calculating the similarity score between their respective vectors. An identical pair of jobs would have identical vectors of features, and hence a similarity score of 1. The more different a pair of jobs, the closer their similarity score is to 0. Similarity scores between vectors of characteristics for jobs are calculated as follows:

- **O*NET occupational data:** In a first step, the similarity score is calculated for ‘Knowledge’, ‘Skills’, and ‘Abilities’ (‘KSA’) as a group. In a second step, the similarity score is calculated for ‘Work Activities’ and ‘Education/Training/Experience’.³ In a third step, a weighted average of similarity scores for KSA, Work Activities and Education/Training/Experience is calculated (see **Table A2** for technical definitions of categories, scalings and weightings).
- **Burning Glass Technologies job postings data:** In a first step, the similarity score is calculated for different ‘Skill Clusters’ (including ‘Baseline’, ‘Specialized’ and ‘Software’ skills). In a second step, the similarity score is calculated for ‘Experience’ and ‘Education’. In a third step, a weighted average of similarity scores for measures for experience, education, and skills is calculated (see **Table A2** for technical definitions of categories, scalings and weightings).

Table A3: Example of an O*NET job zone: Job zone three (of five): medium preparation needed

Education	Most occupations in this zone require training in vocational schools, related on-the-job experience or an associate's degree.
Related experience	Previous work-related skill, knowledge or experience is required for these occupations. For example, an electrician must have completed three or four years of apprenticeship or several years of vocational training, and often must have passed a licensing exam, in order to perform the job.
Job training	Employees in these occupations usually need one or two years of training involving both on-the-job experience and informal training with experienced workers. A recognized apprenticeship program may be associated with these occupations.
Job zone examples	These occupations usually involve using communication and organizational skills to coordinate, supervise, manage or train others to accomplish goals. Examples include hydroelectric production managers, travel guides, electricians, agricultural technicians, barbers, nannies and medical assistants.

Source: US Bureau of Labor Statistics.

Condition 2: Job transition does not require huge leaps in education and experience

When assessing job transitions, similarity scores are the main but not the only way of assessing viable job paths. Other elements that we take into account are the level of education (i.e. the formal mechanism for acquiring skills and knowledge) required and the level of experience (i.e. forming and improving skills to apply a given knowledge) required, both as measured in years.

O*NET uses a classification known as 'job zone' which incorporates these measures into each occupation. There are five job zone categories. Any two occupations that are within the same job zone are similar in terms of the amount of education required to do the work, how much related experience is required to do the work, and how much on-the-job training is required to do the work. An example of a job zone from O*NET's definition is shown in **Table A3**.

To avoid huge leaps in education and experience requirements for two jobs, we exclude job transition options to job zones that are more than one job zone up or down from the starting job when identifying viable job transition options.

Condition 3: Job transition opportunity involves moving to target jobs that are not expected to decline in number

Assessing viable job transition options requires taking into account the long-term sustainability of these job transition moves. Figures on current employment and expected employment per job reveal which jobs might present viable employment options for workers in the future and which jobs are expected to decline in number. In this report, we use data on employment in 2016 and expected employment in 2026 from the US Bureau of Labor Statistics.

Utilizing data from the US Bureau of Labor Statistics is beneficial for our analysis as the data set contains comprehensive and widely acknowledged information on employment on an individual job-level for the United States, aligned to our job categorization taxonomy. Connecting US Bureau of Labor Statistics employment data (based on SOC codes) to job postings data from Burning Glass Technologies and O*NET data (both based on O*NET codes) is achieved via the official O*NET-SOC 2010 to SOC 2010 crosswalk. Where there was more than one O*NET code for a given SOC code, employment numbers (2016 and 2026) were distributed to O*NET codes according to proportions derived from the distribution of the number of job postings by O*NET code provided by Burning Glass Technologies.

For the purpose of identifying viable job transition options, we exclude job transitions that would involve transitions to jobs that are expected to decline by 2026 in the US Bureau of Labor Statistics projections.

Condition 4: Job transition opportunity leads to a level of wage continuity (or increase) that allows individuals to maintain (or improve) their present standard of living

When assessing opportunities for job transitions, one of the key desirable conditions is that living standards of the individual do not decrease after the transition to the new job. This is best assessed by the comparison of wage levels between the starting and subsequent job, and the preference is for this to remain stable or increase after the job transition.

Table A4: Optimization conditions for Job Transition Model

Utility function	Constraints
The sum of job transitions with each job transition, weighted by corresponding sum of similarity score and normalized percentage wage increase (between zero and one)	There are no job transitions to jobs with lower wages
	There are only job transitions from jobs where expected employment in 2026 is lower than in 2016
	There are no job transitions to jobs where expected employment in 2026 is lower than in 2016
	There are no job transitions from jobs in job zone 5 (this is because job zone 5 comprises jobs such as CEOs, managers and scientists, where simulation of job transitions yield unlikely results)
	There are no job transitions with a similarity score of less than 0.85
	Only job transitions to jobs in one job zone lower, equal or one job zone higher are feasible
	Employment per job is smaller than or equal to projected future employment in 2026

Job Transition Pathway Optimization Model

Leadership lens

The leadership lens perspective utilizes a job transition model, based on the viability and desirability conditions set out above, to simulate job movements using a Linear Programming Model that maximizes the value of a utility function and is restricted by a certain set of constraints. **Table A4** provides an overview of the utility function and constraints.

As a basis, the job transition viability and desirability criteria set out above are included in the constraints in the main model in this section. We have limited the optimization to constrain job transitions to jobs where there is no fall in wages (in relation to their starting point). We use `Rglpk_solve_LP()` in R to arrive at a solution that takes as its main constraint the number of jobs in the US economy in 2016 and 2026 and looks to place all employees who are displaced into growing job families.

The number of job transitions by gender is calculated by multiplying the total number of job transitions with the proportion of women-to-men in each starting job. The underlying assumption is that the distribution of gender across workers transitioning to new jobs is equal to the distribution of gender in the starting jobs.

Individual lens

The individual lens perspective shows the job transition options available to workers in any given occupation. It restricts those options to those that meet the viable job transition criteria outlined above.

In this section of the report, selected illustrative jobs are shown, together with their viable job transition options. Further sub-sets of these job transition options are shown, restricting these potential job opportunities according to additional criteria. (A fuller set of such job transition pathways is also shown in Appendix B: Job Transition Pathways.)

The amount of additional experience and education required to facilitate a job transition is calculated using information on average experience and education required to perform a job

from the job postings data. The calculation logic of additional experience and education required depends on whether a job transition happens within the same job family or between different job families.

Within a job family, additional experience/education required is calculated by subtracting the average experience/education in the starting job from the average experience/education required in the target job. Only positive differences are considered (i.e. cases where experience/education requirements in the target job are higher than in the starting job). The underlying assumption is that workers can fully transfer their experience/education to different jobs in the same job family.

