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Disappearing Routine Occupations and Declining Prime-Age Labor Force Participation*

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Abstract

Using several data sources I study the link between disappearing routine occupations and the decline in the labor force participation rate of prime-age individuals since the 1990s. First, I exploit state-level variation and show that states with lower shares of prime-age individuals employed in routine occupations also have lower prime-age participation rates. Second, I narrow the geographic unit to local labor markets and highlight that changes in routine employment and changes in the labor market outcomes of prime-age individuals show great variation across local labor markets (commuting zones) in the United States. My estimation results indicate that commuting zones with larger declines in prime-age routine employment experienced larger declines in the prime-age labor force participation rates between 1990 and 2016. Moreover, disappearing routine employment has mainly reduced the labor force participation rates of prime-age men and women without a bachelor's degree. Lastly, I show that the declines in routine employment were not limited to blue-collar jobs in the manufacturing industries, but were also observed in the non-manufacturing industries.

Keywords: job polarization, labor force participation, prime-age individuals, skills
JEL Classification: E24, E32, J21, J24, J62

1 Introduction

The labor force participation rate of prime-age individuals (age 25-54) in the United States increased steadily in the post-war period, somewhat stabilized in the early 1990s, and declined noticeably since then. Because prime-age individuals have the highest labor force participation rate and are in their most productive working years, a permanent decline in

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their participation rate has implications not only for these individuals' earnings and well-beings at the micro level, but also for the economy's potential for production and growth at the macro level.

In this paper I study the relationship between disappearing routine occupations and the decline in the labor force participation rate of prime-age individuals since the 1990s. Technological advancements and increased international trade, especially with China, have led to a dramatic long-term shift in the composition of occupations and skills demanded by employers. More specifically, job opportunities have continuously shifted away from middle-skill or routine occupations and toward non-routine, high- and low-skill occupations, a phenomenon named "job polarization" (Autor et al., 2003, 2006; Autor, 2010; Acemoglu and Autor, 2011; Tüzemen and Willis, 2013).

I present four new empirical results. First, I use monthly micro-level data from the Current Population Survey (1990-2018) to show that states with lower shares of prime-age individuals employed in routine occupations also have lower prime-age participation rates. More specifically, on average, a 10 percentage point lower routine employment rate is associated with a 3.8 percentage point lower prime-age labor force participation rate.

Second, I use data from the Census (1990, 2000) and the American Community Survey (2014-2016) to emphasize that changes in routine employment and changes in the labor market outcomes of prime-age individuals show great variation across local labor markets (or commuting zones) in the United States. Using a Bartik-style instrument I estimate the differential decline in the prime-age labor force participation rates across commuting zones caused by the differential decline in routine employment. I find that commuting zones at the 25th percentile of the routine employment rate change distribution experienced a 1.6 percentage point larger decline in the prime-age labor force participation rate from 1990 to 2016 than commuting zones at the 75th percentile.

Third, I show that aggregate statistics mask differences in the labor market outcomes of prime-age individuals of different gender and education groups. Disappearing routine employment reduced the labor force participation rates of prime-age individuals without a bachelor's degree. However, the impact was not only on prime-age men, but also on prime-age women.

Lastly, I find that the declines in routine employment were broad based and not limited to blue-collar jobs in the manufacturing industries. A growing literature shows the effect of declining manufacturing employment on the decline in prime-age employment (Charles et al., 2016, 2018). While employment losses in manufacturing were important contributors to the decline in prime-age employment, declines in routine employment in the non-manufacturing industries also contributed to the declines in prime-age employment and the prime-age labor force participation rate. These results imply that policy efforts to stem employment losses in one particular industry may not be enough to counter the broader trend of disappearing routine occupations.

My paper complements recent research studying the effects of increased use of robots and automation in replacing workers in certain occupations and lowering employment and labor force participation, especially among prime-age individuals. Foote and Ryan (2015) find that unemployed middle-skill workers have fewer feasible employment alternatives outside their skill class and the decline in male participation rates in the past several decades was in part related to an "erosion" of middle-skill or routine job opportunities. According to Tüzemen (2018), the number of prime-age men not participating in the labor market rose 2.5 million, from 4.6 million in 1996 to 7.1 million in 2016. Tüzemen (2018) provides a counterfactual exercise which suggests if job polarization had not changed the demand for skills in the labor market, almost 80 percent of these 2.5 million nonparticipants could be employed in 2016. Coglianese (2017) finds that "in-and-outs," prime-age men who temporarily leave the labor force, explain 20-40 percent of the decline in labor force participation between 1984 and 2011, and argues that the rise of in-and-outs does not result from a decline in labor demand. Acemoglu and Restrepo (2017) estimate the impact of industrial robots (one specific type of automation technology) on the local labor market outcomes in the United

States and find that increases in the stocks of robots (approximately one new robot per thousand workers from 1993 to 2007) reduced the employment rate in a commuting zone with the average US exposure to robots by 0.37 percentage points. Different from these studies, I study the impact of disappearing routine occupations in both manufacturing and non-manufacturing industries on the decline in the prime-age labor force participation rate using strong spatial variation across local labor markets. Additionally, I show that declining routine employment has mostly affected the labor market outcomes of prime-age men and women without a bachelor's degree.

