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Labor Supply, Labor Demand, and Potential Labor Shortages Through New U.S. Clean Energy, Manufacturing, and Infrastructure Laws

- **BIL**—*Bipartisan Infrastructure Law*
- **IRA**—*Inflation Reduction Act*
- **CHIPS**—*Creating Helpful Incentives to Produce Semiconductors*

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Table of Contents

1. Introduction

Between November 2021 and August 2022, three major economic policy laws were enacted by the U.S. Congress and signed into law by President Biden. These three laws are the BIL (Bipartisan Infrastructure Law), the IRA (Inflation Reduction Act) and the CHIPS (Creating Helpful Incentives to Produce Semiconductors) Act. In combination, the purpose of these three measures is to support a large-scale expansion of investments in the U.S. in the areas of clean energy, manufacturing, and infrastructure.

This report considers the BIL, the IRA, and the CHIPS Act with respect to their employment impacts within the U.S. economy. This report is a companion to our September 2023 report, *Employment Impacts of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures*. This previous report, as its title conveys, estimated the extent of job creation—i.e. *labor demand*—that will result through BIL, IRA, and CHIPS investments. The current companion study examines the employment impacts of BIL, IRA, and CHIPS from the perspective of *labor supply*—more specifically, the availability of workers within the U.S. labor market to move into the jobs that will be newly generated by BIL, IRA, and CHIPS investments.

With respect to labor demand, we concluded in our September 2023 study that, in combination, investments supported by the BIL, IRA, and CHIPS programs would generate, in total, an average of nearly 3 million jobs per year, as long as investment levels associated with these programs are sustained at their anticipated levels. This level of new job creation will produce widespread new opportunities for U.S. workers across a range of occupations, in all regions of the country. As we showed in the September 2023 study, the expansion of job opportunities generated by BIL, IRA, and CHIPS-related investments will be especially large among occupations that do not require 4-year college degrees as a qualification.

In this current companion study, we focus specifically on the extent to which there are likely to be large enough pools of workers who are qualified and available to move into the jobs that will be newly generated by BIL, IRA, and CHIPS-related investments. In addressing this question, we are especially focused on identifying employment areas in which labor supply shortages could emerge as BIL, IRA, and CHIPS investment levels reach their full targeted levels. As we will see, the largest share of potential labor shortages will be, first, in construction, and then in manufacturing occupations. Thus, our results in this current study further document how BIL, IRA, and CHIPS-related investments will expand opportunities in occupations that do not require 4-year college degrees.

Through identifying areas where such shortages are more likely to emerge, this report can help advance policies that expand the available labor supply in the relevant occupations to meet the increasing opportunities for workers associated with BIL, IRA, and CHIPS. Important policy measures will be in the areas of apprenticeships, job training, job placement, and related programs. Depending on the specific occupation, these include certificate and apprenticeship programs provided by community colleges, unions or industry-

based organizations; occupation-related associate degrees along with internships or other types of hands-on training programs run by community colleges; and 4-year college degree programs.[1]

The structure of this report is as follows. In the next Section 2, we review the overall estimates from our September 2023 study as to the increase in labor demand that will be generated through BIL, IRA, and CHIPS-related investments. This includes our discussion of the three channels through which employment increases result through these investments—i.e. the "direct," "indirect," and "induced" job creation channels. We explain in this section why we focus our analysis on the "direct" job creation channel. We show here that about 1 million of the 3 million jobs in total that will be generated through BIL, IRA, and CHIPS-related investments will be generated through the direct jobs channel, with the other roughly 2 million jobs being generated through either the indirect or induced jobs channels.

In Section 3, we identify 48 specific occupations that are likely to experience significant increases in demand through the direct jobs channel resulting from BIL, IRA, and CHIPS-related investments. We then divide this full set of 48 occupations into two categories—21 occupations with relatively low entry requirements in terms of training, educational credentials, or prior job experience and 27 occupations with more significant such entry requirements. As we will see, BIL, IRA, and CHIPS-related investments will generate a significant expansion of job opportunities in both of these two broad sets of occupational categories.

In Section 4, we focus on the potential for both labor surpluses and labor shortages resulting through BIL, IRA, and CHIPS-related investments with the 27 occupations with significant entry requirements. We show here that, of the 27 such occupations, we estimate that labor surpluses are likely to result with 7 of the occupations and labor shortages will likely emerge with the remaining 20 occupations.

In Section 5, we review the sectoral breakdown and current demographic composition of the workers employed in the 20 occupations in which we estimate that labor shortages will likely emerge. With respect to sectors, we show that, by far, construction is the sector that will most likely face shortages in a range of occupations as BIL, IRA, and CHIPS investments expand to reach their full targeted levels. With respect to the demographic composition of occupations likely to face labor shortages, we find that women especially are seriously underrepresented in these occupations. Black, Indigenous, and other racial/ethnic minority workers are also underrepresented, if to a lesser extent than women. The results that we report here highlight how the overall expansion of employment through BIL, IRA, and CHIPS provides significant opportunities to diversify the occupational workforces that are presently dominated by men or White workers.

In the Appendix of the study, we provide more detail on our methodologies for deriving our results. We also provide brief reviews of the related literature and results of studies that are broadly comparable to ours.[2]

2. Estimating Labor Demand Increases Through BIL, IRA, and CHIPS

Overall Labor Demand Increase

Our September 2023 study provided detailed estimates of labor demand resulting from BIL, IRA, and CHIPS, assuming these three programs are operating at their full capacity. Table 1 summarizes the overall findings of this previous study.

As Table 1 shows, we estimate average annual public spending and corresponding private spending at $303 billion. These average annual figures are over the 5-year time period allocated for both BIL and CHIPS and the 10-year time frame for the IRA. From these spending figures, we then estimate total average annual employment creation to be about 2.9 million jobs. This figure is equal to about 1.8 percent of the overall U.S. labor force as of 2022.

This table also reports total "job years" created through the three programs. This figure is equal to simply the average annual job creation totals for the three programs multiplied by the number of years each of the programs is scheduled to operate. For example, as the table shows, we estimate average annual job creation for BIL as 1.8 million jobs. BIL is scheduled to operate for 5 years. Thus, our estimate for total job years for BIL is 9 million jobs.[3]

In terms of estimating potential labor shortages, the relevant metric is the average annual job creation figure, not the total job-years figure. This is because we are concerned with measuring the increase in labor demand within the given size of the U.S. labor market at a given time period.

TABLE 1.
Average Annual Budgets and Job Creation through BIL, IRA, and CHIPS

	Average Annual Budgets *Public + Estimated Private Spending*	Average Annual Job Creation	Total Job Years
BIL	$170 billion	1.8 million	8.8 million *5-year average job years for BIL programs*
IRA	$98 billion	849,000	8.5 million *10-year average job years for IRA programs*
CHIPS	$35 billion	279,000	1.4 million *5-year average job years for CHIPS programs*
Totals	**$303 billion** *Total combined budgets as share of 2022 U.S. GDP = 1.2%*	**2.9 million** *Total job creation as share of 2022 U.S. labor force = 1.8%*	**18.7 million**

Note: Figures in table are rounded.
Source: Pollin et al. (2023).

Focus on "Direct Jobs" Creation Channel

Our estimate of 2.9 million jobs generated on an average annual basis is derived through three channels of job creation. These are direct, indirect, and induced job creation channels. To illustrate these three channels for job creation, consider the impacts of investments in the respective areas of home retrofitting or installing solar panels:

1. ***Direct job creation***—the jobs created, for example, by retrofitting buildings to make them more energy efficient or installing solar panels;

2. ***Indirect job creation***—the jobs associated with industries that supply intermediate goods for the building retrofits or solar panels, such as glass, steel, and transportation. In other words, indirect jobs are those created along the clean energy investment supply chain;

3. ***Induced job creation***—the expansion of employment that results, for example, when people who are paid in the construction or steel industries spend the money they have earned on other products in the economy. These are the multiplier effects within a standard macroeconomic model.

In Table 2, we show the breakdown of total average annual job creation through the three respective channels—direct, indirect, and induced job creation. The figures in Table 2 combine the jobs generated by BIL, IRA, and CHIPS. As we see, of the 2.9 million total jobs generated through all three channels by all three laws, 1 million (34.5 percent) are direct jobs, 800,000 (27.6 percent) are indirect jobs, and 1.1 million (37.9 percent) are induced jobs.

For the purpose of estimating potential labor supply shortages, we concentrate on the 1 million jobs generated annually through the direct jobs channel. This enables us to focus on the labor supply issues resulting specifically from BIL, IRA, and CHIPS, as opposed to assessing labor supply challenges more generally within the U.S. labor market.

TABLE 2.
Direct, Indirect, and Induced Job Creation Generated Through Combined BIL, IRA, and CHIPS Investments

Average annual job creation estimates

	Number of Average Annual Jobs Created	Percentage of Average Annual Jobs Created
Direct jobs	1.0 million jobs	34.5%
Indirect jobs	800,000 jobs	27.6%
Induced jobs	1.1 million jobs	37.9%
Total	**2.9 million jobs**	**100%**

Source: Pollin et al. (2023).

Here it is important to recognize the distinct distribution of job creation by sector through BIL, IRA, and CHIPS-related investments relative to the sectoral distribution of employment in the U.S. economy overall. We can see this in Table 3, which shows the total number and share of direct job creation by sector through BIL, IRA, and CHIPS as well as the distribution of employment by sector in the overall U.S. economy. As the table shows, fully 44 percent of direct job creation through BIL, IRA, and CHIPS-related investments is concentrated in the construction sector. Another 22 percent of direct job creation is in manufacturing. That is, roughly two-thirds of total direct job creation through BIL, IRA, and CHIPS-related investments are in construction and manufacturing.[4]

This pattern contrasts sharply with the U.S. economy overall, in which, as Table 3 shows, only 5.9 percent of employment is in construction and 6.6 percent is in manufacturing. For the U.S. economy overall, 68 percent of all jobs are in the service sector, whereas with direct jobs through BIL, IRA, and CHIPS-related investments, service sector job creation amounts to about 17 percent of total job creation. In short, BIL, IRA, and CHIPS-related investments will create a major new wave of employment opportunities for workers in the construction and manufacturing sectors. These investments will also enable workers

TABLE 3.
Sectoral Distribution of Employment:

- **Direct Job Creation by Sector Through BIL, IRA, and CHIPS**
- **Sectoral Employment Distribution for Overall U.S. Labor Market**

Overall direct job creation through BIL, IRA, and CHIPS = 1 million jobs/year

Sector	Direct Job Creation Through BIL, IRA, and CHIPS		Pct. Employment by Sector for Overall U.S. Economy
	Average Annual Direct Job Creation	Pct. of Average Annual Direct Job Creation	
Construction	453,000	44.0%	5.9%
Manufacturing	230,000	22.4%	6.6%
Services	172,000	16.7%	68.4%
Transportation and warehousing	117,000	11.4%	4.9%
Utilities	7,800	0.8%	0.3%
Wholesale and retail trade	0	0%	11.7%

Note: Figures in table are rounded. Remaining job creation is divided among agriculture/forestry/hunting; mining and mining-related activities.
Source: Pollin et al. (2023).

employed in other sectors, such as services, to consider for themselves the newly emerging job opportunities opening in construction and manufacturing.

Of course, the increase in employment due to indirect and induced jobs will also generate broader impacts on U.S. labor supply. This is especially the case given that, as we saw in Table 2, indirect and induced jobs represent nearly two-thirds of the total 2.9 million jobs generated on an average annual basis by BIL, IRA, and CHIPS-related investments. But the sectoral distribution of new job creation through the indirect and induced job channels more closely reflects the overall U.S. economy's sectoral distribution of employment, with service-sector jobs constituting the majority of new jobs generated through these indirect and induced job channels. As such, the labor supply issues generated by the indirect and induced jobs channels need to be primarily analyzed within the framework of the overall U.S. labor market. This broader set of labor supply considerations is beyond the scope of this study.[5]

Occupations with Largest Labor Demand Increases from BIL, IRA, and CHIPS

In Tables 4 and 5, we list the set of individual occupations that, by our estimates, will experience the largest increases in labor demand through the direct jobs channel generated by BIL, IRA, and CHIPS investment activities. Table 4 includes the occupations that will experience the largest labor demand increases measured in terms of *absolute number of new job openings* due to BIL, IRA, and CHIPS investments. Table 5 then lists the occupations that will experience the largest *percentage increases* in labor demand through the direct jobs channel generated by BIL, IRA, and CHIPS investments.

As we see in Table 4, the largest absolute increase in labor demand will be for construction laborers, with labor demand increasing by 80,900 jobs due to BIL, IRA, and CHIPS investments combined. This increased demand of 80,900 jobs represents an expansion of 3.8 percent relative to the 2022 employment baseline for construction laborers.

Overall, as Table 4 reports, the increase in labor demand for these 30 occupations amounts to 583,600 jobs, equal to 58 percent of the overall increase of 1 million direct jobs generated by BIL, IRA, and CHIPS investments.