For job transitions between job families, we differentiate between experience and education. With experience, we assume that the additional experience required is the full amount of average experience required in the target job. The underlying assumption is that workers cannot transfer experience to jobs in different job families. With education, we assume that the additional education required is the full amount of education required in the target job. (However, we correct for high school education—12 years are included in number of years of average education required—as we assume that workers do not have to repeat their high school education, even if they transition to jobs within a different job family.)

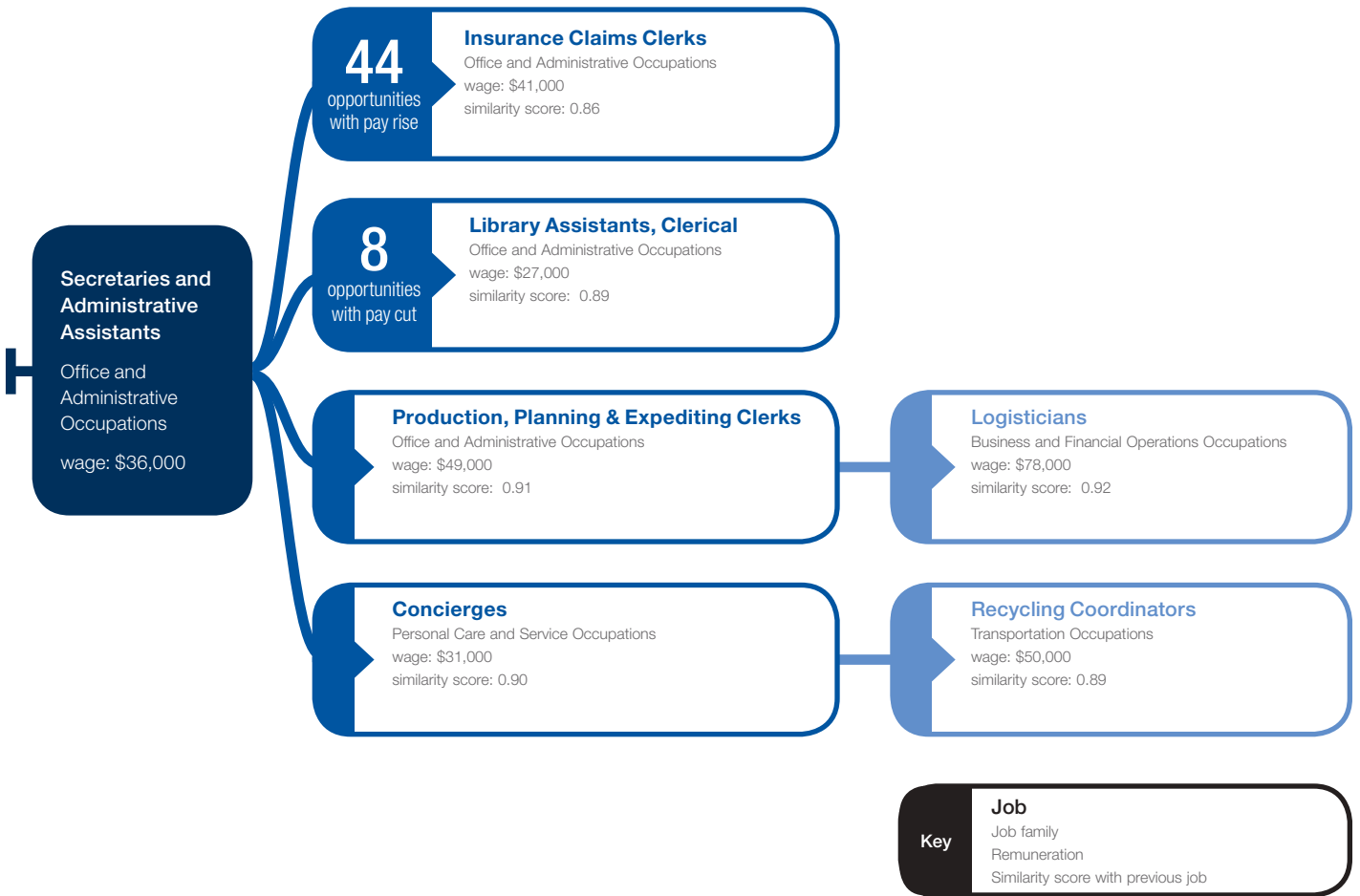
For all of these options, the average wage increase is calculated by subtracting the average wage in the target job from the average wage in the starting job. The average wages are based on job postings data.

Notes

- https://en.wikipedia.org/wiki/Cosine_similarity.
- https://en.wikipedia.org/wiki/Feature_vector.
- The rationale behind this step-wise calculation is to ensure that the effects of education, training and experience are not underweighted. If these factors were to be merged directly with the knowledge, skills, and abilities component, their effects would be diluted, since the O*NET taxonomy contains many more categories of skills than categories of education, training and experience.

Appendix B: Examples of Pathways

Figure B1: Examples of Pathways for Secretaries and Administrative Assistants



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B2: Examples of Pathways for Cashiers