2 Long-Term Trends in the Labor Market

To document the long-term trends in the U.S. labor market, I use aggregate data provided by the Bureau of Labor Statistics as well as micro-level data from the Current Population Survey (CPS), also known as the household survey. The CPS is the primary source of labor force statistics and demographic data for the United States population. The data contain detailed demographic information on individuals, as well as information on their labor market status and employment by industry and occupation. The U.S. Census Bureau collects survey data at monthly frequency from approximately 60,000 households.[1] I average monthly observations for each year to construct annual series.

The first long-term trend in the U.S labor market is the decline in the labor force participation of rate of prime-age (age 25-54) individuals since the 1990s. To highlight the importance of this decline, Figure 1 shows the evolution of the prime-age labor force participation rate since 1948. The prime-age labor force participation rate increased steadily in the post-war period before changing course, somewhat stabilizing in the mid-1990, and declining since. After reaching above 84 percent in the mid-1990, the prime-age labor force participation rate fell 3 percentage points to 81 percent by 2015, its lowest level in the

[1] The survey has a response rate ranging between 91 to 93 percent, which is one of the highest response rates among government surveys. The historical data are available through several public resources, and new micro-data files are published online frequently.

post-Great-Recession period.

Figure 2 shows a similar pattern for the employment-to-population ratio of prime-age individuals, emphasizing the strong relationship between employment and labor force participation of prime-age individuals.

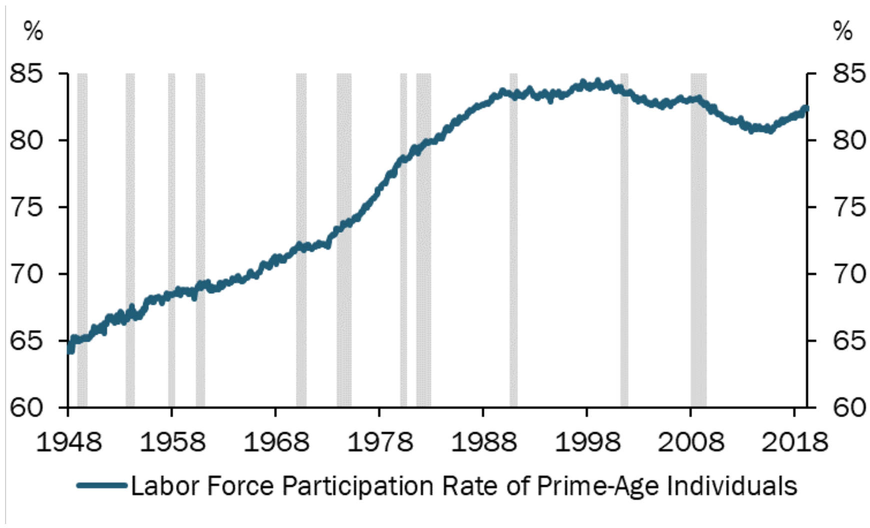


Figure 1: Prime-Age Labor Force Participation Rate, 1948-2018
Notes: BLS, Haver Analytics. Data are monthly and seasonally adjusted.

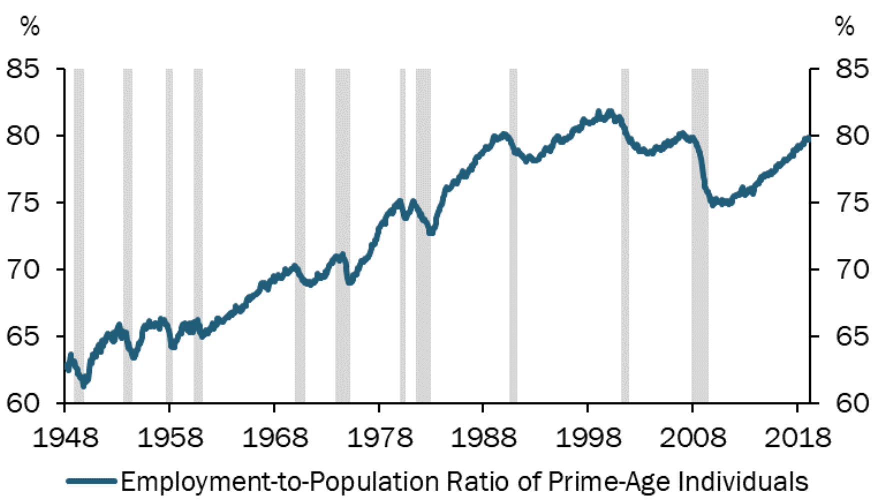


Figure 2: Prime-Age Employment-to-Population Ratio, 1948-2018
Notes: BLS, Haver Analytics. Data are monthly and seasonally adjusted.