Table 5, which lists the occupations that we estimate will experience the largest *percentage* increase in labor demand through the direct jobs channel from BIL, IRA, and CHIPS investments, provides an important complement to the occupations that will experience the largest absolute increases in labor demand. This is because the occupations with high percentage increases in labor demand could create labor market bottlenecks even if the total number of workers that need to be newly hired into these occupations is relatively small.

For example, we estimate that the largest percentage increase in labor demand due to BIL, IRA, and CHIPS will be for pile driver operators. We estimate that the increase in labor demand for pile driver operators will be a small number, at 1,200 workers in total. But this increase in labor demand nevertheless represents an expansion of nearly 32 percent for

TABLE 4.
***Absolute Level* Labor Demand Increases:**
30 Occupations with Largest Absolute Amount of Labor Demand Increases due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment
Construction laborers	80,900	3.8%
First-line supervisors of construction trades and extraction workers	40,000	3.0%
Electrical power-line installers and repairers	34,500	16.4%
Operating engineers and other construction equipment operators	32,500	6.7%
General and operations managers	29,000	0.6%
Bus drivers, school	27,000	3.5%
Carpenters	23,800	1.1%
Miscellaneous assemblers and fabricators	22,900	1.4%
Construction managers	22,100	2.3%
Project management specialists	21,200	1.3%
Shuttle drivers and chauffeurs	19,800	3.1%
Office clerks, general	18,300	0.5%
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	18,100	6.3%
Heavy and tractor-trailer truck drivers	17,300	0.6%
First-line supervisors of mechanics, installers, and repairers	16,200	1.8%
Telecommunications line installers and repairers	15,400	9.7%
Welders, cutters, solderers, and brazers	14,400	3.0%
Secretaries and administrative assistants, except legal, medical, and executive	12,700	0.5%
Bookkeeping, accounting, and auditing clerks	12,200	0.5%
Electricians	11,700	3.6%
Bus drivers, transit and intercity	11,700	3.7%
Laborers and freight, stock, and material movers, hand	11,400	0.3%
First-line supervisors of production and operating workers	9,900	1.4%
Software developers	9,700	0.3%
Customer service representatives	9,100	0.2%
Accountants and auditors	9,000	0.4%
Inspectors, testers, sorters, samplers, and weighers	8,800	1.3%
Civil engineers	8,400	1.8%
Sales representatives of services, except advertising, insurance, financial services, and travel	7,900	0.5%
Industrial engineers	7,700	2.0%
All top 30 occupations	*583,600*	--
Across all occupations	*1.0 million*	*0.5%*

Note: Figures in table are rounded.
Source: See Appendix.

TABLE 5.
***Percentage* Labor Demand Increases:**
30 Occupations with Largest Percentage Increases in Labor Demand due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment
Pile driver operators	1,200	31.8%
Electrical power-line installers and repairers	34,500	16.4%
Water and wastewater treatment plant and system operators	3,500	13.2%
Solar photovoltaic installers	1,300	12.3%
Telecommunications line installers and repairers	15,400	9.7%
Coil winders, tapers, and finishers	1,100	9.6%
Radio, cellular, and tower equipment installers and repairers	1,500	8.0%
Wind turbine service technicians	1,800	7.6%
Operating engineers and other construction equipment operators	32,500	6.7%
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	18,100	6.3%
Semiconductor processing technicians	1,200	6.0%
Pipelayers	1,100	5.0%
Construction laborers	80,900	3.8%
Bus drivers, transit and intercity	11,700	3.7%
Electricians	11,700	3.6%
Bus drivers, school	27,000	3.5%
School bus monitors	5,000	3.5%
Crane and tower operators	1,600	3.2%
Plumbers, pipefitters, and steamfitters	5,500	3.1%
Shuttle drivers and chauffeurs	19,800	3.1%
Welders, cutters, solderers, and brazers	14,400	3.0%
First-line supervisors of construction trades and extraction workers	40,000	3.0%
Electrical and electronic engineering technologists and technicians	3,000	2.7%
Industrial engineering technologists and technicians	1,800	2.5%
Sheet metal workers	1,700	2.4%
Mobile heavy equipment mechanics, except engines	5,000	2.4%
Construction managers	22,100	2.3%
Occupational health and safety specialists	3,000	2.3%
Electrical engineers	5,200	2.1%
Computer numerically controlled tool operators	3,900	2.1%
All top 30 occupations	376,500	--
Across all occupations	*1.0 million*	*0.5%*

Notes: Two additional criteria apply to the occupations in this list: (1) only occupations with a minimum of 1,000 direct jobs added from the BIL, IRA, and CHIPS spending and (2) only occupations with a sufficient annual sample size (50 observations) for the employment growth analysis are included. 2022 employment is estimated based IMPLAN and BEA employment estimates. Figures in tables are rounded.
Source: See Appendix.

pile driver operators relative to the 2022 employment level for this occupation. Thus, it will be critical to recognize the needs for expanding labor supply in occupations in which the supply needs are high in percentage terms, even if relatively low in absolute numbers.

Some of the occupations listed in Table 4 are also included in Table 5. These are occupations in which increases in labor demand generated by BIL, IRA, and CHIPS-based investments will be high both in absolute numbers and in percentage terms. Among these occupations are, for example, construction laborers, in which the absolute increase in labor demand is 80,900 and the percentage increase is 3.8 percent relative to the 2022 employment level; first-line supervisors of construction trades and extraction workers, in which the absolute labor demand increase is 40,000 and the percentage increase is 3.0 percent; and operating engineers and other construction equipment operators, in which the absolute labor demand increase is 32,500 and the percentage increase is 6.7 percent.

Overall, there is a total of 48 different occupations among those listed in Tables 4 and 5. These are the occupations in which the increase in the absolute level and/or the percentage increase in labor demand through the direct jobs channel is among the largest 30 across all occupations. In Table 6, we list all 48 occupations which are among the largest 30 according to either of our measures.

TABLE 6.

***Absolute Level* or *Percentage* Labor Demand Increases:**

48 Occupations with Either Largest Absolute Amount or Percentage Increase in Labor Demand due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment	Annual Direct Jobs Added as % of Total Direct Jobs
Construction laborers	80,900	3.8%	8.1%
First-line supervisors of construction trades and extraction workers	40,000	3.0%	4.0%
Electrical power-line installers and repairers	34,500	16.4%	3.5%
Operating engineers and other construction equipment operators	32,500	6.7%	3.3%
General and operations managers	29,000	0.6%	2.9%
Bus drivers, school	27,000	3.5%	2.7%
Carpenters	23,800	1.1%	2.4%
Miscellaneous assemblers and fabricators	22,900	1.4%	2.3%
Construction managers	22,100	2.3%	2.2%
Project management specialists	21,200	1.3%	2.1%
Shuttle drivers and chauffeurs	19,800	3.1%	2.0%
Office clerks, general	18,300	0.5%	1.8%
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	18,100	6.3%	1.8%
Heavy and tractor-trailer truck drivers	17,300	0.6%	1.7%
First-line supervisors of mechanics, installers, and repairers	16,200	1.8%	1.6%
Telecommunications line installers and repairers	15,400	9.7%	1.5%
Welders, cutters, solderers, and brazers	14,400	3.0%	1.4%
Secretaries and administrative assistants, except legal, medical, and executive	12,700	0.5%	1.3%
Bookkeeping, accounting, and auditing clerks	12,200	0.5%	1.2%
Bus drivers, transit and intercity	11,700	3.7%	1.2%
Electricians	11,700	3.6%	1.2%
Laborers and freight, stock, and material movers, hand	11,400	0.3%	1.1%
First-line supervisors of production and operating workers	9,900	1.4%	1.0%
Software developers	9,700	0.3%	1.0%
Customer service representatives	9,100	0.2%	0.9%
Accountants and auditors	9,000	0.4%	0.9%
Inspectors, testers, sorters, samplers, and weighers	8,800	1.3%	0.9%
Civil engineers	8,400	1.8%	0.8%
Sales representatives of services, except advertising, insurance, financial services, and travel	7,900	0.5%	0.8%
Industrial engineers	7,700	2.0%	0.8%

Continued

TABLE 6. *(continued)*

Absolute Level or _Percentage_ Labor Demand Increases

48 Occupations with Either Largest Absolute Amount or Percentage Increase in Labor Demand due to BIL, IRA, and CHIPS

Occupation Title	Number of Annual Direct Jobs	Annual Direct Jobs Added as % of 2022 Employment	Annual Direct Jobs Added as % of Total Direct Jobs
Plumbers, pipefitters, and steamfitters	5,500	3.1%	0.6%
Electrical engineers	5,200	2.1%	0.5%
School bus monitors	5,000	3.5%	0.5%
Mobile heavy equipment mechanics, except engines	5,000	2.4%	0.5%
Computer numerically controlled tool operators	3,900	2.1%	0.4%
Water and wastewater treatment plant and system operators	3,500	13.2%	0.4%
Electrical and electronic engineering technologists and technicians	3,000	2.7%	0.3%
Occupational health and safety specialists	3,000	2.3%	0.3%
Wind turbine service technicians	1,800	7.6%	0.2%
Industrial engineering technologists and technicians	1,800	2.5%	0.2%
Sheet metal workers	1,700	2.4%	0.2%
Crane and tower operators	1,600	3.2%	0.2%
Radio, cellular, and tower equipment installers and repairers	1,500	8.0%	0.2%
Solar photovoltaic installers	1,300	12.3%	0.1%
Pile driver operators	1,200	31.8%	0.1%
Semiconductor processing technicians	1,200	6.0%	0.1%
Coil winders, tapers, and finishers	1,100	9.6%	0.1%
Pipelayers	1,100	5.0%	0.1%
All 48 occupations	*632,000*		*63.4%*

Note: Figures in table are rounded.
Source: This table combines the occupations listed in Tables 4 and 5.

3. Analyzing 48 High-Demand Occupations by Job Entry Requirements

From the list of 48 specific occupations shown in Table 6 as experiencing large labor demand increases through the direct jobs channel with BIL, IRA, and CHIPS, we identify 21 occupations that do not require significant levels of prior training, educational credentials or prior work experience. We refer to these occupations as having relatively low entry requirements. The other 27 high-demand occupations do require some significant levels of training, educational credentials or prior work experience, i.e. they require one or more significant entry requirements. We consider these two groups of occupations in turn. We are focused, in particular, as to what these groups of occupations by entry requirements imply in terms of potential labor shortages resulting from BIL, IRA, and CHIPS-related investments.

21 Occupations with Relatively Low Entry Requirements

Table 7 lists the 21 occupations with relatively low entry requirements. In each of the 21 occupations, the formal educational credential is no more than a high school diploma or equivalent. Further, these occupations do not require prior work experience in a related job. The typical level of on-the-job training is either "short-term" or "moderate-term" as defined by the Labor Department. The Labor Department defines "short-term" training as one month or less of on-the-job experience and informal training. It defines "moderate-term" training as more than one month but less than one year of combined on-the-job experience and informal training.

In fact, virtually all of the jobs listed in Table 7 do entail significant skill requirements, even while the formal educational or training requirements are relatively modest. This becomes clear through considering the actual job requirements for workers in these 21 occupations. As examples among the occupations listed as requiring no more than a high school education, no related prior work experience and only "short-term" on-the-job training are pipelayers and customer service representatives. Pipelayers are responsible for assembling and connecting pipe systems for water mains, sewers and drains. Before laying pipes, they must inspect the ground, dig the pipe trenches, and seal the pipe joints successfully with cement glue. Customer service representatives typically must generate sales leads, build relationships with customers, handle customer complaints, provide appropriate solutions and follow up to ensure resolutions.[6]

Among the occupations listed that require "moderate-term" on-the-job training but no more than a high school diploma and no prior work experience in a related occupation are solar photovoltaic installers and semi-conductor processing technicians. Solar photovoltaic installers assemble, install, or maintain solar PV systems in compliance with site assessments and schematics. This can include measuring, cutting, assembling, and bolt-

TABLE 7.