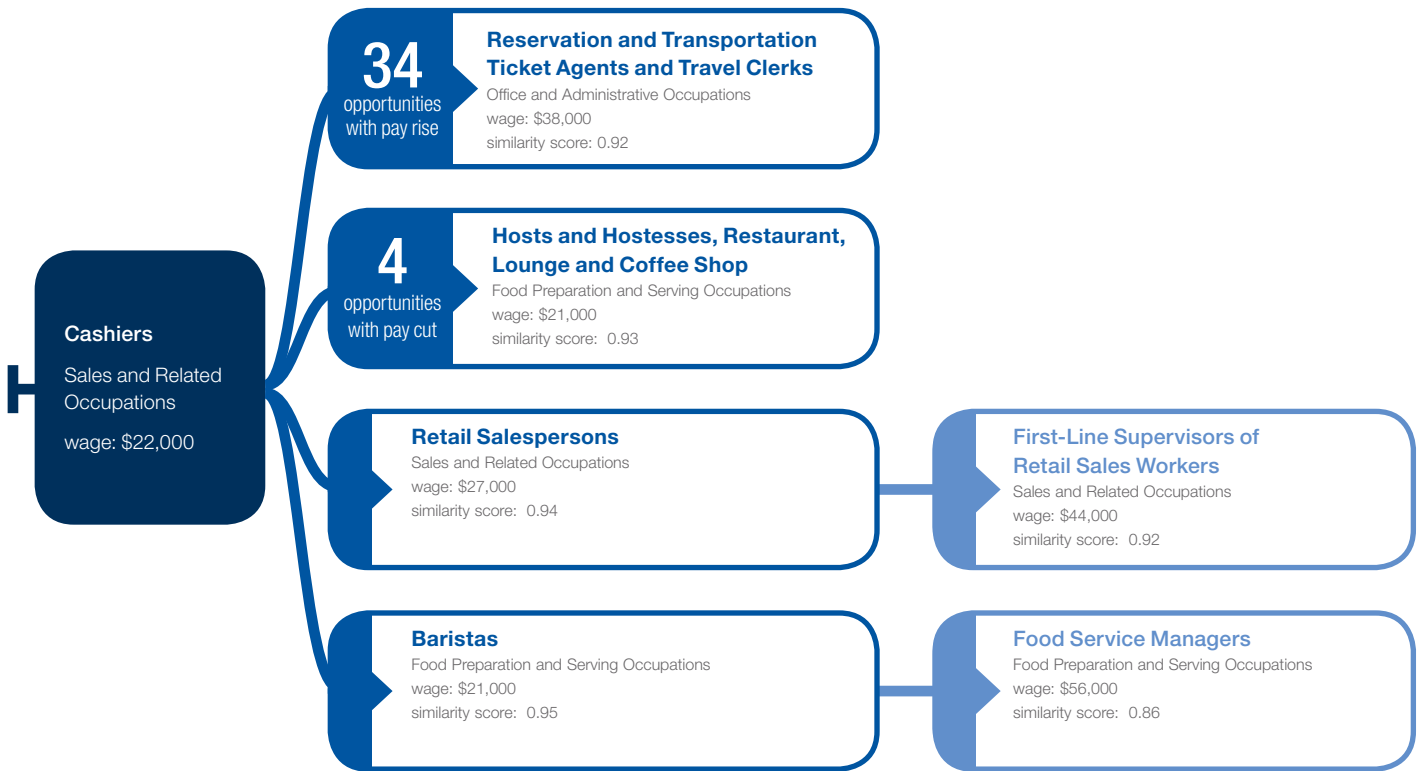
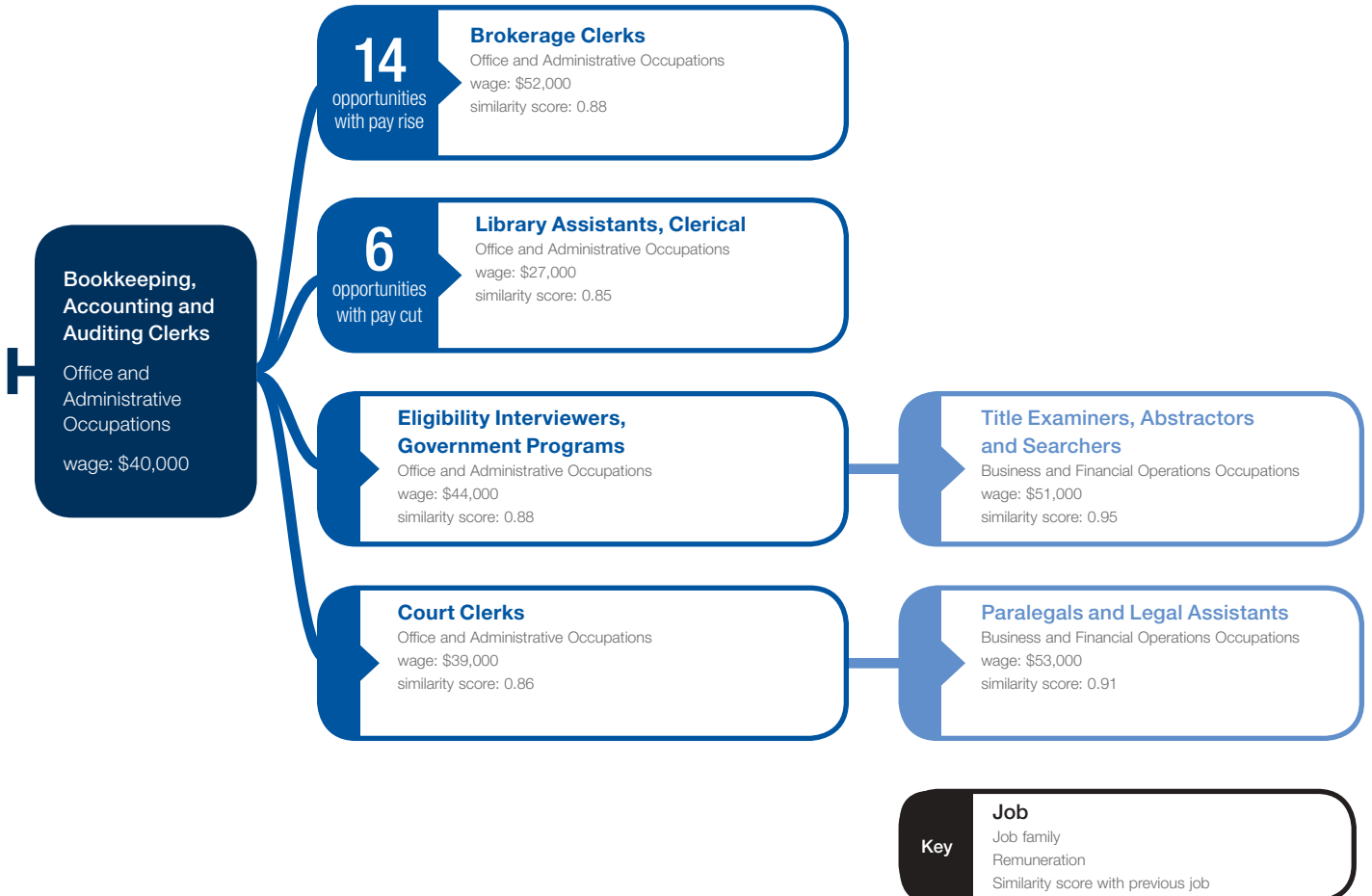


Figure B3: Examples of Pathways for Bookkeeping, Accounting & Auditing Clerks



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B4: Examples of Pathways for Assembly Line Workers