Since 2015, the prime-age labor force participation rate has increased slightly, as shown in Table 1, but remains below its 1990 level.

Table 1: Prime-Age Labor Market Outcomes

	Labor Force Participation Rate (percent)	Employment-to-Population Ratio (percent)
1990	83.49	79.66
2000	84.07	81.47
2015	80.95	77.29
2018	82.29	79.56

Notes: CPS data, author's calculations.

The second long-term trend in the U.S. labor market is the persistent shift in the composition of jobs due to factors that have affected the demand side of the labor market. More specifically, technological advancements allowed for wider use of computers and robots, which resulted in firms substituting capital for workers who perform "routine" tasks, that are procedural, repetitive, and well suited for automation. Similarly, technological advancements allowed some routine tasks to be performed at distance, leading to offshoring. Increased imports from China, due to the surge in the Chinese productivity and reduced trade barriers, induced firms to change production techniques and reduce use of labor, especially in manufacturing (Autor et al., 2015).[2] All these factors led to lower demand for workers specializing in routine tasks and caused a shift in the composition of jobs. More specifically, in the past few decades, job opportunities have shifted away from routine (middle-skill) occupations and toward non-routine, high- and low-skill occupations, a phenomenon named "job polarization" (Autor et al., 2003, 2006; Autor, 2010; Acemoglu and Autor, 2011; Tüzemen and Willis, 2013).

As a result of job polarization, the share of employed working-age (age 16-64) individuals in routine occupations in the United States has fallen sharply since 1990 as reported in Table 2.[3] These occupations are "routine cognitive occupations," such as white-collar, sales, office and administrative support jobs, and "routine manual occupations," such as

[2] That being said, import competition might have increased in regions where automation was rising for other reasons.

[3] For the statistics related to job polarization, the sample excludes workers who are self-employed or working without pay, and are employed in military or agricultural occupations and industries. To classify routine versus non-routine and manual versus cognitive occupations, I use 3-digit Census occupation codes and map them to the major occupation codes yielding to a classification consistent with Acemoglu and Autor (2011). See Appendix A for more details.

blue-collar, production, construction and extraction, installation, maintenance and repair, transportation and material moving jobs. The employment share of routine occupations declined from 56.3 (28.6 + 27.7) percent in 1990 to 43 (22.0 + 21.0) percent in 2018. Moreover, Figure 3 shows that these shifts in employment away from routine occupations toward non-routine occupations occurred continuously and persistently since the 1990s.

Table 2: Employment Shares by Occupations, Working-Age Individuals

	1990 (percent)	2000 (percent)	2015 (percent)	2018 (percent)
Non-routine Cognitive Occupations	(29.10)	(34.05)	(38.20)	(39.46)
Management and Business Operations & Finance	11.64	13.91	14.65	15.11
Professionals	17.46	20.14	23.55	24.35
Routine Cognitive Occupations	(28.58)	(26.37)	(23.21)	(22.00)
Sales	11.16	11.43	10.19	9.78
Office & Administrative Support	17.41	14.95	13.02	12.22
Routine Manual Occupations	(27.65)	(24.76)	(20.79)	(20.95)
Construction Trades & Extraction	5.28	5.35	4.76	5.07
Production	11.24	8.85	6.22	6.02
Installation, Maintenance & Repair	3.99	3.83	3.49	3.33
Transportation & Material Moving	7.14	6.73	6.31	6.52
Non-routine Manual Occupations	(14.67)	(14.82)	(17.80)	(17.59)
Services	14.67	14.82	17.80	17.59

Notes: CPS data, author's calculations. People who are in farming and armed forces occupations and industries and people who are self-employed or working without pay are excluded.