21 Occupations with Low Entry Requirements

21 of the 48 Occupations with Largest Absolute Level or Percentage Labor Demand Increases Due to BIL, IRA, and CHIPS

Occupation Title	Entry-Level Requirements		Typical On-the-Job Training Needed to Attain Competency in the Occupation
	Typical Education Needed	Work Experience in a Related Occupation	
Construction laborers	No formal educational credential	None	Short-term on-the-job training
Laborers and freight, stock, and material movers, hand	No formal educational credential	None	Short-term on-the-job training
Pipelayers	No formal educational credential	None	Short-term on-the-job training
Shuttle drivers and chauffeurs	No formal educational credential	None	Short-term on-the-job training
Customer service representatives	High school diploma or equivalent	None	Short-term on-the-job training
Office clerks, general	High school diploma or equivalent	None	Short-term on-the-job training
Secretaries and administrative assistants, except legal, medical, and executive	High school diploma or equivalent	None	Short-term on-the-job training
School bus monitors	High school diploma or equivalent	None	Short-term on-the-job training
Bus drivers, school	High school diploma or equivalent	None	Short-term on-the-job training
Inspectors, testers, sorters, samplers, and weighers	High school diploma or equivalent	None	Moderate-term on-the-job training
Miscellaneous assemblers and fabricators	High school diploma or equivalent	None	Moderate-term on-the-job training
Sales representatives of services, except advertising, insurance, financial services, and travel	High school diploma or equivalent	None	Moderate-term on-the-job training
Solar photovoltaic installers	High school diploma or equivalent	None	Moderate-term on-the-job training
Pile drivers	High school diploma or equivalent	None	Moderate-term on-the-job training
Operating engineers and other construction equipment operators	High school diploma or equivalent	None	Moderate-term on-the-job training
Welders, cutters, solderers, and brazers	High school diploma or equivalent	None	Moderate-term on-the-job training
Coil winders, tapers, and finishers	High school diploma or equivalent	None	Moderate-term on-the-job training
Electrical, electronic, and electromechanical assemblers	High school diploma or equivalent	None	Moderate-term on-the-job training
Semiconductor processing technicians	High school diploma or equivalent	None	Moderate-term on-the-job training
Bus drivers, transit and intercity	High school diploma or equivalent	None	Moderate-term on-the-job training
Computer numerically controlled tool operators and programmers	High school diploma or equivalent	None	Moderate-term on-the-job training

Sources: U.S. Bureau of Labor Statistics, Employment Projections Program (2023a); Table 6.

ing structural framing and solar modules. Semi-conductor processing technicians identify and monitor production machines for quality. This entails identifying machine faults and production rate errors.[7]

The fact that, due to BIL, IRA, and CHIPS-related investments, employment demand will expand significantly in these 21 occupations with low entry requirements creates major new opportunities for workers who have not been strongly attached to a prior occupation or have faced a recent period of unemployment or underemployment. It also follows that the prospects are strong that job openings for these positions can be largely filled by the overall pool of available workers within the labor market of any given region of the country. If we allow that a significant share of currently unemployed or underemployed workers will be able to relocate to another region for a good job opportunity, then the full pool of unemployed and underemployed workers throughout the U.S. labor market can be drawn upon to fill the positions that are opening up in these 21 occupations with relatively modest credential requirements.

The data in Table 8 provides a sense of the opportunities that will become available in these 21 occupations through investments tied to BIL, IRA, and CHIPS. As we reported above, we estimate that a total of 310,000 jobs will be generated per year in these 21 occupations by BIL, IRA, and CHIPS-related investments. This figure contrasts with the 5.9 million people who were unemployed and a total of 11 million people who were unemployed, underemployed, or discouraged from looking for work in 2022.[8] That is, the 310,000 jobs in the 21 occupations with relatively low entry requirements amounts to only 5.3 percent of the total pool of unemployed workers and 2.8 percent of unemployed, underemployed, and discouraged workers in 2022. This is also while these labor market measures were at historically low levels in 2022. Thus, in considering the U.S. labor market overall, there is clearly more than sufficient supply of workers available to move into the roughly 300,000 jobs with relatively low entry requirements generated by BIL, IRA, and CHIPS-related investments.

As noted above, it is not realistic to expect, for example, that all 11 million unemployed, underemployed, and discouraged workers throughout the U.S. labor market will be able to move anywhere in the U.S. to accept one of the 310,000 new jobs in these 21 low entry requirement-occupations. Thus, in panel B of Table 8, we illustrate how these job openings may vary by region with estimates from our forthcoming state-level reports for Colorado, Michigan, Ohio, and Oregon.

These figures on increased labor demand in the four states are for *all occupations* through the direct jobs channel by BIL, IRA, and CHIPS-related investments, not only the 21 occupations with relatively low entry requirements. The relevant labor demand figures by detailed occupational categories are not available at the level of individual states. Still, from these more aggregated figures that are available, it is clear that the pool of unemployed and underemployed workers in these four states greatly exceeds the number of new jobs in all occupations generated by BIL, IRA, and CHIPS-related investments. As we see, the total labor demand increase ranges between 7.0 and 8.9 percent of unemployed,

TABLE 8.
Job Creation Through BIL, IRA, and CHIPS Relative to Unemployment Levels: U.S. and State-Level Figures

A) U.S. Labor Market: Increased Labor Demand Through BIL, IRA, and CHIPS for 21 Occupations with Low Entry Requirements Relative to Unemployment Levels
Increased Labor Demand for 21 Occupations = 310,000 jobs

National unemployment level (U-3), 2022	5.9 million
Increased labor demand for 21 occupations relative to unemployment level	5.3% *(=310,000/5.9 million)*
National unemployment + underemployment + discouraged worker level (U-6), 2022	11.0 million
Increased labor demand for 21 occupations relative to unemployment + underemployment + discouraged worker level	2.8% *(=310,000/11 million)*

Sources: U.S. Bureau of Labor Statistics (2024a, 2024b); Table 7.

B) Four State Labor Markets: Increased Labor Demand Through BIL, IRA, and CHIPS for all Occupations Relative to Unemployment Levels

	Increased Labor Demand Through BIL, IRA, and CHIPS	Labor Demand Increase as Share of Unemployment Level (U-3)	Labor Demand Increase as Share of Unemployment + Underemployment + Discouraged Worker Level (U-6)
Colorado	15,500	15.5%	7.4%
Michigan	25,000	12.6%	7.5%
Ohio	35,200	15.6%	8.9%
Oregon	11,500	12.5%	7.0%

Note: Figures in table are rounded.
Sources: Pollin et al. (forthcoming); U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics (2023).

underemployed, and discouraged workers in Colorado, Michigan, Ohio, and Oregon. If we then further assume roughly that labor demand for the 21 lower-credentialed occupations amounts to about one-third of all new jobs generated by BIL, IRA, and CHIPS—as is true for the overall U.S. labor market—that would suggest that these percentages for the four states for labor demand for the 21 low entry-requirement occupations will be similar to the national figure. That is, within the Colorado, Michigan, Ohio and Oregon labor markets, the total labor demand increase through BIL, IRA, and CHIPS-related investments would amount to between 2 and 3 percent of total unemployed, underemployed, and discouraged workers in these four states as of 2022.

In short, within all regions of the U.S. economy, investments tied to BIL, IRA, and CHIPS will generate significant opportunities in occupations with relatively low credential requirements. At the same time, these job opportunities represent relatively small shares of available unemployed, underemployed, and discouraged workers, even while looking at the state-level. This correspondingly means that we should not expect significant labor shortages to emerge in these 21 occupations resulting from BIL, IRA, and CHIPS-related investments.

27 Occupations with Significant Entry Requirements

The 27 occupations on our full list of 48 occupations that do require significant prior training, educational credentials, or on-the-job experience can be grouped into three categories of training, education, or experience. These are:

- Occupations requiring training or prior experience along with a high school diploma;
- Occupations requiring an apprenticeship program or similar training and a high school diploma[9];
- Occupations with postsecondary educational requirements.

These 27 occupations are listed in Table 9. As we see in Table 9, these 27 listed occupations include a range of requirements. Some require only a high-school degree but some significant on-the-job training. Others entail higher degrees of formal education. Five of the 27 occupations require significant work experience. Up to 5 years of prior experience are required for crane and tower operators, first-line supervisors of mechanics, and first-line supervisors of production and operating workers. Five years or more of experience are needed for first-line supervisors of construction trades and extraction and general and operations managers.

TABLE 9.

27 Occupations with Significant Entry Requirements

27 of the 48 Occupations with Largest Absolute Level or Percentage Labor Demand Increases due to BIL, IRA, and CHIPS

Occupation Title	Entry-Level Requirements		Typical On-the-Job Training Needed to Attain Competency in the Occupation
	Typical Education Needed	Work Experience in a Related Occupation	
Crane and tower operators	High school diploma or equivalent	Up to 5 years	Moderate-term on-the-job training
First-line supervisors of mechanics, installers, and repairers	High school diploma or equivalent	Up to 5 years	None
First-line supervisors of production and operating workers	High school diploma or equivalent	Up to 5 years	None
Mobile heavy equipment mechanics, except engines	High school diploma or equivalent	None	Long-term on-the-job training
Electrical power-line installers and repairers	High school diploma or equivalent	None	Long-term on-the-job training
Water and wastewater treatment plant and system operators	High school diploma or equivalent	None	Long-term on-the-job training
First-line supervisors of construction trades and extraction	High school diploma or equivalent	5 years or more	None
Carpenters	High school diploma or equivalent	None	Apprenticeship
Electricians	High school diploma or equivalent	None	Apprenticeship
Sheet metal workers	High school diploma or equivalent	None	Apprenticeship
Plumber, pipefitters, steamfitters	High school diploma or equivalent	None	Apprenticeship
Heavy and tractor-trailer truck drivers	Postsecondary nondegree award	None	Short-term on-the-job training
Telecommunications line installers and repairers	Postsecondary nondegree award	None	Moderate-term on-the-job training
Wind turbine service technicians	Postsecondary nondegree award	None	Long-term on-the-job training
Bookkeeping, accounting, and auditing clerks	Some college, no degree	None	Moderate-term on-the-job training
Radio, cellular, tower equip install and repairers	Associates degree	None	Moderate-term on-the-job training
Industrial engineering technologists and technicians	Associates degree	None	None
Electrical and electronic engineering technologists and technicians	Associates degree	None	None
Accountants and auditors	Bachelor's degree	None	None
Civil engineers	Bachelor's degree	None	None
Construction managers	Bachelor's degree	None	Moderate-term on-the-job training
Electrical engineers	Bachelor's degree	None	None
General and operations managers	Bachelor's degree	5 years or more	None
Industrial engineers	Bachelor's degree	None	None
Occupational health and safety specialists	Bachelor's degree	None	None
Project management specialists	Bachelor's degree	None	None
Software developers	Bachelor's degree	None	None

Sources: U.S. Bureau of Labor Statistics, Employment Projections Program (2023a); Table 6.

4. Estimating Potential Labor Surpluses and Shortages for 27 Occupations with Significant Entry Requirements

In this section, we describe our approach for estimating likely labor surpluses and shortages that would result within the current U.S. labor market as investment activities generated by BIL, IRA, and CHIPS expand to their full targeted levels.

Our definitions of "labor surplus" and "labor shortage" occupations are straightforward. "Labor surplus" occupations are those in which our estimate of the available supply of workers in the occupation is *greater than* the demand that would be generated through BIL, IRA, and CHIPS-related investments, in combination with other factors within the U.S. economy that impact labor demand. "Labor shortage" occupations are those in which we estimate the available supply of workers in an occupation is *less than* the demand that would be generated through BIL, IRA, and CHIPS investments, in combination with other factors within the U.S. economy that impact labor demand.

As we have noted at the outset, of the 27 high-demand occupations with significant entry requirements, we estimate that there are likely to be labor surpluses in 7 and labor shortages in 20 of the 27 occupations in total with significant entry requirements. The steps we have taken to derive these estimates are as follows.

To begin with, we calculate labor supply based on a midpoint estimate of the unemployment level for each specific occupation as well as, where relevant, the number of people who have completed, in 2022, the appropriate apprentice or college-level programs (see Appendix for details). We then measure labor demand based on projections of: 1) annual economic growth in each occupation; 2) projected retirement rates in the various occupations; as well as 3) the additional labor demand generated through the direct jobs channel by BIL, IRA, and CHIPS-related investments.

More specifically, in Table 10, we report estimates of increases in labor demand for the 27 occupations that we listed in Table 9. To estimate overall demand for these occupations, we first generate our own estimates of increased labor demand due to: 1) the average economic growth trajectory in the relevant occupations; and 2) normal retirement rates for workers in the relevant occupations; along with 3) increased demand generated through the direct jobs channel by BIL, IRA, and CHIPS investments. These are the figures we report in columns 1 – 3 and add up in column 4 of Table 10.