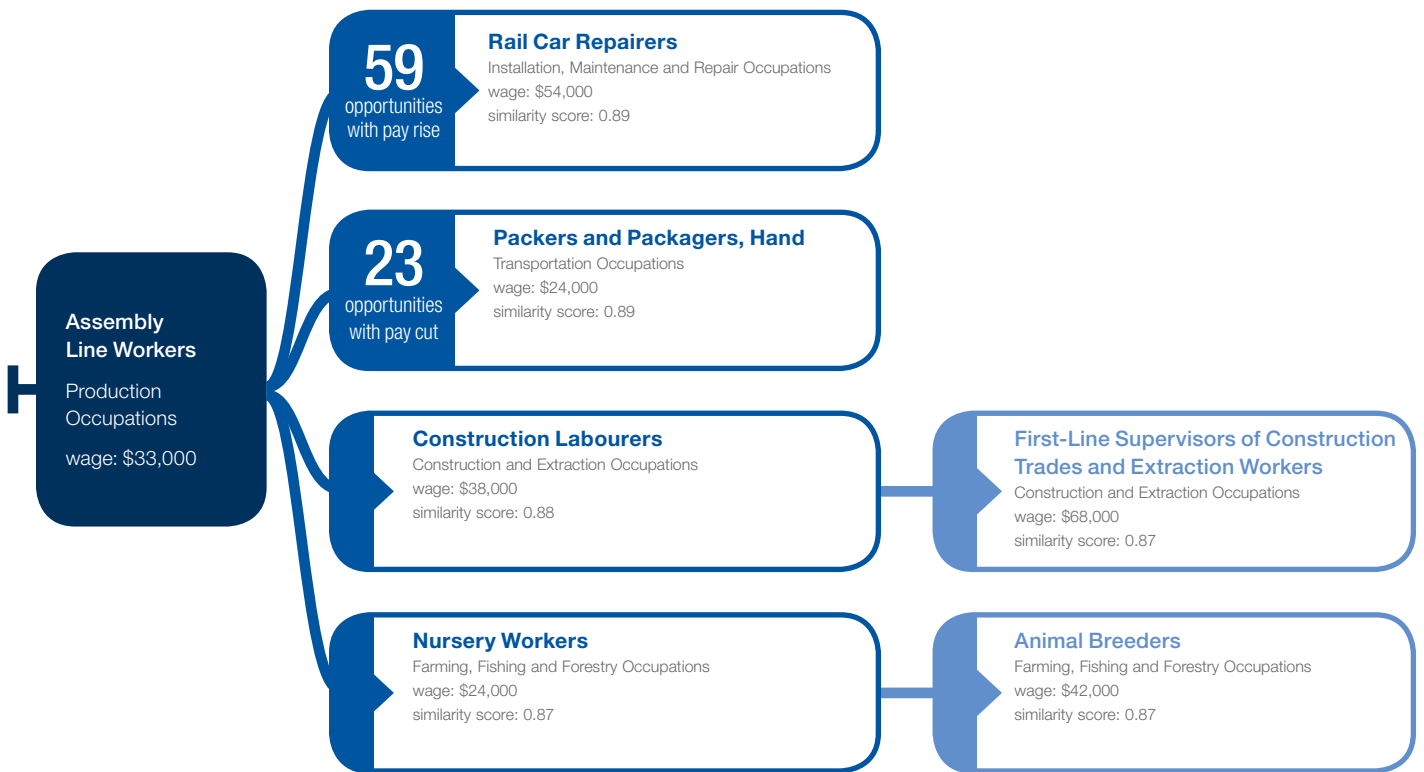


Figure B5: Examples of Pathways for Customer Service Representatives

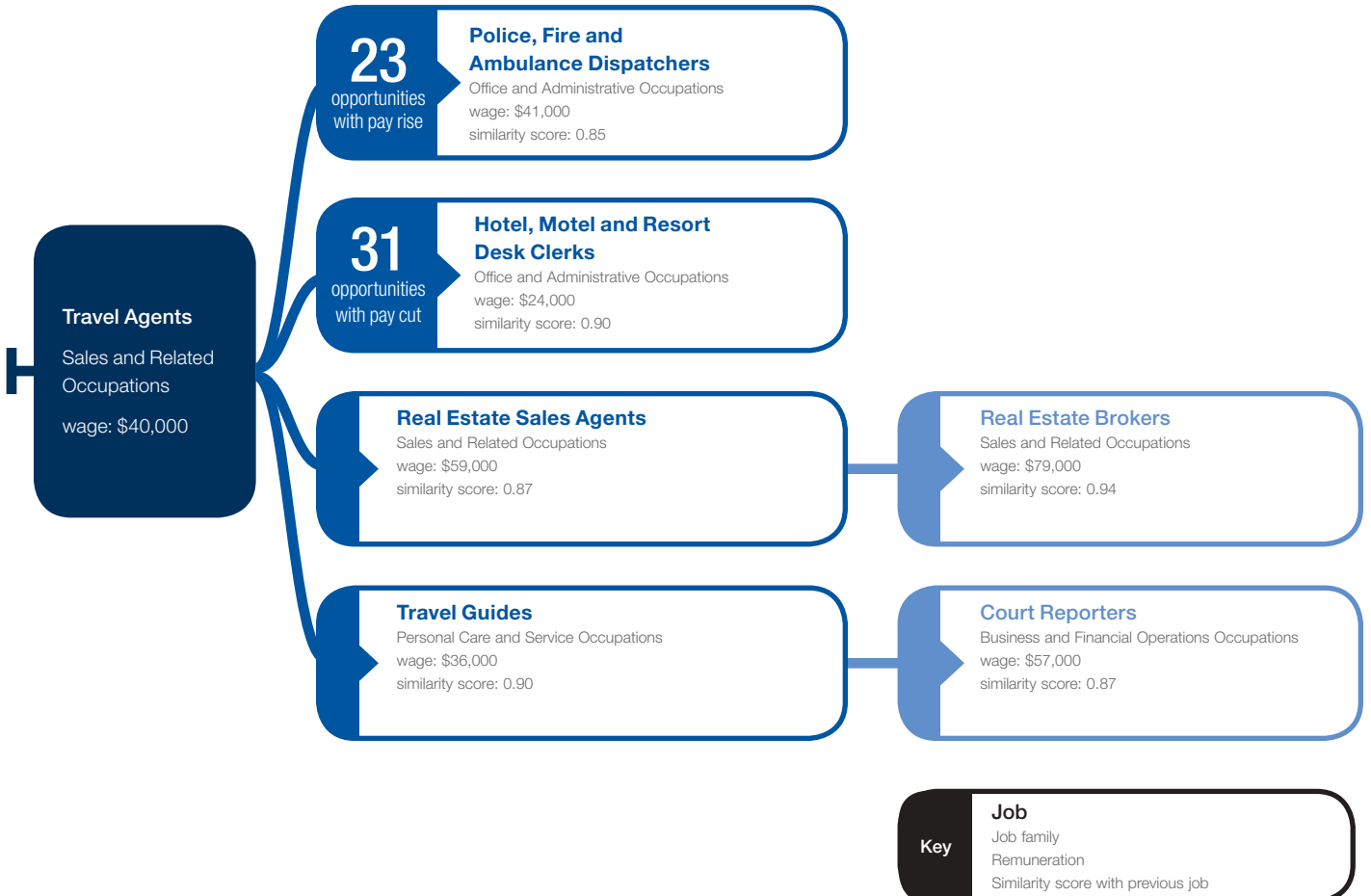


Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B6: Examples of Pathways for Heavy and Tractor-Trailer Truck Drivers



Figure B7: Examples of Pathways for Travel Agents



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B8: Examples of Pathways for Construction and Building Inspectors