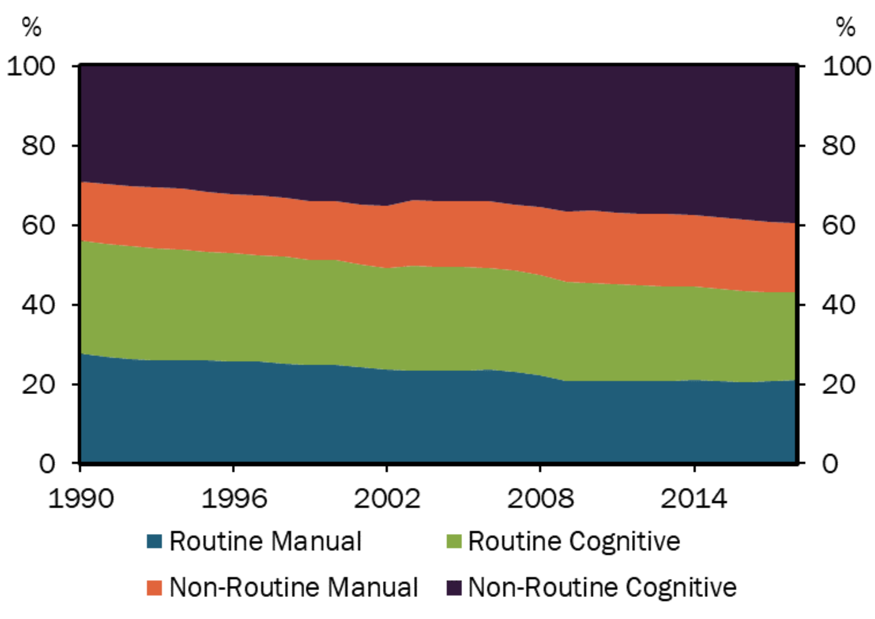


Figure 3: Employment Shares by Occupations, Working-Age Individuals
Notes: CPS data, author's calculations.

New technologies have increased the relative productivity of workers in high-skill occupations by complementing their skill sets. Workers suitable for these positions are typically highly educated and can perform tasks requiring analytical ability, problem solving, and creativity. Tasks performed in high-skill occupations cannot be easily automated, making them non-routine occupations. These are managerial, professional, and technical occupations, such as in engineering, finance, management and medicine. As these occupations require higher levels of cognitive ability, they are called "non-routine cognitive occupations." Technological advancements led to the creation of more high-skill occupations and a greater demand for workers to fill these jobs (Acemoglu, 1998, 2002). Evidently, the employment share of workers in high-skill occupations increased by more than 10 percentage points, rising from 29.1 percent in 1990 to 39.5 percent in 2018 as seen in Table 2.

Similarly, tasks performed in low-skill occupations are harder to automate, as they are physically demanding and require human interaction, and the demand for workers to fill low-skill occupations has also increased. Workers in these occupations typically do not have a college degree. Low-skill occupations are service oriented, such as food preparation, cleaning, and security and protective services. These occupations are called "non-routine manual occupations," and their employment share rose from 14.7 percent in 1990 to 17.6 percent in 2018.

How did this change in the composition of jobs in the economy affected employment among prime-age individuals? Looking at which occupations they worked in reveals that 54.3 percent of employed prime-age individuals had a routine occupation in 1990 and this share has fallen to 41.1 percent by 2018 as shown in Table 3. Similarly, routine employment rate of prime-age individuals (routine employment over population) declined from 42.1 percent in 1990 to 32.0 percent in 2018, due to declines in both routine manual and routine cognitive employment, resulting in a lower prime-age employment-to-population ratio.

To conclude, the majority of prime-age individuals were employed in routine occupations in the 1990s and their labor force participation rate and employment-to-population ratio have declined since then, concurrent with the decline in routine job opportunities.

Table 3: Prime-Age Routine Employment Statistics

Routine Employment/Total Employment			
	Routine (percent)	Routine Manual (percent)	Routine Cognitive (percent)
1990	54.29	28.05	26.24
2000	49.21	25.19	24.01
2015	42.42	21.15	21.26
2018	41.08	20.94	20.13
Routine Employment/Population			
	Routine (percent)	Routine Manual (percent)	Routine Cognitive (percent)
1990	42.11	21.76	20.35
2000	39.24	20.09	19.15
2015	32.07	16.00	16.08
2018	32.04	16.33	15.70

Notes: CPS data, author's calculations. The sample excludes workers who are in farming and armed forces occupations and industries, people who are self-employed, or working without pay.

2.1 State-Level Analysis

Based on the evidence provided previously, I hypothesize that declining employment and labor force participation among prime-age individuals are highly correlated with disappearing routine occupations. I test my hypothesis using state-level data from the CPS and estimate a model of the form:

$$LM_{st} = \alpha + \beta_1 Routine_{st} + \beta_2 X_{st} + \delta_s + \phi_t + \epsilon_{st} \quad (1)$$

where LM_{st} represents the labor market outcomes of prime-age individuals in state s at date t (month-year). The labor market outcomes of interest are the prime-age labor force participation rate and the prime-age employment-to-population ratio. The variable $Routine_{st}$ measures the share of prime-age population employed in routine occupations in state s and date t. I include control variables X_{st} to account for other potential influences that may impact prime-age labor market outcomes, such as the share of prime-age population with a bachelor's degree or higher, and the share of prime-age population that is foreign-born. I also control for the share of prime-age population employed in manufacturing in the state as several studies have shown the adverse effect of declining manufacturing employment on the prime-age labor market outcomes in the United States (Acemoglu et al., 2016; Pierce and Schott, 2016; Charles et al., 2016, 2018). Additionally, I control for the prime-age unemployment rate in each state, which accounts for the cyclical changes in the state's economic condition. Time and state fixed effects are also included. The coefficient of interest is β_1, which quantifies the correlation between routine employment and the labor market outcomes of prime-age individuals at the state level. I weight each observation by each state's prime-age population and cluster the standard errors by state. The sample covers monthly data for 1994-2018. The sample starts in 1994, because the information on foreign-born status does not exist before this date. The summary statistics are provided in Appendix B.