Next, we present in column 5, an alternative set of labor demand estimates by occupation provided by the U.S. Labor Department (DOL). The DOL's methodology for estimating their labor demand figures have both similarities and differences with ours. On the one hand, these DOL labor demand figures similarly take account of changes due to economic growth and retirements. On the other hand, the DOL estimates adds to their modeling the

TABLE 10.
Overall Increase in Labor Demand for 27 Occupations with Significant Entry Requirements

	Estimate of Total Labor Demand Increase						
	1) BIL, IRA, and CHIPS as Source of Increased Labor Demand	2) Economic Growth as Source of Increased Labor Demand	3) Retirements as Source of Increased Labor Demand	4) Total Labor Demand Increase *(columns 1+2+3)*	5) Alternative DOL Estimate of Total Labor Demand Increase	6) Midpoint Estimate of Labor Demand Increase *(midpoint of columns 4 and 5)*	7) Pct. of Increased Labor Demand from BIL, IRA, and CHIPS *(columns 1/6)*
General and operations managers	29,000	182,400	273,700	485,100	425,700	455,400	6.4%
Software developers	9,700	258,800	76,700	345,200	271,600	308,400	3.1%
Heavy and tractor-trailer truck drivers	17,300	9,200	92,000	118,500	337,200	227,850	7.6%
Bookkeeping, accounting, and auditing clerks	12,200	-88,800	266,300	189,700	247,600	218,650	5.6%
Accountants and auditors	9,000	58,300	162,000	229,300	177,100	203,200	4.4%
Carpenters	23,800	4,200	127,100	155,100	172,900	164,000	14.5%
Project management specialists	21,200	95,900	83,100	200,200	123,100	161,650	13.1%
First-line supervisors of construction trades and extraction workers	40,000	-5,300	87,500	122,200	108,700	115,450	34.6%
Construction managers	22,100	65,100	62,200	149,400	72,600	111,000	19.9%
First-line supervisors of mechanics, installers, and repairers	16,200	-7,100	42,500	51,600	75,200	63,400	25.6%
First-line supervisors of production and operating workers	9,900	9,400	39,100	58,400	67,400	62,900	15.7%
Civil engineers	8,400	29,000	29,500	66,900	29,900	48,400	17.4%
Industrial engineers	7,700	18,800	19,200	45,700	27,500	36,600	21.0%
Electrical power-line installers and repairers	34,500	6,300	13,000	53,800	16,600	35,200	98.0%

Continued

TABLE 10. *(continued)*
Overall Increase in Labor Demand for 27 Occupations with Significant Entry Requirements

	Estimate of Total Labor Demand Increase				5) Alternative DOL Estimate of Total Labor Demand Increase	6) Midpoint Estimate of Labor Demand Increase *(midpoint of columns 4 and 5)*	7) Pct. of Increased Labor Demand from BIL, IRA, and CHIPS *(columns 1/6)*
	1) BIL, IRA, and CHIPS as Source of Increased Labor Demand	2) Economic Growth as Source of Increased Labor Demand	3) Retirements as Source of Increased Labor Demand	4) Total Labor Demand Increase *(columns 1+2+3)*			
Electricians	11,700	11,500	15,100	38,300	31,400	34,850	33.6%
Electrical engineers	5,200	2,700	16,200	24,100	14,200	19,150	27.2%
Mobile heavy equipment mechanics, except engines	5,000	0	11,400	16,400	18,700	17,550	28.5%
Telecommunications line installers and repairers	15,400	0	4,000	19,400	15,600	17,500	88.0%
Plumbers, pipefitters, and steamfitters	5,500	4,500	7,400	17,400	15,800	16,600	33.1%
Electrical and electronic engineering technologists and technicians	3,000	6,800	8,400	18,200	10,800	14,500	20.7%
Occupational health and safety specialists	3,000	0	6,000	9,000	16,400	12,700	23.6%
Industrial engineering technologists and technicians	1,800	4,400	5,400	11,600	6,800	9,200	19.6%
Sheet metal workers	1,700	3,400	4,700	9,800	6,300	8,050	21.1%
Water and wastewater treatment plant and system operators	3,500	2,300	2,500	8,300	2,200	5,250	66.7%
Crane and tower operators	1,600	-1,500	2,900	3,000	4,500	3,750	42.7%
Wind turbine service technicians	1,800	-1,000	1,600	2,400	3,800	3,100	58.1%
Radio, cellular, and tower equipment installers and repairers	1,500	-100	1,200	2,600	2,000	2,300	65.2%

Note: Figures in table are rounded.
Source: See Appendix.

labor demand impacts of worker quits and career changes, and focus less on the specifics of the BIL, IRA, and CHIPS-related employment impacts. To take advantage of the information supplied by Labor Department estimates, we use as our final working estimate the midpoint figure between our own overall labor demand estimate in column 4 and the Labor Department estimate in column 5. We report these figures in column 6 of Table 10.

Finally, in column 7, we report our estimate of the share of overall labor demand by occupation generated through the direct jobs channel by BIL, IRA, and CHIPS investments. We estimate this by dividing figures in column 1 by those in column 6. As we see in column 7, our estimate of the BIL/IRA/CHIPS share of overall labor demand increase varies widely among the 27 listed occupations. The lowest share is 3.1 percent of the 308,400 labor demand increase for software developers. The high figure is 98.0 percent for the 35,200 electrical power-line installers and repairers. The average share for BIL/IRA/CHIPS as a source of overall labor demand increase for these 27 occupations is 30.2 percent.

In Tables 11 and 12, we divide up the full set of 27 occupations we included in Tables 9 and 10—i.e. the 27 high-demand occupations that also require significant entry requirements. Table 11 first lists the 7 occupations among the 27 total in which, by our estimates, there will likely be labor surpluses relative to the labor demand increase. Table 12 then includes the 20 remaining occupations in which we estimate there will be likely labor shortages relative to the labor demand increase. Both the Table 11 and Table 12 figures are listed according to our estimate of the absolute size of either the labor surplus or labor shortage for each of the listed occupations.

In focusing in particular on the 20 labor shortage occupations in Table 12, we have also grouped these occupations according to the extent of training, experience or formal educational attainment that is necessary in each occupation. Our three groupings, again, are:

- Occupations requiring training or prior experience along with a high school diploma;
- Occupations requiring an apprenticeship program or similar training and a high school diploma;
- Occupations with postsecondary educational requirements.

In principle, it would be useful to also identify occupations in which increased labor demand through BIL, IRA, and CHIPS-related investments are in approximate balance with the available labor supply in these occupations. A reasonable measure for an occupation in approximate demand/supply balance would be when the difference between labor demand and supply is no more than 10 percent either way—i.e. labor demand is no more than 10 percent greater than labor supply or labor supply is no more than 10 percent greater than labor demand.

By this definition, none of the 27 occupations listed in Tables 11 and 12 are in approximate balance. With respect to the labor surplus occupations in Table 11, the one with the closest relationship between labor supply and demand is sheet metal workers, in which the labor supply is approximately 17 percent greater than labor demand. With the labor short-

TABLE 11.

Estimates of Labor Surpluses for 7 Occupations with Significant Entry Requirements

Occupations with Likely Labor Supply Surpluses Associated with BIL, IRA and CHIPS Investments at Full Targeted Levels

	1) Increased Labor Demand	2) Labor Supply	3) Labor Demand Increases Relative to Labor Supply *Percentages (= columns 1-2)/(column 1)*	4) Labor Demand Increases Relative to Labor Supply *Number of Jobs (=columns 1-2)*
1) Project management specialists	161,650	303,450	-87.7%	-141,800
2) Plumber, pipefitters, steamfitters	16,600	36,400	-119.3%	-19,800
3) Electricians	34,850	54,550	-56.5%	-19,700
4) Electrical engineers	19,150	30,350	-58.5%	-11,200
5) Industrial engineering technologists and technicians	9,200	13,750	-49.5%	-4,550
6) Wind turbine service technicians	3,100	6,740	-117.4%	-3,640
7) Sheet metal workers	8,050	9,450	-17.4%	-1,400

Note: Figures in table are rounded.
Source: See Appendix.

age occupations in Table 12, the demand for general and operations managers is approximately 11 percent greater than the available labor supply. With electrical and electronic engineering technologists and technicians, labor demand is approximately 16 percent greater than the available labor supply.

Overall, the results are generally clear as to the occupations in which labor shortages should emerge as BIL, IRA, and CHIPS-related investments reach their full levels of activity, and correspondingly, where labor surpluses should be available to fill the expansion of employment resulting from these programs. Table 13 provides aggregated summary figures of our results. As we see there, again, we estimate that 7 occupations will experience labor surpluses, with the full extent of surpluses for all 7 occupations totaling to about 200,000 jobs. With the 20 occupations that we estimate will experience labor shortages, the full extent of these shortages will be about 1.1 million jobs. Note again that these figures for surpluses and shortages take account of the impact of BIL, IRA, and CHIPS investments *combined with* the other sources generating labor demand for these occupations—i.e. overall economic growth and retirement rates for the respective occupations.

TABLE 12.

Estimates of Labor Shortages for 20 Occupations with Significant Entry Requirements

Occupations with Likely Labor Supply Shortages Associated with BIL, IRA, and CHIPS Investments at Full Targeted Levels

A) Occupations Requiring Training or Prior Experience Along with High School Diploma

	1) Increased Labor Demand	2) Labor Supply	3) Labor Demand Increases Relative to Labor Supply *Percentages (= columns 1-2)/(column 1)*	4) Labor Demand Increases Relative to Labor Supply *Number of Jobs (=columns 1-2)*
1) First-line supervisors of construction trades and extraction	115,400	23,900	79.3%	91,500
2) First-line supervisors of mechanics, installers, and repairers	63,400	2,550	96.0%	60,850
3 First-line supervisors of production and operating workers	62,900	15,500	75.4%	47,400
4 Electrical power-line installers and repairers	35,200	3,950	88.8%	31,250
5) Mobile heavy equipment mechanics (except engines)	17,550	5,350	69.5%	12,200
6) Water and wastewater treatment plant and system operators	5,250	500	90.5%	4,750
7) Crane and tower operators	3,750	2,700	28.0%	1,050

.

B) Occupations Requiring Apprentice Program or Similar Training and High School Diploma

	1) Increased Labor Demand	2) Labor Supply	3) Labor Demand Increases Relative to Labor Supply *Percentages (= columns 1-2)/(column 1)*	4) Labor Demand Increases Relative to Labor Supply *Number of Jobs (=columns 1-2)*
8) Carpenters	164,000	100,550	38.7%	63,450

.

Continued

TABLE 12. *(continued)*

Estimates of Labor Shortages for 20 Occupations with Significant Entry Requirements

Occupations with Likely Labor Supply Shortages Associated with BIL, IRA, and CHIPS Investments at Full Targeted Levels

C) Occupations with Postsecondary Educational Requirements

	1) Increased Labor Demand	2) Labor Supply	3) Labor Demand Increases Relative to Labor Supply *Percentages (= columns 1-2)/(column 1)*	4) Labor Demand Increases Relative to Labor Supply *Number of Jobs (=columns 1-2)*
9) Bookkeeping, accounting, and auditing clerks	218,650	43,200	80.2%	175,450
10) Heavy and tractor-trailer truck drivers	227,850	54,250	76.2%	173,600
11) Software developers	308,400	152,000	50.7%	156,400
12) Accountants and auditors	203,200	91,450	55.0%	111,750
13) Construction managers	111,000	46,600	58.0%	64,600
14) General and operations managers	455,000	407,050	10.5%	47,950
15) Civil engineers	48,400	30,250	37.5%	18,150
16) Industrial engineers	36,600	21,750	40.6%	14,850
17) Telecommunications line installers and repairers	17,500	3,970	77.3%	13,530
18) Occupational health and safety specialists	12,700	6,350	50.0%	6,350
19) Electrical and electronic engineering technologists and technicians	14,500	12,200	15.9%	2,300
20) Radio, cellular tower equipment installers and repairers	2,300	1,740	24.3%	560

Note: Figures in table are rounded.
Source: See Appendix.

TABLE 13.

Summary Figures for Labor Surplus and Labor Shortage Occupations Among 27 Occupations with Significant Entry Requirements

	Occupations with Labor Surpluses	Occupations with Labor Shortages
Number of occupations	7	20
Overall extent of surpluses/shortages *(based on BIL, IRA, and CHIPS investments and all other labor demand sources)*	202,090	1,097,760

Source: Tables 11 and 12.

5. Sectoral and Demographic Composition with the 20 Labor-Shortage Occupations

Sectoral Shortages: Predominantly in Construction

In Table 14, we provide figures for the three sectors with the largest concentration of direct jobs created by BIL, IRA, and CHIPS for each of the 20 occupations in which we have estimated a high likelihood of facing labor shortages. As Table 14 shows, construction is by far the sector with the highest concentration of occupational employment that is likely to experience labor shortages as BIL, IRA, and CHIPS investments expand to reach their full targeted levels. The construction sector has the largest concentration of employment with 14 of the 20 occupations in which we anticipate likely labor shortages. Moreover, in 11 of these 20 occupations, construction industry jobs account for 50 percent or more of overall employment, and with 7 of the 20 occupations, the construction sector accounts for fully 80 percent or more of overall jobs.

Further, construction sector jobs are most prevalent in all three of the categories we present in Table 14 that sort the 20 occupations according to their respective training, experience, and educational requirements. Thus, jobs in the construction sector are most prevalent for 5 of the 7 occupations that require some training or prior experience along with a high school diploma. The construction sector is still most prevalent in 8 of the 12 occupations which require postsecondary educational credentials.

In addition to these figures for the construction sector, manufacturing sector jobs are most prevalent in 4 of the 20 occupations overall. The utilities and information sectors are most prevalent in 1 occupation each.

Broadly speaking, in multiple employment areas, the expansion of BIL, IRA, and CHIPS-related investments to their full targeted levels will generate corresponding needs for increased training, apprenticeships, and postsecondary educational programs. Clearly though, working from the Table 14 results, a high priority area for expanding such programs should be with a large number of construction occupations.

Demographic Disparities by Gender, Race, and Ethnicity

In Table 15, we provide figures on the demographic composition of the current workforce employed in the 20 occupations that are likely to face labor shortages resulting from BIL, IRA, and CHIPS-related investments. These figures are useful, in particular, because they suggest ways through which the overall expansion of employment through BIL, IRA, and CHIPS can also create opportunities to diversify the workforce in occupations that are presently dominated by men or White workers.

TABLE 14.