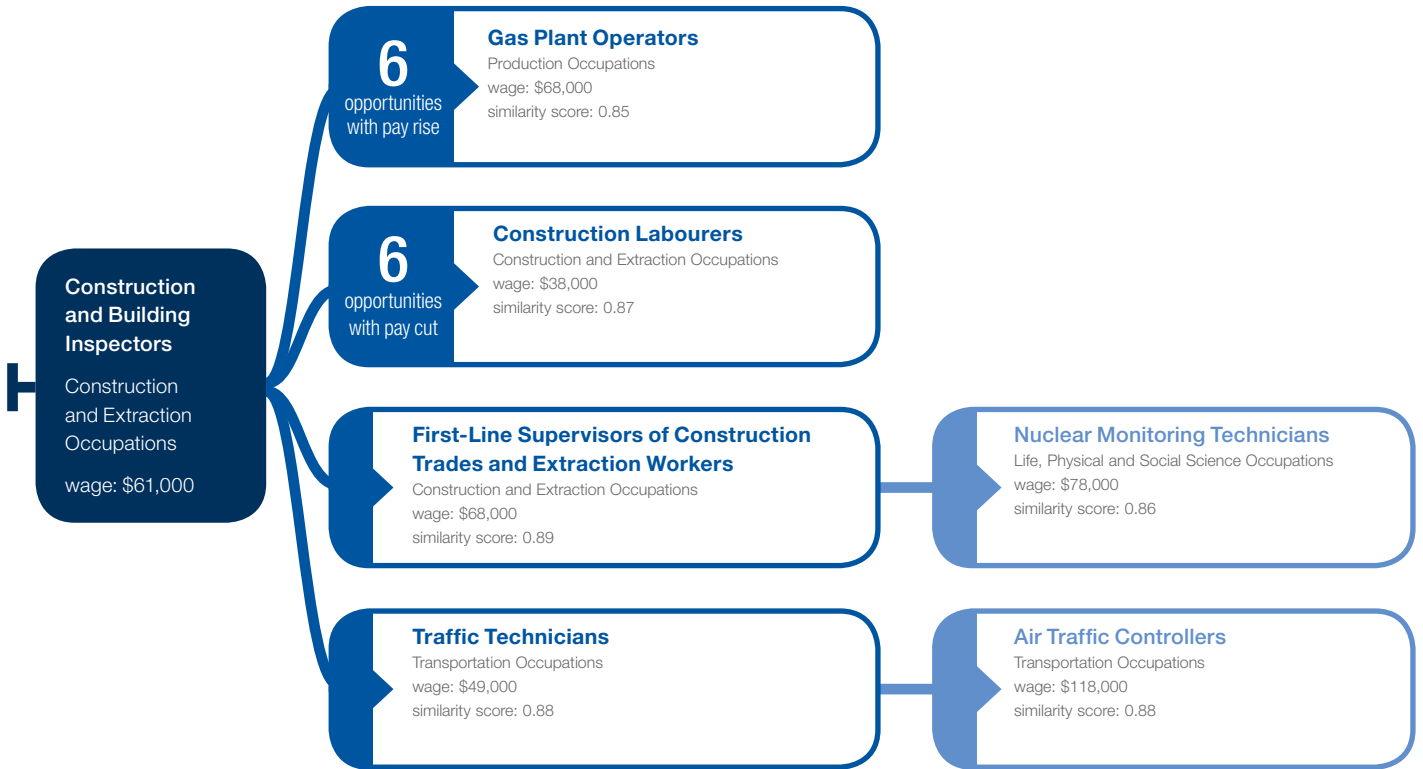
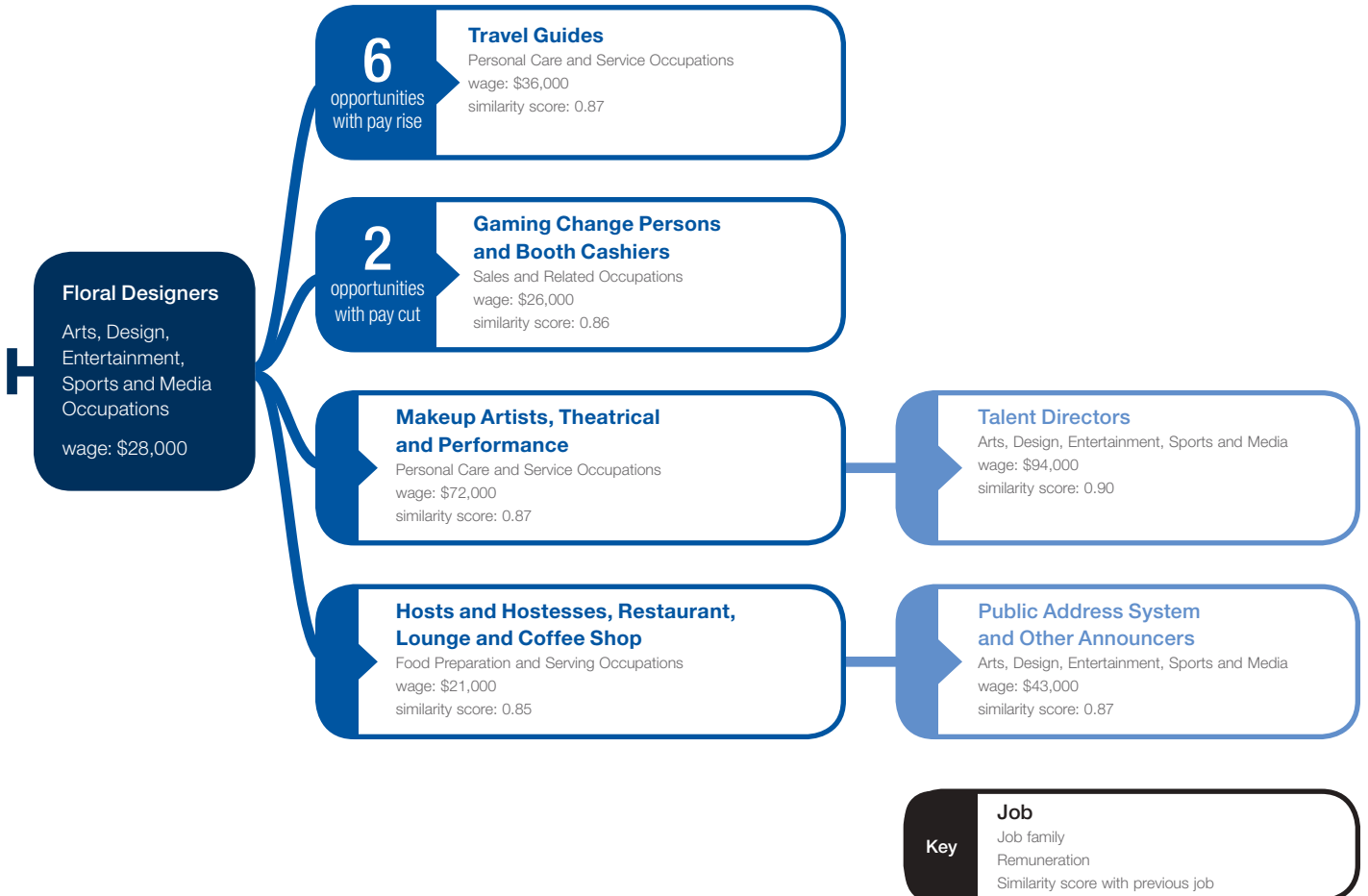