A panel regression (fixed effects) of Equation 1 indicates that, there is a statistically significant and positive relationship between prime-age routine employment and the labor market outcomes of prime-age individuals. That is, states with lower shares of prime-age population employed in routine occupations also have lower prime-age labor force participation rates and lower prime-age employment-to-population ratios. More specifically, on average, a 10 percentage point lower share of prime-age population employed in routine occupations is associated with a 3.8 percentage point lower prime-age labor force participation rate and a 3.6 percentage point lower prime-age employment-to-population ratio as reported in Table 4.

The statistically significant, positive relationship between routine employment and participation rates is robust to the inclusion of control variables one at a time (columns 2-4). When all control variables are included (column 5), the labor force participation rates and employment-to-population ratios have statistically significant and positive correlations with the share of college-educated prime-age population and have statistically significant and negative correlations with the share of foreign-born prime-age individuals. The labor market outcomes of prime-age individuals are lower in states with lower shares of prime-age population employed in manufacturing; however, the estimated coefficients are small in magnitude (0.05 and 0.11) relative to the estimated coefficients associated with routine employment.

The prime-age unemployment rate is negatively correlated with the prime-age employment-to-population ratio and positively correlated with the prime-age labor force participation rate. The results for the unweighted versions of these regressions are similar and provided in Appendix C.

Table 4: Panel Regression of the Prime-Age Labor Market Outcomes on the Share of Prime-Age Population Employed in Routine Occupations, 1994-2018

	Prime-Age Labor Force Participation Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Share in Routine Employment	0.267***	0.351***	0.265***	0.252***	0.281***	0.375***
	(0.019)	(0.017)	(0.020)	(0.020)	(0.018)	(0.019)
Share of College-Educated		0.227***				0.248***
		(0.019)				(0.019)
Share of Foreign-Born			-0.023			-0.043*
			(0.027)			(0.022)
Share in Manufacturing Employment				0.053*		0.056**
				(0.028)		(0.025)
Unemployment Rate					0.075**	0.179***
					(0.031)	(0.025)
N	15300	15300	15297	15294	15300	15291
R-squared (within)	0.433	0.494	0.433	0.434	0.434	0.507
	Prime-Age Employment-to-Population Ratio					
	(1)	(2)	(3)	(4)	(5)	(6)
Share in Routine Employment	0.411***	0.522***	0.410***	0.379***	0.269***	0.357***
	(0.028)	(0.026)	(0.028)	(0.027)	(0.018)	(0.018)
Share of College-Educated		0.302***				0.236***
		(0.020)				(0.018)
Share of Foreign-Born			-0.016			-0.042**
			(0.028)			(0.021)
Share in Manufacturing Employment				0.114***		0.054**
				(0.038)		(0.023)
Unemployment Rate					-0.730***	-0.632***
					(0.030)	(0.025)
N	15300	15300	15297	15294	15300	15291
R-squared (within)	0.691	0.740	0.691	0.694	0.770	0.799

Notes: CPS state-level panel data from 1994 to 2018. Each variable is constructed at monthly level and state level. All regressions include time fixed effects and state fixed effects. Each observation is weighted by the state's prime-age population in 1994. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

3 How Has the Disappearance of Routine Jobs Impacted the Prime-Age Labor Force Participation Rate?

State-level analysis yields a robust, positive relationship between employment of prime-age individuals in routine occupations and their labor force participation rate. Having established this robust correlation, next I search for a causal effect of declining routine employment on prime-age labor force participation.

My expectation for a causal relationship is based on empirical evidence which suggest the following mechanism. First, a majority of prime-age individuals were employed in routine occupations in the 1990s and their employment and labor force participation rates have decreased since then with declining routine job opportunities. Empirical evidence shows that when workers lose their routine occupations, they are more likely to return to employment at other routine occupations rather than moving to non-routine occupations because these workers have fewer feasible employment alternatives outside their skill class (Cortes et al., 2014; Foote and Ryan, 2015). Therefore, evidence suggests that, due to lack of job opportunities for their skills, displaced workers who could not return to employment may eventually leave the labor force.