Economic Sectors with Highest Employment Concentration Among 20 Occupations with Likely Labor Supply Shortages

Includes 3 sectors with highest concentration of newly created direct jobs in occupations facing likely labor shortages

A) Occupations Requiring Training or Prior Experience Along with High School Diploma

Occupations	Sectors in Which Occupations Are Concentrated		
1) First-line supervisors of construction trades and extraction	Construction (97.5%)	Administrative and support and waste management and remediation services (0.5%)	Manufacturing (0.5%)
2) First-line supervisors of mechanics, installers, and repairers	Construction (83.9%)	Manufacturing (5.0%)	Transportation and warehousing (3.9%)
3) First-line supervisors of production and operating workers	Manufacturing (82.5%)	Utilities (7.0%)	Construction (5.7%)
4) Electrical power-line installers and repairers	Construction (98.3%)	Utilities (1.7%)	Information (0.02%)
5) Mobile heavy equipment mechanics (except engines)	Construction (84.9%)	Agriculture, forestry, fishing, and hunting (6.0%)	Other services (except public administration) (2.8%)
6) Water and wastewater treatment plant and system operators	Utilities (98.0%)	Administrative and support and waste management and remediation services (1.3%)	Manufacturing (0.3%)
7) Crane and tower operators	Construction (81.3%)	Transportation and warehousing (8.8%)	Manufacturing (7.6%)

B) Occupations Requiring Apprentice Program or Similar Training with High School Diploma

Occupation	Sectors in Which Occupations Are Concentrated		
8) Carpenters	Construction (67.6%)	Manufacturing (19.1%)	Agriculture, forestry, fishing, and hunting (5.3%)

Continued

TABLE 14. *(continued)*

Economic Sectors with Highest Employment Concentration Among 20 Occupations with Likely Labor Supply Shortages

C) Occupations with Postsecondary Educational Requirements

Occupations	Sectors in Which Occupations Are Concentrated		
9) Bookkeeping, accounting, and auditing clerks	Construction (49.5%)	Manufacturing (13.8%)	Professional, scientific, and technical services (9.0%)
10) Heavy and tractor-trailer truck drivers	Construction (39.3%)	Transportation and warehousing (30.1%)	Agriculture, forestry, fishing, and hunting (13.8%)
11) Software developers	Manufacturing (43.5%)	Professional, scientific, and technical services (36.5%)	Information (13.9%)
12) Accountants and auditors	Construction (44.3%)	Manufacturing (23.1%)	Professional, scientific, and technical services (17.9%)
13) Construction managers	Construction (98.6%)	Professional, scientific, and technical services (0.7%)	Utilities (0.3%)
14) General and operations managers	Construction (44.9%)	Professional, scientific, and technical services (15.7%)	Manufacturing (15.5%)
15) Civil engineers	Construction (71.5%)	Professional, scientific, and technical services (26.4%)	Utilities (1.0%)
16) Industrial engineers	Manufacturing (82.8%)	Professional, scientific, and technical services (11.1%)	Construction (3.0%)
17) Telecommunications line installers and repairers	Information (71.9%)	Construction (23.9%)	Professional, scientific, and technical services (2.3%)
18) Occupational health and safety specialists	Construction (71.1%)	Manufacturing (10.0%)	Professional, scientific, and technical services (8.6%)
19) Electrical and electronic engineering technologists and technicians	Manufacturing (74.1%)	Professional, scientific, and technical services (12.1%)	Construction (10.7%)
20) Radio, cellular tower equipment installers and repairers	Construction (95.5%)	Information (3.1%)	Manufacturing (1.2%)

Note: See Tables 7 and 9 for more details on job requirements.
Source: See Appendix.

TABLE 15.
Gender and Race Composition of Workers in Occupations with Likely Labor Supply Shortages, 2022

Occupation	By Gender		% White, non-Latinx	% BIPOC (incl. Latinx)					
	% Men***	% Women***		Total, % BIPOC (incl. Latinx)	% Black, non-Latinx	% Asian, non-Latinx	% Amer. Indian/ Aleut/ Eskimo, non-Latinx	% Other*, non-Latinx	% Latinx**
Total U.S. workforce	53.2%	46.8%	60.5%	39.5%	12.7%	6.9%	0.7%	0.9%	18.6%
First-line supervisors of construction trades and extraction	95.8%	4.2%	66.9%	33.1%	4.1%	1.6%	1.4%	0.3%	25.8%
First-line supervisors of mechanics, installers, and repairers	94.7%	5.3%	76.1%	23.9%	5.4%	4.0%	1.6%	1.0%	11.9%
First-line supervisors of production and operating workers	77.4%	22.6%	59.4%	40.6%	15.2%	6.5%	0.3%	0.3%	18.5%
Electrical power-line installers and repairers	98.5%	1.5%	78.5%	21.5%	5.5%	0.8%	1.3%	1.8%	12.1%
Mobile heavy equipment mechanics, except engines	98.7%	1.3%	75.3%	24.7%	4.5%	0.2%	0.6%	0.9%	18.5%
Water and wastewater treatment plant and system operators	93.6%	6.4%	78.0%	22.0%	10.5%	0.6%	0.4%	0.4%	11.0%
Crane and tower operators	99.4%	0.6%	77.1%	22.9%	7.0%	1.5%	0.0%	0.0%	14.4%
Carpenters	96.5%	3.5%	50.5%	49.5%	4.9%	2.0%	0.5%	0.7%	41.7%
Bookkeeping, accounting, and auditing clerks	15.0%	85.0%	69.5%	30.5%	8.8%	6.3%	0.5%	0.6%	14.7%

Continued

TABLE 15. *(continued)*
Gender and Race Composition of Workers in Occupations with Likely Labor Supply Shortages, 2022

Occupation	By Gender		% White, non-Latinx	% BIPOC (incl. Latinx)					
	% Men***	% Women***		Total, % BIPOC (incl. Latinx)	% Black, non-Latinx	% Asian, non-Latinx	% Amer. Indian/ Aleut/ Eskimo, non-Latinx	% Other*, non-Latinx	% Latinx**
Heavy and tractor-trailer truck drivers	89.9%	10.1%	40.3%	59.7%	25.5%	1.7%	0.5%	1.1%	31.5%
Software developers	78.1%	21.9%	50.3%	49.7%	5.5%	36.1%	0.6%	1.4%	6.0%
Accountants and auditors	41.2%	58.8%	67.7%	32.3%	9.7%	11.9%	0.5%	0.7%	9.6%
Construction managers	91.5%	8.5%	74.7%	25.3%	5.1%	2.7%	0.4%	0.8%	16.5%
General and operations managers	64.6%	35.4%	71.1%	28.9%	9.7%	5.6%	0.7%	1.4%	11.6%
Civil engineers	83.1%	16.9%	65.5%	34.5%	5.6%	16.0%	0.2%	0.5%	12.3%
Industrial engineers	75.2%	24.8%	67.3%	32.7%	8.0%	16.9%	0.2%	1.2%	6.3%
Telecommunications line installers and repairers	95.3%	4.7%	64.3%	35.7%	10.1%	1.3%	1.1%	1.5%	21.8%
Occupational health and safety specialists	50.8%	49.2%	68.5%	31.5%	8.2%	11.0%	0.6%	1.1%	10.9%
Electrical and electronic engineering technologists and technicians	85.8%	14.2%	63.4%	36.6%	11.8%	9.4%	0.1%	0.6%	14.6%
Radio, cellular, tower equip. install and repairers	85.8%	14.2%	58.4%	41.6%	11.6%	4.5%	0.1%	0.7%	25.5%

Note: *"Other" includes the following groups: Hawaiian/Pacific Islanders and multi-racial. ** The CPS survey, on which these data are based, asks respondents to identify whether they are "Spanish, Hispanic, or Latino." We use Latinx here because of the growing usage of this ethnic category to identify people with Latin American, as opposed to, Spanish heritage. We use Latinx to be more inclusive across gender categories. ***Labor Department data include only binary gender categories.
Source: Authors' analysis of 2022 Basic Monthly data files of the Current Population Survey.

The largest current demographic disparity in these 20 occupations is with respect to gender. Employment is dominated by male workers in most of the jobs. This is not surprising, given that, as we have seen, most of the occupations are within the historically male-dominated construction sector. Thus, for the overall U.S. workforce, about 53 percent of all jobs are held by men. But male workers accounted for at least 90 percent or more of the workforce in 10 of the 20 occupations and at least 75 percent in 16 of the 20 occupations in which we have estimated labor shortages emerging through BIL, IRA, and CHIPS-related investments. The only occupation in this grouping of 20 in which women are dominant is in bookkeeping, accounting, and auditing clerks. Among this occupation, women make up 85 percent of the workforce. Women are also a majority, with 59 percent of the workforce, of accountants and auditors.

One important implication from these figures on gender demographics is that the training, apprenticeship, and postsecondary educational programs that are needed to increase the supply of workers in these 20 occupations should be actively recruiting women. This is especially the case with respect to all the relevant construction occupations. Recruitment efforts should be fortified by pre-apprenticeship programs that prepare candidates for apprenticeship programs[10], as well as affirmative action plans such as those required for construction contracts that receive significant federal funding to ensure equitable access.[11] Wrap-around services such as subsidized childcare, mentoring programs, and effective sexual harassment prevention policies should be implemented to improve the retention of women in training programs.[12] Similar efforts need to take place at the workplace to recruit, retain and promote women into occupations that have been historically inaccessible to them and to reform workplace environments that have impeded their inclusion.

There are also significant disparities by race and ethnicity within most of these 20 occupations, though not as large as the gender-based disparities. Thus, for the overall U.S. workforce, White non-Latinx workers comprise about 61 percent of the total pool of workers. But the share of White non-Latinx workers exceeds 61 percent in 15 of the 20 occupations with likely labor shortages resulting from BIL, IRA, and CHIPS-related investments. Broadly speaking, this result follows from the fact that the U.S. construction workforce has long been not only male-dominated, but, more specifically, White male-dominated. Again, these racial disparities point to the need for more intentional recruiting, hiring, retention, and promotion policies.[13] In addition to the interventions described above, transportation subsidies may be important in cases where potential workers from under-represented racial and ethnic groups do not live near sites of employment. Anti-racism trainings and policies paired with affirmative action hiring plans will also be important as discrimination continues to act as a barrier to employment.[14]

There are two exceptions to this pattern within the construction jobs among the 20 occupations. These are carpenters, in which roughly half of the current workforce is Black, Indigenous, and people of color (BIPOC), with 42 percent being Latinx; and heavy and tractor trailer truck drivers, in which nearly 60 percent of the current workforce are BIPOC. Among these 60 percent, 26 percent are Black and 32 percent are Latinx. Outside the construction

occupations, among software developers, about half are BIPOC. In this case, 36 percent of the 50 percent BIPOC are Asian.

In the two occupations in which women workers are a majority—i.e. bookkeeping, accounting, and auditing clerks; and accountants and auditors—most of the current workforce are still White female workers.

Overall again, these figures suggest that the training, apprenticeship and postsecondary education programs that are needed to expand the labor supply in these 20 occupations should be committed to recruiting and retaining people from underrepresented groups. These recruitment and retention efforts should also extend into the workplace. This will enable workers to most effectively access the growing opportunities being generated by BIL, IRA, and CHIPS-related investments.

Appendix

1. Literature on Identifying Labor Supply Shortages

There is no single agreed-upon *indicator* or set of indicators for estimating labor supply shortages for a single economic sector or occupation. Rather, researchers have drawn upon a range of labor market measures, including, in some cases, qualitative as well as quantitative data.

One valuable and indicative study is a 1999 paper by Carolyn M. Veneri of the U.S. Labor Department's Bureau of Labor Statistics. In this paper, titled "Can Occupational Labor Shortages be Identified using Available Data?" Veneri writes:

> No specific sources of data exist that provide a measure of occupational shortages. In the absence of any definitive measure, analysts generally rely on labor market data to corroborate anecdotal reports of employers' difficulties in filling jobs. Such data include trends in employment and earnings as well as the unemployment rate for a particular occupation (p. 150).

Veneri reviews various conceptions of labor market shortages as well as previous efforts to operationalize these concepts. This includes labor market survey work performed under the rubric of the broader standard Current Population Survey (CPS) and the Occupational Employment Survey (OES). Veneri concludes as follows:

> In sum, CPS and OES data provide insight into changes in labor market conditions for specific occupations. Used alone, however, these data are not adequate to definitively identify the existence of labor market shortages for a specific occupation. Besides, limiting analysis to indicators such as employment, unemployment, and wages does not present a complete picture of the market for a particular occupation. The labor market data should be combined with background information on the occupation and knowledge of the workings of the labor market. In addition, information on supply, such as data on demographic characteristics, education by field of study, and employer's requirement regarding education and training plays a significant role in completing an analysis of an occupation's labor market. Current and potential occupational shortages can best be analyzed on a case by case basis, and the analysis should focus on one occupation or a group of related occupations and should provide a detailed investigation into factors affecting supply and demand. Conclusions about shortages should not be based on general labor market statistics alone or anecdotal evidence alone (p. 21).