Figure B9: Examples of Pathways for Floral Designers

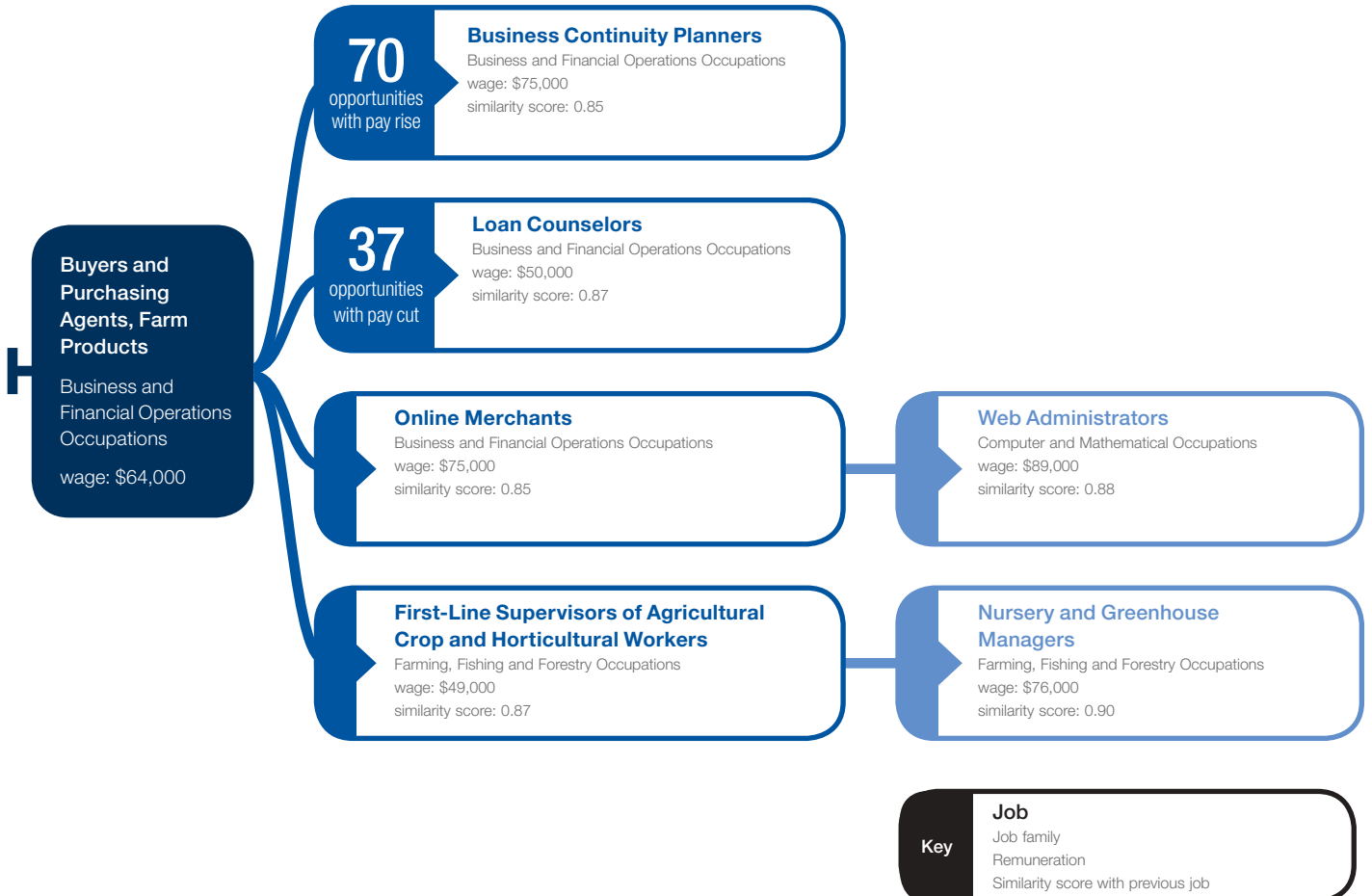


Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B10: Examples of Pathways for Radio and Television Announcers



Figure B11: Examples of Pathways for Buyers and Purchasing Agents, Farm Products



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B12: Examples of Pathways for Postmasters and Mail Superintendents