To test for a causal relationship between declining routine employment and declining prime-age labor force participation, I exploit variation across local labor markets or "commuting zones," which allows for analyses at a more granule geographic level than states. The declines in prime-age participation and routine employment vary largely across commuting zones and this regional variation is the key component of my identification strategy.

3.1 Trends in Local Labor Markets

I use data from the 1990 and 2000 United States Decennial Census and 2014-2016 American Community Surveys (ACS) provided by the Census Integrated Public Use Micro Samples (IPUMS) (Ruggles et al., 2018). All data are part of the Decennial Census Program and provide detailed information on demographics as well as on the labor market status of individuals along with their occupations and industries. The Census samples for 1990 and 2000 include 5 percent of the population, while the ACS provides 1 percent sample of the population each year. Given the relatively small size of the ACS, I pool 2014, 2015, and 2016 ACS data together, which I refer to as "2016 ACS data." I restrict the sample to prime-age individuals, excluding those who are self-employed, working without pay, and working in the military or agricultural occupations or industries. I also exclude people who live in institutional group quarters, such as correctional facilities and nursing homes. I use 3-digit Census occupations and map them to the major occupation codes yielding to a classification consistent with Acemoglu and Autor (2011). I provide a consistent categorization of occupations and industries across different years in Appendix A.

My analyses take place at the level of commuting zones, which provide a time-consistent representation of regional economies and cover both urban and rural areas across the United States. In the 1990 Census, there are 741 commuting zones and each commuting zone reflects a local economy. I use crosswalks provided by Autor et al. (2013) to link public micro use areas (PUMAs) in the ACS and Census data to commuting zones. Each observation's weight is then determined by multiplying the original survey's weight with the adjustment factors from matching with the commuting-zone crosswalks. Since a commuting zone is not bounded by a state line, I assign a commuting zone to the state that has the highest employment share of that commuting zone.

Figure 4 indicates that changes in the routine employment rate of prime-age individuals from 1990 to 2016 showed variation across local labor markets. However, share of prime-age population employed in routine occupations declined in almost all commuting zones across all states, which are not limited to the states in the Midwest and South East that experienced big declines in manufacturing employment. Similarly, Figure 5 shows that declines in the prime-age labor force participation rates show big variations across commuting zones.

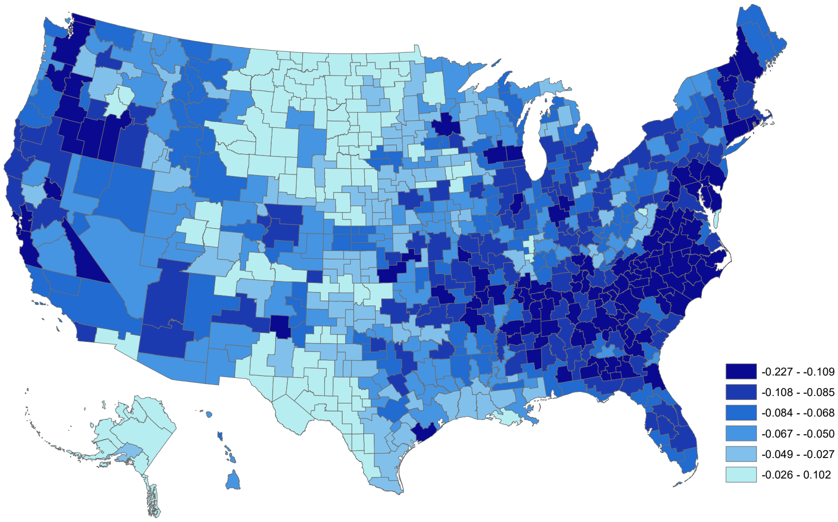


Figure 4: Change in the Share of Prime-Age Population Employed in Routine Occupations, Commuting Zones, 1990-2016

Notes: ACS and Census data, author's calculations.

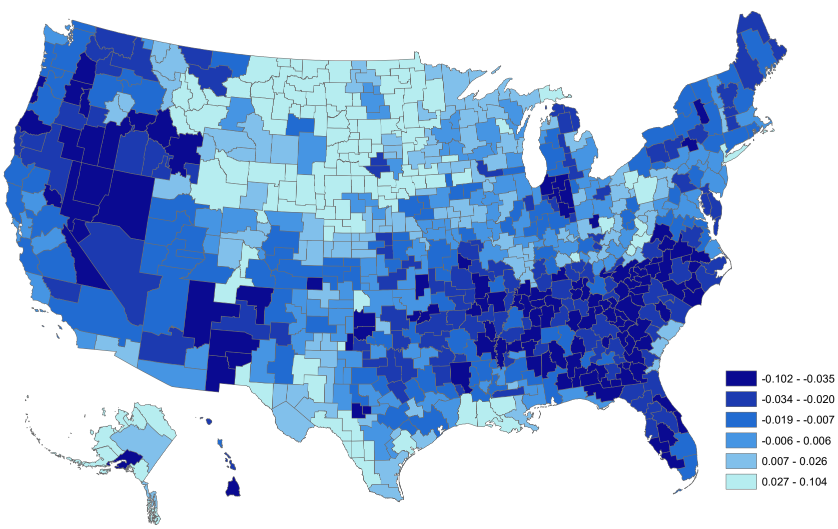


Figure 5: Change in the Prime-Age Labor Force Participation Rate, Commuting Zones, 1990-2016

Notes: ACS and Census data, author's calculations.