A more recent 2013 study by Barnow, Trutko, and Piatek titled "How Do We Know Occupational Labor Shortages Exist" reached conclusions similar to those by Veneri. Barnow et al. write:

> Measuring occupational shortages is difficult. There are many reasons why it is difficult to determine if a shortage is present. First, the best indication of a shortage is an increase in the number and duration of vacancies, but in the United States occupational vacancy data are not available for most occupations. Second, there is no precise dividing line between a tight labor market and a shortage. Third, the Standard Occupational Classification (SOC) system used in the United States measures occupations too coarsely for measuring shortages; for example, all computer programmers are included in a single occupation, but employers want programmers with specific skills, such as Java or HTML. Finally, using interviews to assess the presence of a shortage is imprecise (p. 6).

In the absence of a straightforward set of indicators, efforts to estimate shortages have generally followed the approach by Veneri (1999) of combining available labor market data on both labor supply and demand. For example, a 2018 study by Evan Linksy of the Michigan's Bureau of Labor Market Information and Strategic Initiatives identifies occupational labor shortages in the state's labor market by constructing indices of labor supply and demand from existing measures. His labor supply index includes data on employment level and change and completers of post-secondary educational programs. He constructs a labor demand index from a database of online job postings, projected occupational job openings and growth. A comparison of the labor supply and labor demand index scores determines each occupation's labor supply status—that is, whether, for individual occupations, there exists a shortage, a surplus or a balance between labor supply and demand.

A 2022 paper by Bauer, Edelberg and Estep titled "A Closer Look at a Hot Labor Market," uses data on job openings and hiring from the Labor Department's Job Openings and Labor Turnover Survey (JOLTS) program by industry to assess whether various segments of the U.S. labor market are "hot" (experiencing large expansions) or "tight" (employers are experiencing difficulty filling job openings). Among their findings, Bauer et al. conclude that the job-openings-to-unemployment ratio may overstate shortages because "an unusually large fraction of hiring is coming from people who reported they were outside the labor force (meaning that they were not unemployed and actively seeking work."[15] Bauer et al. also find that the job-openings-to-hiring ratio suggests that labor markets may be tight, but not as tight as what is indicated by the job-openings-to-unemployment ratio. In any case, we are unable to utilize the detailed approach employed in this paper, since the JOLTS program does not provide data on hiring rates at the occupational level.

We conclude from this brief literature review that for us to reasonably assess potential labor supply shortages on an individual occupational basis, we will need to combine information from multiple data sources, on both labor supply and demand. This includes data on unemployment levels, job openings, and each occupation's specific requirements for education, training, and experience. In measuring unemployment levels, we will consider both the relatively narrow unemployment measure, U-3, as well as the more expansive measure, U-6, which we describe in more detail below (also see endnote 8). By incorporating both the U-3 and U-6 measures of unemployed and underemployed population, we obtain a fuller sense of the extent to which employers may tap into the pool of people available to fill jobs.

2. Estimating Labor Supply for Relevant Occupations

Our estimates of the current labor supply, by occupation, are based on two basic sources: the unemployed and newly trained workers.

Unemployed workers

As noted above, we use two measures to estimate the potential labor supply of qualified workers coming from unemployed workers. The first is the main definition of unemployment used by the Labor Department—its U-3 measure of unemployment--which includes only those workers who do not have a job, have actively sought employment in the preceding four weeks, and are available to work.[16] The second measure is a more expansive concept of unemployment, which takes into account employed workers who would like to work more but cannot get additional employment and workers who have left the labor force because they became discouraged about their job opportunities.

More specifically, this second measure is the Labor Department's "U-6" measure. The U-6 measure of unemployment adds to its U-3 measure the following two additional groups of workers. The first is "marginally attached workers." These marginally attached workers include those who are currently neither working nor looking for work but indicate that they want and are available for a job and have looked for work sometime in the past 12 months. Also included in this group of marginally attached workers are "discouraged workers." Discouraged workers are those who have given a job-market related reason for not currently looking for work. The second group of workers included in the U-6 measure are the "under-employed." Under-employed workers are workers employed part time for economic reasons and who want and are available for full-time work but have had to settle for a part-time schedule.

Finally, the labor force for each of these unemployment rates by occupation is limited to those with some current or past experience working in that occupation.[17]

Our unemployment figures are presented by occupation in Table A1, col. 1. We have grouped occupations in the same way as in Table 12 in the main text, that is, by the job requirements. We estimate that the number of sufficiently skilled workers available from the pool of unemployed workers will range between the number of unemployed workers by the official U-3 definition and the number of unemployed workers by the expanded U-6 definition, and therefore use the midpoint of this range in our labor supply estimate. These figures are based on the 2022 Current Population Survey (CPS). The CPS is a household survey administered by the U.S. Census Bureau, on behalf of the Bureau of Labor Statistics of the U.S. Labor Department. The basic monthly survey of the CPS collects information from about 60,000 households every month on a wide range of topics including basic demographic characteristics, educational attainment, and employment status. All estimates use the CPS-provided sampling weights to make the estimates nationally representative.

Newly trained workers

We have two basic categories of newly trained workers: those completing apprenticeships and those completing a post-secondary educational program.

For data on apprenticeships, we rely on state and national data included in the Registered Apprenticeship Partners Information Database System (RAPIDS) maintained by the U.S. Labor Department. The database includes data on all apprenticeships registered with the U.S. Department of Labor or the relevant state apprenticeship agency. Such apprenticeships are subject to an approval process by the U.S. Labor Department or state agency, as well as industry representatives. This database publishes apprenticeship completions by year and occupation.[18] Our figures are apprenticeship completers for Fiscal Year 2022 and are presented in Table A1, panel B, col. 2.

For data on completers of post-secondary education, including certificates and degrees, we rely on the National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS) database.[19] This database includes information on program completions from every postsecondary institution that participates in the federal student financial aid programs, including colleges, universities, and technical and vocational institutions. Specifically, the NCES IPEDS database includes degree and non-degree credentials acquired through credit-bearing programs. One limitation of these data is that they do not include non-credit bearing programs.[20] Unfortunately, data on non-credit bearing programs are generally not available. According to a 2023 National Skills Coalition report:

TABLE A1.
Indicators of Labor Supply: Occupations with Significant Job Requirements

A) Occupations with Training or Experience Requirements, High School Diploma Only

Occupational Title	1) Unemployment Level		(2) Annual Level of Labor Supply *(Unemp. Level Midpoint)*
	U-3	U-6	
First-line supervisors of construction trades and extraction	19,100	28,700	23,900
First-line supervisors of mechanics, installers, and repairers	1,200	3,900	2,550
First-line supervisors of production and operating workers	13,900	17,200	15,550
Electrical power-line Installers and repairers	3,700	4,200	3,950
Mobile heavy equipment mechanics, except engines	3,400	7,300	5,350
Water and wastewater treatment plant and system operators	400	600	500
Crane and tower operators	2,600	2,800	2,700

B) Occupations with Apprenticeship Program or Similar Training Requirements, High School Diploma only

Occupational Title	1) Unemployment Level		(2) Apprentice-ship Completers	(3) Annual Level of Labor Supply *(Unemp. Level Midpoint + Apprenticeships)*
	U-3	U-6		
Carpenters	62,100	131,000	4,000	100,550
Electricians	33,400	53,500	11,100	54,550
Plumber, pipefitters, steamfitters	23,800	35,000	7,000	36,400
Sheet metal workers	5,900	9,400	1,800	9,450

Continued

TABLE A1. *(continued)*
Indicators of Labor Supply: Occupations with Significant Job Requirements

C) Occupations with Postsecondary Educational Requirements

Occupational Title	1) Unemployment Level		(2) Postsecondary Degree/ Certificate Completers, 2022	(3) Annual Level of Labor Supply *(Unemp. Level + Education Completers)*
	U-3	U-6		
General and operations managers	22,600	29,700	380,900	407,050
Software developers	33,000	39,600	115,700	152,000
Heavy and tractor-trailer truck drivers	38,600	51,500	9,200	54,250
Bookkeeping, accounting, and auditing clerks	26,700	46,500	6,600	43,200
Accountants and auditors	23,500	33,600	62,900	91,450
Project management specialists	14,800	23,100	284,500	303,450
Construction managers	27,100	53,300	6,400	46,600
Civil engineers	8,300	9,800	21,200	30,250
Industrial engineers	3,800	4,100	17,800	21,750
Electrical engineers	3,000	4,500	26,600	30,350
Telecommunications line installers and repairers	3,000	4,800	70	3,970
Electrical and electronic engineering technologists and technicians	2,300	3,300	9,400	12,200
Occupational health and safety specialists	2,100	3,000	3,800	6,350
Industrial engineering technologists and technicians	1,500	2,200	11,900	13,750
Wind turbine service technicians	30	50	6,700	6,740
Radio, cellular, tower equip. install and repairers	1,100	2,300	40	1,740

Note: Figures in table are rounded.
Source: See Appendix text.

> Data are generally not available for programs and credentials offered by education and training providers that do not receive state or federal funding. Additionally, for programs and credentials which are not eligible for federal aid, including noncredit programs and industry certifications, robust data on enrollment, attainment, and educational and labor market outcomes are lacking. These gaps in data and reporting on the full range of NDCs [non-degree credentials] limit the ability to identify high-impact credentials that benefit both credential seekers and employers (Cruse et al., 2023, p. 23).

To identify the relevant credential programs for each occupation, we use the NCES' crosswalk between the Standard Occupational Classification (SOC codes) used by the NEM and the NCES' Classification of Instructional Programs (CIP) database.[21] For example, the NCES matches the occupation, "Bookkeeping, accounting, and auditing clerks" to postsecondary programs and fields of study that

educational institutions categorize as, "Accounting Technology/Technician and Bookkeeping." As another example, the occupation "Software Developers" is matched with postsecondary fields of study and programs including: "Artificial Intelligence," "Information Technology," "Informatics", "Computer Programming/Programmer, General," "Data Science," and so on. We include in our number of degree or certificate completers all those that the NCES reports have been awarded in 2022 a relevant postsecondary credential that meets or exceeds an occupation's educational entry-level requirement as reported by the Labor Department (see Table 9 in the main text).

Our figures on degree and certificate completers are presented in Table A1, panel C, col. 2.

3. Estimating Current Labor Demand for Relevant Occupations

A) BIL, IRA, and CHIPS as a Source of Increased Labor Demand

To estimate the increase of labor demand due to BIL, IRA, and CHIPS programs, we use the employment findings from Pollin et al. (2023). Specifically, we use the estimates from that report of the number of direct jobs created annually by those programs, and the industry composition of those direct jobs, to determine the increase in labor demand by occupation.

To translate the increase in jobs by industry to increases in jobs by occupation at a highly detailed level, we merge the level and industry composition of the direct jobs created annually from Pollin et al. (2023) to the Labor Department's 2022 National Employment Matrix (NEM). The NEM provides the distribution of employment in 2022 for about 800 detailed occupations within about 300 detailed industries. The NEM is based on data from the following Labor Department Bureau of Labor Statistics programs: the Occupational Employment and Wage Statistics (OEWS), the Current Employment Statistics (CES), and the Current Population Survey (CPS). A major advantage of using estimates from the NEM is that it uses occupational distribution information from establishment surveys (OEWS) that sample over one million establishments over a 3-year period.

For details on how the job creation estimates by industry are developed, see Pollin et al. (2023). Note that the jobs figures in Pollin et al. (2023), based on IMPLAN modeling, uses the Bureau of Economic Analysis (BEA) definition of employment.

B) Economic Growth as a Source of Increased Labor Demand

To estimate the increase of labor demand due to economic growth, we use the average annual growth in employment by occupation, from 2014–2019, based on data from the CPS, using the CPS-provided sampling weight to make the estimates nationally representative. We use the employment growth rate for this period—2014–2019—as the best estimate of the employment trends we can expect in the near-future, given that the U.S. economy has by now, nearly fully recovered to pre-pandemic levels of economic activity.

We do not use employment trends during the more recent years of 2020 to 2022 because employment was severely affected by the COVID-19 pandemic. The risks posed by COVID-19, and the public policy responses to reduce these risks, dramatically reduced economic activity causing exceptionally large declines in employment. Near the height of the COVID-19 crisis—in the 2nd quarter of 2020—the overall unemployment rate reached 13.0 percent. At the same time, the employment effects varied widely depending on the type of work or occupation and by industry. Over roughly the past two years—2022 and 2023—the U.S. economy continued to add jobs back at a rapid pace.

Employment levels across sectors have, either fully or nearly fully recovered to pre-pandemic levels. Additionally, the national unemployment rate has fallen to pre-pandemic levels—currently at 3.9 percent. The dramatic labor market changes during 2020–2022 are clearly specific to the COVID-pandemic, and not indicative of longer-term trends. We therefore treat these COVID-related impacts as short-term.

The impact of COVID-19 is evident in the data we present in Table A2. We present, in column 1, the annual average employment growth rate prior to the pandemic (2014–2019). The last row in the table shows the figures for workers across all occupations—-not just among the 48 occupations listed—which indicate employment trends overall. We can see that during 2014–2019, the number of workers finding employment in most of the 48 occupations grew, and employment across all occupations rose by an average annual rate of 1.5 percent. In column 2 we show the figures for the years of the COVID pandemic from 2019–2022. During 2019–2022, the number of workers finding employment in the majority of these occupations declined and the average annual employment growth across all occupations dropped to a rate of 0.5 percent.