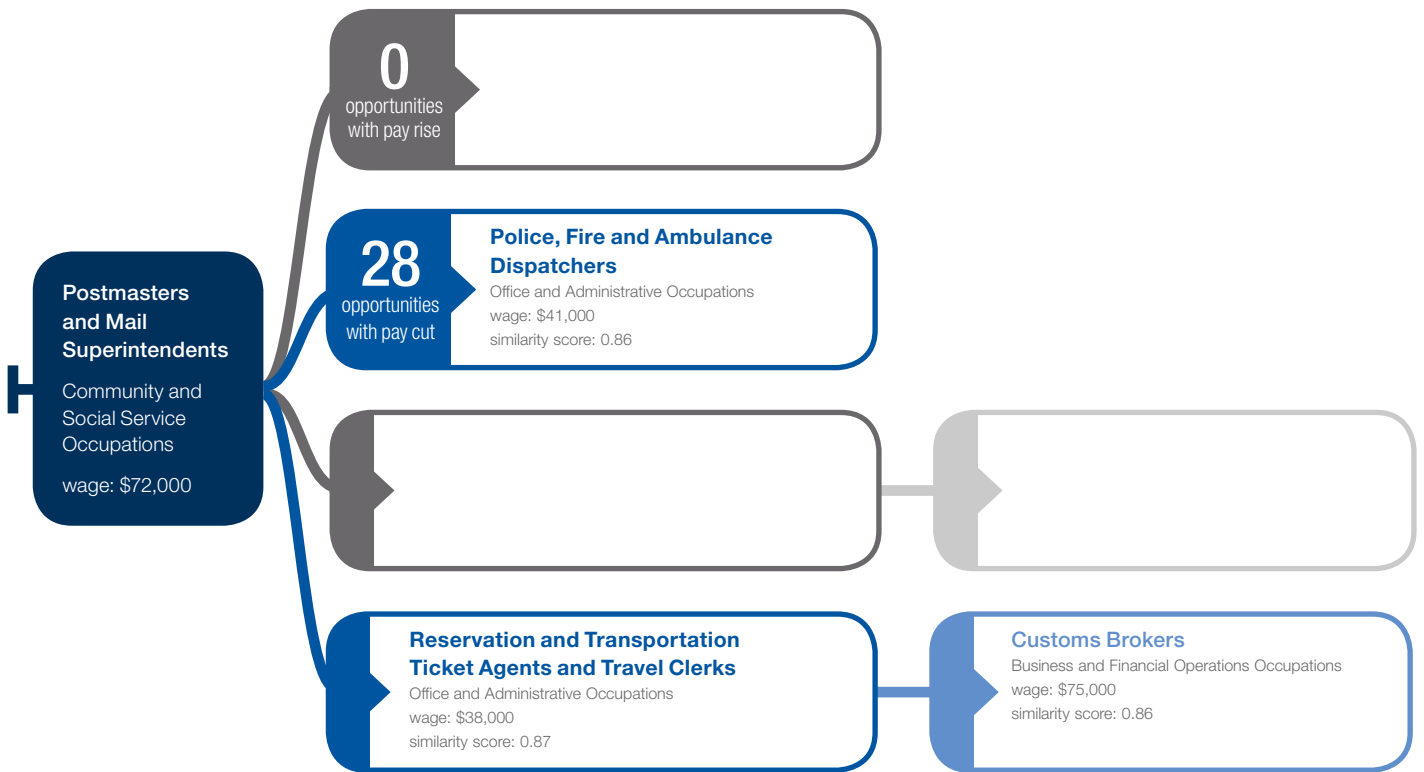
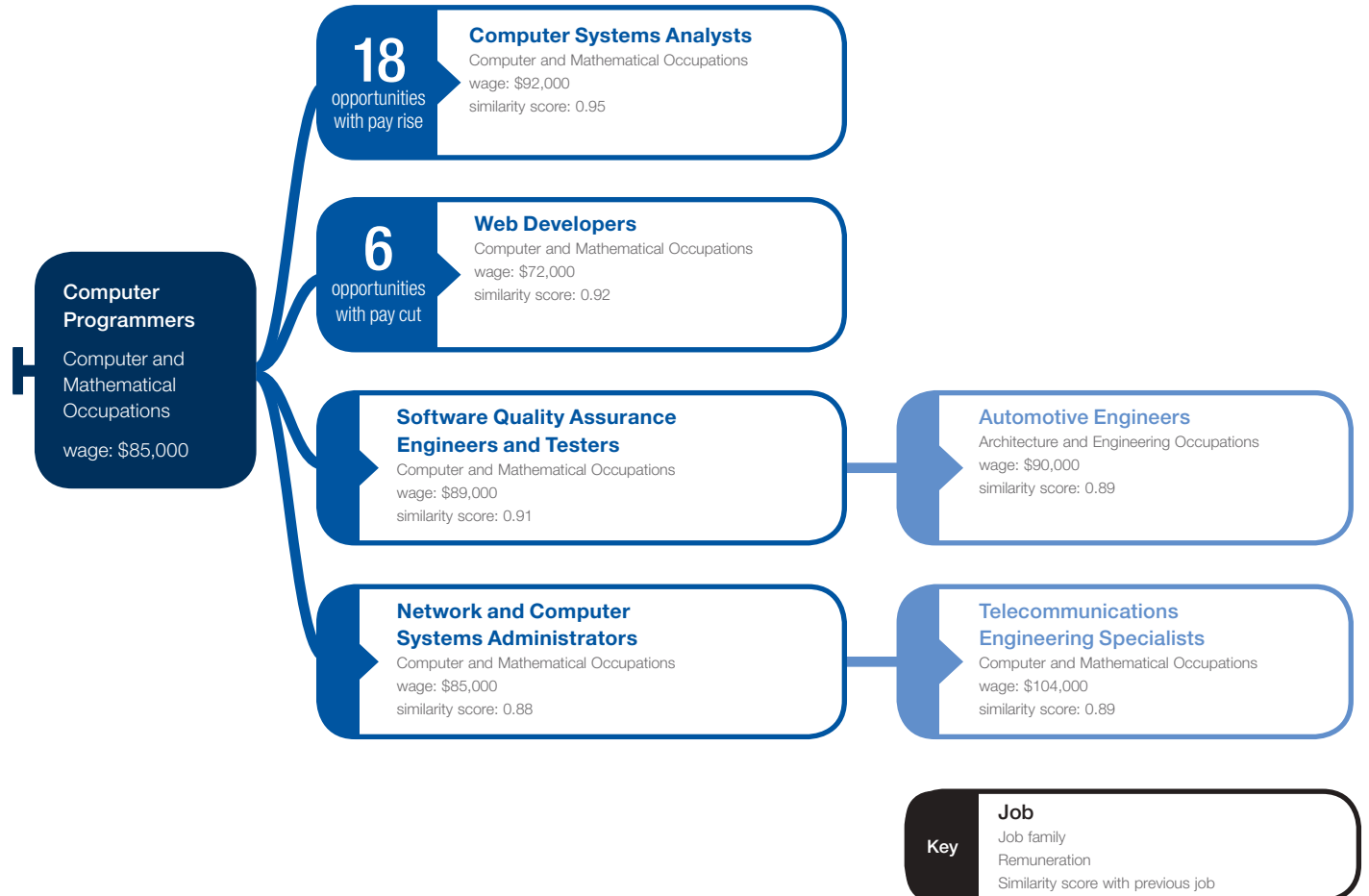