Comparing Figure 4 and Figure 5, the colors follow similar patterns; that is, local labor markets with larger declines in the share of prime-age population employed in routine jobs experienced larger declines in the prime-age labor force participation rates.

To further illustrate this point, Figure 6 plots changes in the prime-age labor force participation rates against changes in the share of prime-age population employed in routine occupations between 1990 and 2016. A weighted regression implies a statistically significant and positive correlation between these long-term trends across commuting zones.

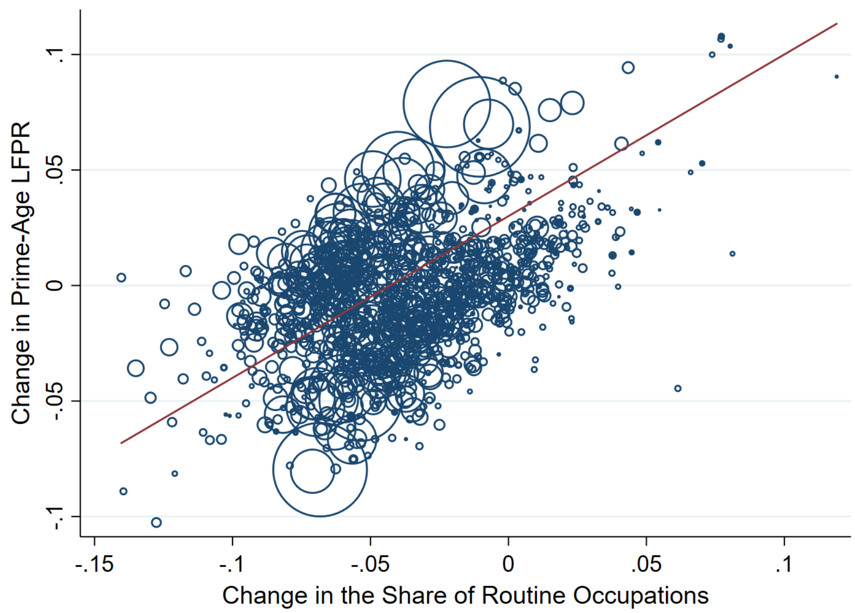


Figure 6: Change in the Prime-Age Labor Force Participation Rate vs. Change in the Share in Routine Occupations, 1990-2016
Notes: ACS and Census data, author's calculations. Each circle corresponds to a commuting zone and the size of the circle reflects the size of prime-age population in each commuting zone in 1990. The weighted regression line of the scatter plot has a slope of 0.700 with a robust standard error of 0.036.

3.2 Commuting-Zone Level Analysis

I model the relationship between the changes in routine employment and the changes in the prime-age labor market outcomes at the commuting-zone level as follows:

$$\Delta LM_{k\tau} = \alpha_t + \beta_1 \Delta Routine_{k\tau} + \beta_2 X_{kt} + \epsilon_{k\tau} \quad (2)$$

where $\Delta LM_{k\tau}$ represents the change in the labor market outcomes of prime-age individuals at commuting zone k and in time interval τ. The main labor market outcomes of interest are the prime-age labor force participation rate and the prime-age employment-to-population ratio. Variable $\Delta Routine_{k\tau}$ measures the change in the share of prime-age population employed in routine occupations in commuting zone k and in time interval τ. I include additional control variables X_{kt} measuring initial demographic characteristics and initial labor market structure in each commuting zone. These controls are the share of prime-age population with a bachelor's degree or higher, the share of prime-age population that is foreign-born, and the prime-age female labor force participation rate in commuting zone k at the starting time period t. The coefficient of interest is β_1, which quantifies the relationship between changes in the shares of prime-age individuals in routine jobs and changes in the labor market outcomes of prime-age individuals at the commuting-zone level.

I consider stacked differences (1990-2000 and 2000-2016), adjusted to correspond to changes in 10-year equivalent periods per commuting zone. It is useful to use stacked differences to exploit the differential change in routine employment between the 1990s and 2000s and to directly control for the commuting-zone-level trends. The stacked-differences regressions include a dummy variable for the 2000-2016 time period. All regressions are weighted by the population of prime-age individuals in each commuting zone in the starting time period. Census division dummies are included and standard errors are clustered at the state level.