Thus, in our analysis, we use the employment trends during the years immediately preceding the pandemic—during more normal times of 2014–2019—as our estimates of employment trends in the near-future. That is, to estimate the increase in labor demand due to economic growth, by occupation, we use the average annual growth rate during 2014–2019 shown in col. 1 of Table A2.

C) Retirements as a Source of Increased Labor Demand

To approximate the level of labor demand due to retiring workers—i.e., job openings created by workers retiring and leaving the labor force—we need to estimate the percent of the current workforce that is likely to leave the labor force for retirement in the near future. To do this, we use the CPS to estimate the percent of workers near retirement age (at least 64 years old) within each occupation and apply this percent to the 2022 employment level for that occupation. We then discount this number by 20 percent because, again according to estimates from the CPS, as of 2022, about 20 percent of workers 65 years and older are in the labor force.[22] This discounted number is what we use to account for the job openings created by retirement by occupation presented in col. 3 of Table 10. This 20 percent figure is an approximation and may underestimate the increase in job openings for physically-demanding occupations—such as construction occupations—where more workers may retire and leave the labor force faster than in more sedentary occupations. For example, the share of employed workers 65 years and older is lower in construction occupations (5 percent) and production occupations (6 percent) than in administrative and office support occupations (7 percent). The share of employed workers 65 years and older across all occupations is about 7 percent.[23]

D) Alternative Estimate of Increased Labor Demand: The Job Openings Rate from the Labor Department's Employment Projection Program

As another estimate of the increase in labor demand by occupation, we use the annual job openings rates published by the Labor Department's Employment Projections program for its 2022–2032 projections. The advantage of using this estimate is that the EP data attempts to incorporate information about patterns of workers quits, fires, and switching between occupations, alongside the factors of economic growth and retirements that we use in our estimate. Moreover, the Labor Department's projections also attempt to incorporate the impacts of, "new technologies and leg-

TABLE A2.

Average Annual Employment Growth Rate

Among Top 48 Occupations with Largest Percent or Level Job Increases due to BIL, IRA, and CHIPS

Occupational Title	Annual Average Growth	
	Pre-Pandemic 2014-2019	Thru-Pandemic 2019-2022
Shuttle drivers and chauffeurs	14.1%	-6.2%
Water and wastewater treatment plant and system operators	8.8%	-5.4%
Computer numerically controlled tool operators and programmers	8.6%	-10.2%
Software developers	8.1%	6.0%
Construction managers	6.9%	2.1%
Civil engineers	6.3%	0.5%
Industrial engineering technologists and technicians	6.1%	-2.1%
Electrical and electronic engineering technologists and technicians	6.1%	-2.1%
Project management specialists	6.0%	10.6%
Sheet metal workers	4.9%	-2.1%
Industrial engineers	4.8%	-3.5%
Customer service representatives	4.2%	2.1%
Construction laborers	4.1%	2.8%
Semiconductor processing technicians	3.8%	3.1%
Laborers and freight, stock, and material movers, hand	3.7%	0.2%
General and operations managers	3.6%	3.2%
Electricians	3.5%	0.2%
Sales representatives of services, except advertising, insurance, financial services, and travel	3.2%	3.4%
Electrical power-line installers and repairers	3.0%	-3.8%
Accountants and auditors	2.7%	-5.7%
Pipelayers	2.5%	1.5%
Plumbers, pipefitters, and steamfitters	2.5%	1.5%
Operating engineers and other construction equipment operators	2.2%	-0.5%
Pile driver operators	2.2%	-0.5%
Office clerks, general	2.1%	-2.7%
Solar photovoltaic installers	1.5%	-1.9%
Inspectors, testers, sorters, samplers, and weighers	1.3%	-0.8%
First-line supervisors of production and operating workers	1.3%	-1.7%
Electrical engineers	1.1%	1.2%
School bus monitors	0.6%	8.8%

Continued

TABLE A2. *(continued)*

Average Annual Employment Growth Rate

Among Top 48 Occupations with Largest Percent or Level Job Increases due to BIL, IRA, and CHIPS

Occupational Title	Annual Average Growth	
	Pre-Pandemic 2014-2019	Thru-Pandemic 2019-2022
Heavy and tractor-trailer truck drivers	0.3%	3.8%
Carpenters	0.2%	-0.3%
Mobile heavy equipment mechanics, except engines	0.0%	2.0%
Occupational health and safety specialists	0.0%	30.4%
Telecommunications line installers and repairers	0.0%	-9.8%
Miscellaneous assemblers and fabricators	0.0%	1.7%
First-line supervisors of construction trades and extraction	-0.4%	-0.9%
Radio, cellular, tower equip. install and repairers	-0.4%	-4.9%
Welders, cutters, solderers, and brazers	-0.8%	-2.4%
First-line supervisors of mechanics, installers, and repairers	-0.8%	-3.5%
Bus drivers, school	-1.4%	-3.2%
Bus drivers, transit and intercity	-1.4%	-3.2%
Secretaries and administrative assistants, except legal, medical, and executive	-2.1%	-5.4%
Crane and tower operators	-3.0%	-1.5%
Bookkeeping, accounting, and auditing clerks	-3.8%	3.6%
Wind turbine service technicians	-4.2%	-0.3%
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers and finishers	-9.3%	0.4%
Coil winders, tapers and finishers	-9.3%	0.4%
All occupations	*1.5%*	*0.2%*

Note: Figures in table are rounded.
Source: See Appendix text.

islation." In fact, the DOL specifically discusses the employment impact of both the IRA and CHIPS laws in generating employment projections in the overview of its most recent estimates.[24] In other words, the Labor Department's job opening rates should incorporate, to some extent, the impact of at least the IRA and CHIPS laws as well as the job openings resulting from worker retirements, quitting and so on. The figures we present in column 5 of Table 10 are the levels of job openings by occupation, based on the annual job openings rates published by the EP program for 2022–2023.[25] The DOL figures are broadly in same range as our total labor demand increase estimates (col. 4 of Table 10).

4. Alternative Studies on Jobs Related to Infrastructure Investments

In this section, we discuss similarities and differences in the occupations we examine as compared to other recent studies that have analyzed jobs created from infrastructure investments. Such studies include a 2022 Brookings Institution report, "Seizing the U.S. infrastructure opportunity: Investing in current and future workers," by Joseph W. Kane and a 2021 Georgetown University report, "15 Million Infrastructure Jobs: An Economic Shot in the Arm to the COVID-19 Recession," by Anthony P. Carnevale and Nicole Smith. The Brookings Institution report examines features of the labor market for occupations located in infrastructure-related sectors and engaged in "infrastructure job activities." Infrastructure job activities include those engaged in the "design, construction, operation and governance" of infrastructure assets. The Georgetown University report does not provide a similarly detailed description of their methodology, however, it is also concerned with examining the employment situation of "infrastructure jobs."[26] We focus our discussion on the Brookings Institution report for the sake of simplicity since the Brookings Institution and Georgetown University reports highlight similar sets of occupations.

There is significant overlap in the occupations that we identify among the direct jobs created by IRA, BIL, and CHIPS program spending and those identified by the Brookings Institution and Georgetown University reports. This is because infrastructure-related spending is the focus of the larger two of the three spending packages: the IRA and BIL laws. For example, the first set of occupations highlighted in the Brookings Institution report are the "Fifteen largest occupations by infrastructure employment and activity, 2021 (Table 1, p. 17)." These 15 infrastructure occupations are singled out due to their high employment levels in 2021. Seven of these 15 occupations overlap with the occupations we specifically examine in this report. These include: Laborers and Freight, Stock, and Material Movers, Hand; Heavy and Tractor-Trailer Truck Drivers; Electricians; Plumbers, Pipefitters, and Steamfitters; Bus Drivers, School; Civil Engineers; and Shuttle Drivers and Chauffeurs. The remaining 8 occupations in the Brookings Institution list of 15 are among the occupations that our jobs demand analysis identifies as adding direct jobs but are *not* included in this report because they are not among the top 48 occupations with the largest level or percentage increase in jobs due to BIL, IRA, and CHIPS spending (see Table 6 in the main text). In other words, the labor demand analysis underlying this report identifies all 15 of the occupations highlighted by the Brookings report as increasing due to the BIL/IRA/CHIPS spending. The difference between the reports is the criteria used to choose which occupations to highlight. The Brookings Institution highlights occupations on the basis of their 2021 employment levels whereas our report focuses on the occupations that we expect to experience the largest increase in jobs due to the BIL/IRA/CHIPS spending levels specifically.

There are also significant differences in the occupations that we identify among the direct jobs created by BIL/IRA/CHIPS spending and those identified by the Brookings Institution and Georgetown University reports. These differences can be largely explained by the following.

First, our analysis begins with BIL/IRA/CHIPS investment spending among *businesses* involved in infrastructure activities, and we include *all* the occupations that comprise such businesses. That is, we do not restrict our occupations to those specifically engaged in infrastructure job activities as does the Brookings Institution analysis, as we note above.[27] For example, we have in our list of occupations among direct jobs: Buying and Purchasing Agents; Human Resource Specialists; Bookkeeping Clerks; and Customer Service Representatives. These occupations are important to the general operations of businesses but are not specifically involved in the Brookings-defined "infrastructure job activities."

Second, we analyze the job creation linked to the specific spending amounts detailed in the BIL/IRA/CHIPS laws. The Brookings Institution report analyzes infrastructure activities as a category, rather than with specific reference to the BIL/IRA/CHIPS laws. As a result, our infrastructure spending will likely diverge in certain places from what is included in those reports. Examples of these occupations include, "Pump Operators, Except Wellhead Pumpers," and "Flight Attendants," which the Brookings Institution reports highlight due to the high rate at which workers separate from these infrastructure-related jobs (see Figure 11, p. 27).

Third, the IMPLAN modeling of economic activity underlying our labor demand estimates aggregates some of the economic activities within the public sector. Exceptions to this include education, health, utilities, and ground transit services. As a result, our job estimates of the types of jobs created within the public sector can be imprecise. For this reason, we may miss occupations that appear primarily in the public sector. Examples of these occupations include Highway Maintenance Workers; Septic Tank Services and Sewer Pipe Clearers; Forest and Conservation Technicians, and Traffic Technicians. These are among the infrastructure jobs that the Brooking Institution's report highlights as having a large share of workers with only a high school degree or a high separation rate.

Finally, to analyze finely detailed occupation categories by industry, we relied on the BLS' National Employment Matrix (described above) which estimates the occupational distribution of employment by highly detailed industry categories (U.S. Bureau of Labor Statistics, Employment Projections Program, 2023d). The trade-off in using this database is that the BLS does not report figures for occupations with small employment levels or poor data quality within industry. Specifically, the BLS does not display within-industry employment figures for "occupations with fewer than 50 jobs, confidential data, or poor-quality data." As a result, our analysis may miss infrastructure-related occupations that have—within-industry—small employment levels or occupations for which the BLS does not have sufficient data to report. Examples of such occupations with small employment levels include: Dredge Operators; Paving, Surfacing, and Tamping Equipment Operators; and Rail Car Repairers. These are among the occupations that the Brooking Institutions highlight as having a large share of workers with only a high school degree or a high separation rate.

Endnotes

1 The BLS Occupational Outlook Handbook (2023a) provides information specific to each occupation's job requirements. While the BLS provides the most careful descriptions on job requirements by occupations for the overall U.S. labor market, its assessments do not take full account of differences by regional or local labor markets. These differences by region or local labor markets can be significant in some cases. It is beyond the scope of this study to assess where such significant differences may be prevalent.

2 One important consideration in evaluating the expanding employment opportunities generated by BIL, IRA, and CHIPS-related investments that we cover in our September 2023 study but do not summarize or expand on here is the area of job quality. Our September 2023 study reports figures on wages, health insurance coverage, retirement plans, and union membership in the current U.S. labor market for the BIL, IRA, and CHIPS-related jobs. These job quality results that we reported in the previous study provide valuable background in connection with the labor supply and potential labor shortage issues on which we focus at present.

3 That is, 1.8 million jobs as an average annual figure x 5 years = 9 million job years. The 9 million job figures is actually rounded up from the 8.8 million job figure reported in our September 2023 study.

4 Here and throughout the report, labor demand, employment, and job creation due to BIL, IRA, and CHIPS, refers to direct jobs only, unless otherwise specified.

5 Some basic references on the impact of job training programs generally for increasing job prospects for U.S. workers include U.S. Department of Labor et al. (2014) *What Works in Job Training: A Synthesis of the Evidence*; Holzer (2022) *Do Sectoral Training Programs Work?*; and Baird et al. (2022) "RCT Evidence on Differential Impact of U.S. Job Training Programs by Pre-Training Employment Status."

6 The BLS' Occupational Employment and Wages Program (2023a) provides a job description for pipelayers. The BLS' Occupational Outlook Handbook (2023b) provides a job description for customer service representatives.