Figure B13: Examples of Pathways for Computer Programmers



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

Figure B14: Examples of Pathways for Cooks, Fast Food

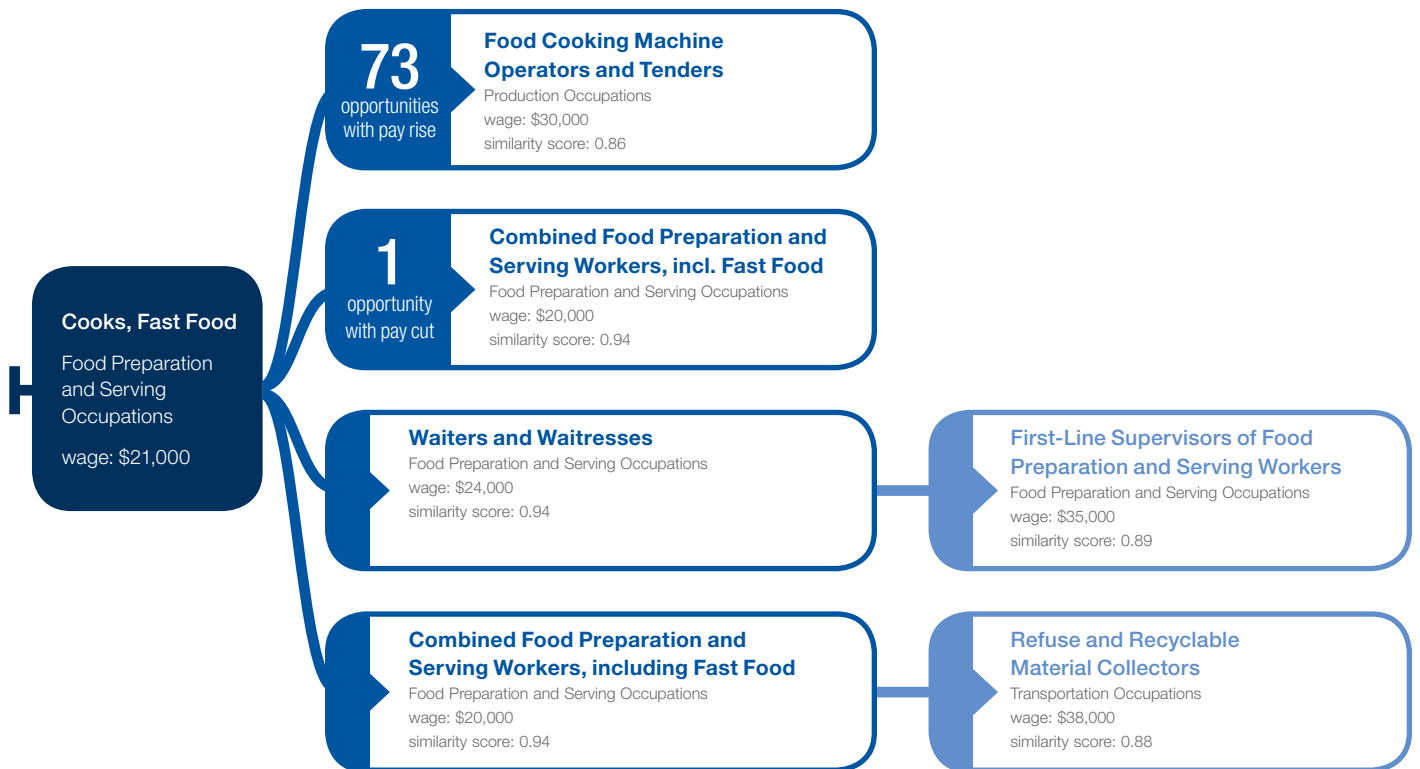
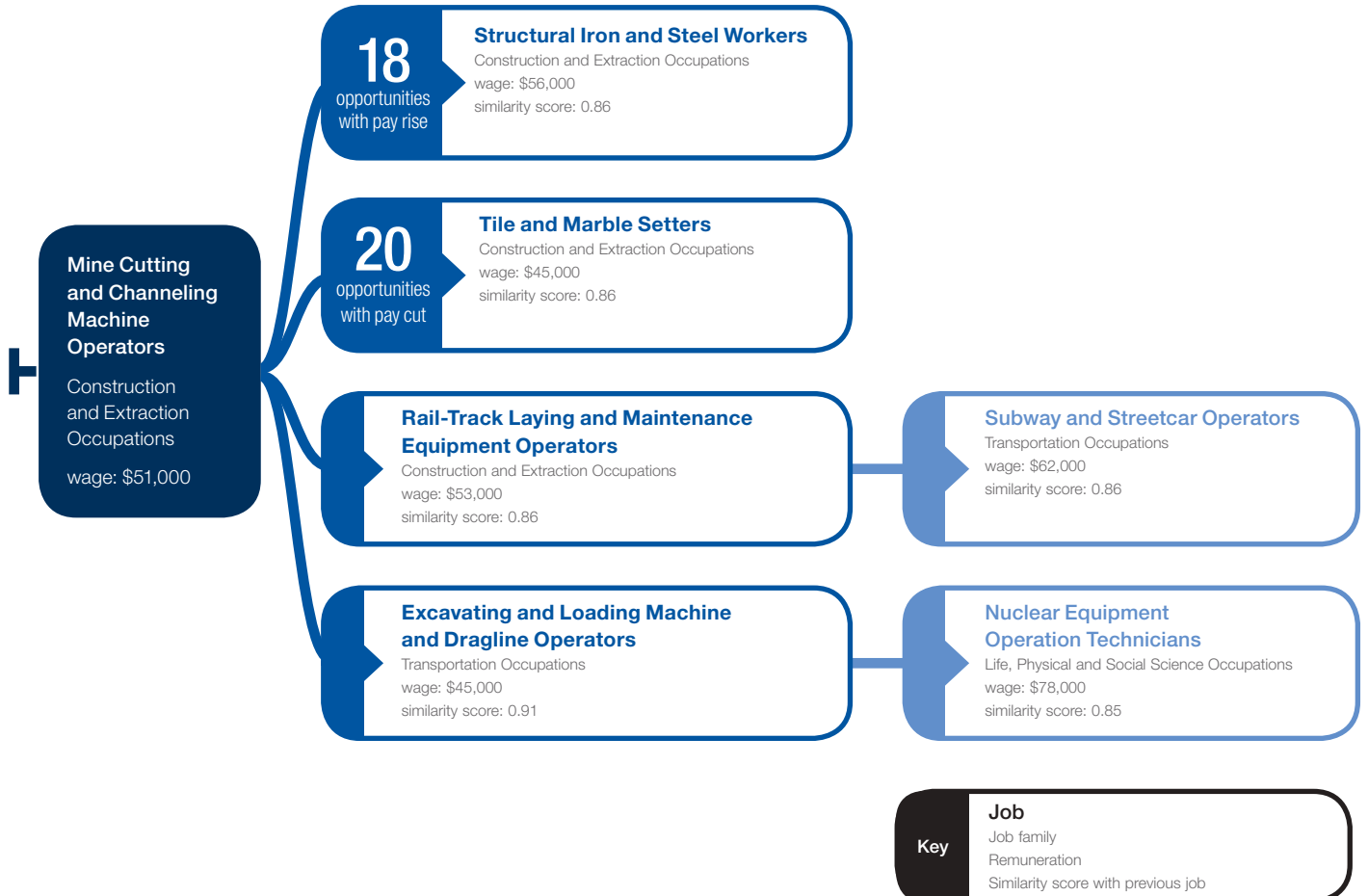


Figure B15: Examples of Pathways for Mine Cutting and Channeling Machine Operators



Source data: Burning Glass Technologies and US Bureau of Labor Statistics.

System Initiative Partners

The World Economic Forum would like to thank the Partners of the System Initiative on Shaping the Future of Education, Gender and Work for their support and guidance of the System Initiative.

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To learn more about the System Initiative, please refer to the System Initiative website: <https://www.weforum.org/system-initiatives/shaping-the-future-of-education-gender-and-work>.

Acknowledgements

Towards a Reskilling Revolution: A Future of Jobs for All is an insight tool published by the World Economic Forum's System Initiative on Shaping the Future of Education, Gender and Work, in collaboration with The Boston Consulting Group and using proprietary data provided exclusively for this report by Burning Glass Technologies.

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Thank you to those at The Boston Consulting Group who provided support and expertise: Hans-Paul Bürkner, Natalia Schmidt, Judith Wallenstein and Zheng Wei Yap.

Thank you to the System Initiative on Education, Gender and Work team: Nada Abdoun, Piyamit Bing Chomprasob, Genesis Elhussein, Sofia Michalopoulou, Paulina Padilla Ugarte, Valerie Peyre, Brittany Robles, Pearl Samandari, Lyuba Spagnoletto and Susan Wilkinson.

Thank you to Michael Fisher for his excellent copyediting work, Kamal Kamaoui and the World Economic Forum's Publications team for their invaluable contribution to the production of this White Paper; and Neil Weinberg for his superb graphic design and layout.



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