7 The BLS' Occupational Outlook Handbook (2023c) provides a job description for solar photovoltaic installers. The BLS' Occupational Employment and Wages Program (2023b) provides a job description for semiconductor processing technicians.

8 The 5.9 million unemployed figure refers to the BLS' "U-3" measure of unemployment. The 11 million of unemployed, underemployed and discouraged workers refers to the BLS' "U-6" alternative measure of unemployment (U.S. Bureau of Labor Statistics, Data Retrieval: Labor Force Statistics (CPS), 2020). We use the term "discouraged worker" interchangeably with "workers marginally attached to the labor force." See Appendix for detailed definitions and also U.S. Bureau of Labor Statistics, Current Population Survey (2015).

9 According to the Bureau of Labor Statistics of the U.S. Labor Department, the training typical of apprenticeship programs includes, "…at least 144 hours of occupation-specific technical instruction and 2,000 hours of on-the-job training per year, over a 3- to 5-year period." (U. S. Bureau of Labor Statistics, Employment Projections Program, 2023c).

10 For an overview of such programs, see Johnson and Spiker (2018).

11 For evidence on the effectiveness of affirmative action policies see Miller (2019); Kurtulus (2015), and Wicks-Lim (2013).

12 In a 2018 report for the Oregon Department of Transportation, sociologists Lindsey Wilkinson and Maura Kelly find that such workplace interventions contribute to greater highway construction apprenticeship completion rates, particularly among BIPOC men and women (Wilkinson and Kelly, 2018).

13 For an overview of racial disparities among apprenticeships, see Camardelle (2023).

14 See endnote 11.

15 Bauer et al. (2022), p. 2.

16 U.S. Bureau of Labor Statistics, Current Population Survey (2015).

17 IPUMS CPS (2023).

18 U.S. Department of Labor, ApprenticeshipUSA (n.d.).

19 U.S. Department of Education et al. (n.d.).

20 U.S. Department of Education et al. (n.d.-a).

21 U.S. Department of Education et al. (n.d.-b).

22 U.S. Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey (2024a).

23 U.S. Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey (2024b).

24 Colato and Ice (2023).

25 U.S. Bureau of Labor Statistics, Employment Projections Program (2023d).

26 The Georgetown University report cites as the source of its estimates the, "Georgetown University Center on Education and the Workforce forecast using data from US Census Bureau and US Bureau of Labor Statistics, Current Population Survey (CPS); US Census Bureau, American Community Survey (ACS); US Bureau of Labor Statistics; and IHS Markit." Their report focuses on the House infrastructure spending bill that passed in 2020--the INVEST in America Act--which includes $1.5 trillion of spending on infrastructure.

27 See p. 24 of the 2014 Brookings report (Kane and Puentes, 2014) that provides more details on the methodology underlying the 2022 Brookings report (Bauer et al., 2022).

References

Baird, Matthew D., John Engberg, and Italo A. Gutierrez. 2022. "RCT evidence on differential impact of US job training programmes by pre-training employment status," *Labour Economics* (75). https://doi.org/10.1016/j.labeco.2022.102140

Barnow, Burt S., John Trutko, and Jaclyn Schede Piatak. 2013. "How Do We Know Occupational Labor Shortages Exist?" Employment Research 20(2): 4-6. https://doi.org/10.17848/1075-8445.20(2)-2

Bauer, Lauren, Wendy Edelberg, and Sara Estep. 2022. A Closer Look at a Hot Labor Market. October. (Washington DC: Brookings Institution). https://www.brookings.edu/wp-content/uploads/2022/10/Hamilton-Project-A-Closer-Look-at-a-Hot-Labor-Market.pdf

Camardelle, Alex. 2023. "Five Charts To Understand Black Registered Apprentices in the United States," Joint Center for Political and Economic Studies. March 20. https://jointcenter.org/wp-content/uploads/2023/03/Five-Charts-To-Understand-Black-Registered-Apprentices-in-the-United-States.pdf

Carnevale, Anthony P. and Nicole Smith. 2021. 15 Million Infrastructure Jobs: An Economic Shot in the Arm to the COVID-19 Recession. Washington DC: Georgetown University. https://cew.georgetown.edu/wp-content/uploads/cew-15_million_infrastructure_jobs-fr.pdf

Colato, Javier and Lindsey Ice. 2023. "Industry and occupational employment projections overview and highlights, 2022–32," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, October. https://doi.org/10.21916/mlr.2023.24

Cruse, Lindsey Reichlin, Jennifer Stiddard, Roderick Taylor and Jeannine LaPrad. 2023. The Non-Degree Credential Quality Imperative. Washington DC: National Skills Coalition. https://nationalskillscoalition.org/wp-content/uploads/2023/07/The-NDCQ-Imperative-report_fnl2-1.pdf

Holzer, Harry J. 2022. Do Sectoral Training Programs Work? January 12. Washington DC: Brookings Institution. https://www.brookings.edu/articles/do-sectoral-training-programs-work-what-the-evidence-on-project-quest-and-year-up-really-shows/

IPUMS CPS, University of Minnesota, www.ipums.org. 2023. "OCC2010, Universe." https://cps.ipums.org/cps-action/variables/OCC2010#universe_section

Johnson, Melissa and Katie Spiker. 2018. Broadening the apprenticeship pipeline: Pre-employment training and affordable childcare are key to access and retention in work-based learning programs. August. (Washington DC: National Skills Coalition). https://nationalskillscoalition.org/wp-content/uploads/2023/02/Broadening-the-Apprenticeship-Pipeline_web.pdf

Kane, Joseph W. 2022. Seizing the U.S. infrastructure opportunity: Investing in current and future workers. December. Washington DC: Brookings Institution. https://www.brookings.edu/articles/infrastructure-workforce/

Kane, Joseph and Robert Puentes. 2014. Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs. Metropolitan Policy Program, May. Washington DC: The Brookings Institution.

Kurtulus, Fidan Ana. 2015. "The Impact of Affirmative Action on the Employment of Minorities and Women over Three Decades: 1973-2003," *Upjohn Institute Working Paper* 15-221, Kalamazoo, MI: W.E. Upjohn Institute for Employment Research. https://doi.org/10.17848/wp15-221

Linksy, Evan. 2018. "An Analysis of occupational supply and demand in the Michigan labor market," *Michigan's Labor Market News,* 74(10), December, pp. 16-19.

Miller, Conrad. 2019. "Affirmative Action and Its Persistent Effects: A New Perspective," *California Management Review*, 61(3), 19–33. https://doi.org/10.1177/0008125619849443

National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS) database. n.d. "About IPEDS." Accessed February 7, 2024. https://nces.ed.gov/ipeds/about-ipeds

Pollin, Robert, Jeannette Wicks-Lim, and Shouvik Chakraborty. (forthcoming). "Employment Impacts for Colorado of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures," PERI Research Report.

--- (forthcoming). "Employment Impacts for Michigan of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures," PERI Research Report.

--- (forthcoming). "Employment Impacts for Ohio of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures," PERI Research Report.

--- (forthcoming). "Employment Impacts for Oregon of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures," PERI Research Report.

Pollin, Robert, Jeannette Wicks-Lim, and Shouvik Chakraborty, Gregor Semieniuk, Chirag Lala. 2023. "Employment Impacts of New Clean Energy, Manufacturing, and Infrastructure Laws: Job Creation, Job Quality, and Demographic Distribution Measures," PERI Research Report, September. https://peri.umass.edu/publication/item/1758-employment-impacts-of-new-u-s-clean-energy-manufacturing-and-infrastructure-laws

U.S. Bureau of Labor Statistics, 2024a. "Total Unemployed, Plus All Persons Marginally Attached to the Labor Force, Plus Total Employed Part Time for Economic Reasons, as a Percent of the Civilian Labor Force Plus All Persons Marginally Attached to the Labor Force (U-6) [U6RATE]," retrieved from FRED, Federal Reserve Bank of St. Louis. Accessed February 6, 2024. https://fred.stlouisfed.org/series/U6RATE

--- 2024b. "Unemployment Rate [UNRATE]," retrieved from FRED, Federal Reserve Bank of St. Louis. Accessed February 6, 2024. https://fred.stlouisfed.org/series/UNRATE

U.S. Bureau of Labor Statistics, Current Population Survey. 2015. "Labor Force Statistics from the Current Population Survey: How the Government Measures Unemployment," October 8. https://www.bls.gov/cps/cps_htgm.htm

U.S. Bureau of Labor Statistics, Data Retrieval: Labor Force Statistics (CPS). 2020. "HOUSEHOLD DATA Table A-15. Alternative measures of labor underutilization," February 19. https://www.bls.gov/webapps/legacy/cpsatab15.htm

U.S. Bureau of Labor Statistics, Employment Projections Program. n.d. "Occupational Projections database." Accessed February 7, 2024. https://www.bls.gov/emp/data.htm

U.S. Bureau of Labor Statistics, Employment Projections Program. 2023a. "Education and training assignments by detailed occupation, Table 5.4 Education and training assignments by detailed occupation, 2022," September 6. https://www.bls.gov/emp/tables/education-and-training-by-occupation.htm#top

--- 2023b. "Employment by detailed occupation: Table 1.2. Employment by detailed occupation, 2022 and projected 2032," September 6. https://www.bls.gov/emp/tables/emp-by-detailed-occupation.htm

--- 2023c. "Employment Projections Data Definitions," September 6. https://www.bls.gov/emp/documentation/definitions.htm

--- 2023d. "National Employment Matrix, Industry-occupation matrix data, by industry." September 6. https://www.bls.gov/emp/tables/industry-occupation-matrix-industry.htm

U.S. Bureau of Labor Statistics, Labor Force Statistics from the Current Population Survey. 2024a. "CPS Tables, Annual Averages,3. Employment status of the civilian noninstitutional population by age, sex, and race." January 26. https://www.bls.gov/cps/cpsaat03.htm

--- 2024b. "CPS Tables, Annual Averages, 11b. Employed persons by detailed occupation and age." January 26. https://www.bls.gov/cps/cpsaat11b.htm

U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics. 2023. "Alternative measures of labor underutilization by state, 2022 annual averages (percent)," January 27. https://www.bls.gov/lau/stalt22q4.htm

U.S. Bureau of Labor Statistics, Occupational Employment and Wage Statistics. 2023a. "Occupational Employment and Wages, May 2022, 47-2151 Pipelayers," April 23. https://www.bls.gov/oes/current/oes472151.htm

--- 2023b. "Occupational Employment and Wages, May 2022, 51-9141 Semiconductor Processing Technicians," April 23. https://www.bls.gov/oes/current/oes519141.htm

U.S. Bureau of Labor Statistics, Occupational Outlook Handbook. 2023a. September 6. https://www.bls.gov/ooh/home.htm

--- 2023b. "Customer Service Representatives." September 6. https://www.bls.gov/ooh/office-and-administrative-support/customer-service-representatives.htm

--- 2023c. "Solar photovoltaic installers." September 6. https://www.bls.gov/ooh/construction-and-extraction/solar-photovoltaic-installers.htm

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS). n.d. Accessed February 7, 2024. https://nces.ed.gov/ipeds/

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, Integrated Postsectondary Education Data System (IPEDS), Classification of Instructional Programs (CIP). n.d.-a. "2023-24 Survey Materials, Instructions for the IPEDS Completions Component." Accessed February 7, 2024. https://surveys.nces.ed.gov/ipeds/public/survey-materials/instructions?instructionid=30080

--- n.d.-b. "What New at CIP? New Release: 2020 CIP/SOC Crosswalk," Accessed February 7, 2024. https://nces.ed.gov/ipeds/cipcode/Files/CIP2020_SOC2018_Crosswalk.xlsx

U.S. Department of Labor, ApprenticeshipUSA. n.d. "Data and Statistics." Accessed February 7, 2024. https://www.apprenticeship.gov/data-and-statistics

U.S. Department of Labor, U.S. Department of Commerce, U.S. Department of Education, and the U.S. Department of Health and Human Services. 2014. What Works in Job Training: A Synthesis of the Evidence. July 22. https://www.dol.gov/sites/dolgov/files/OASP/legacy/files/jdt.pdf

Veneri, Carolyn M. 1999. "Can occupational labor shortages be identified using available data?" *Monthly Labor Review*, March, pp. 15-21. https://www.bls.gov/opub/mlr/1999/03/art2full.pdf

Wicks-Lim, Jeannette. 2013. "A stimulus for affirmative action? The impact of the American Recovery and Reinvestment Act on women and minority workers in construction," In *Capitalism on Trial: Explorations in the Tradition of Thomas E. Weisskopf* (Jeannette Wicks-Lim and Robert Pollin, eds.), chapter 16, Northampton, MA: Edward Elgar Publishing. https://doi.org/10.4337/9781782540854.00027

Wilkinson, Lindsey and Maura Kelly. 2018. Continuing to Build a More Diverse Workforce in the Highway Trades: 2018 Evaluation of the ODOT/BOLI Highway Construction Workforce Development Program. Final report submitted to the Oregon Bureau of Labor and Industries and Oregon Department of Transportation. https://pdxscholar.library.pdx.edu/soc_fac/96/

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