In order to identify the causal effect of changes in labor demand (for workers to fill routine occupations) on the local labor market outcomes, I employ an instrumental variables estimation strategy that exploits differential exposure to common labor demand shocks. More specifically, in the spirit of the Bartik instrument (Bartik, 1991), I construct an instrument, which predicts local routine employment growth by interacting the initial employment rate in a routine occupation at a commuting zone with the national growth rate of employment in that routine occupation:

$$IV_{k\tau} = \sum_{n=1}^{J} \psi_{jkt} \left(\frac{Routine_{j(-k)t+1} - Routine_{j(-k)t}}{Routine_{j(-k)t}} \right) \tag{3}$$

where the first term ψ_{jkt} is the share of prime-age individuals employed in routine occupation j in commuting zone k in starting time period t. $Routine_{j(-k)t}$ and $Routine_{j(-k)t+1}$ represent the share of prime-age individuals employed in occupation j in all commuting zones but k and in time periods t and $t+1$, respectively. Therefore, the second term measures the growth rate of employment in routine occupation j in all commuting zones except commuting zone k between time periods t and $t+1$.

Following the argument in Goldsmith-Pinkham et al. (2018), the first term measures the exposure of the commuting zone to the common shocks measured in the second term. The weights ψ_{jkt} are fixed over time; therefore, the identifying variation comes from a comparison of commuting zones with high versus low initial shares of prime-age population employed in routine jobs. Variation over time is driven by changes in the national employment growth rates in routine occupations, and therefore, is not associated with changes in a commuting-zone's labor supply. Moreover, because the calculated national employment growth of each occupation excludes employment growth in the commuting zone of interest, occupational composition in that commuting zone does not cause a bias (Blanchard and Katz, 1992).

Figure 7 shows the performance of the IV by plotting the predicted changes in the share of local prime-age population in routine jobs against the observed changes between 1990 and 2016. The magnitude of F-statistic at the first stage is greater than the threshold of 10, indicating the instrument is not weak (Staiger and Stock, 1997). A weighted regression line of the scatter plot has a slope of 0.41 with a robust standard error of 0.013.

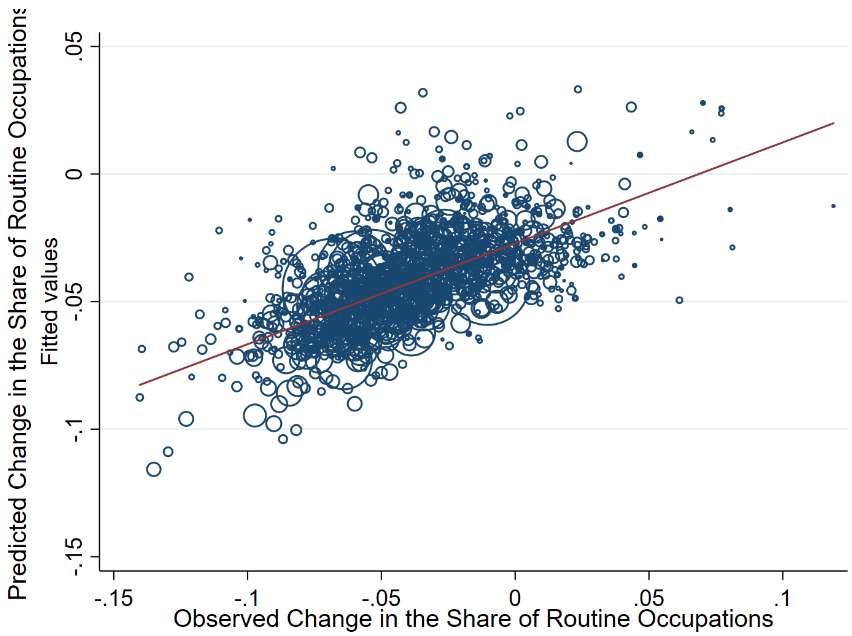


Figure 7: Predicted vs. Actual Change in the Share of Prime-Age Population Employed in Routine Occupations, 1990-2016

Notes: ACS and Census data, author's calculations. Each circle corresponds to a commuting zone and the size of the circle reflects the size of prime-age population in each commuting zone in initial time period. The weighted regression line of the scatter plot has a slope of 0.407 with a robust standard error of 0.013.

Table 5 shows the coefficients of β_1 from estimating Equation 2 by 2SLS regression and instrumenting for $\Delta Routine_{k\tau}$ with the IV. The decline in the share of prime-age population in routine occupations led to statistically significant declines in the labor force participation rate and the employment-to-population ratio of prime-age individuals. These results are robust to the inclusion of various control variables. The difference in declines in the prime-age routine employment rates in commuting zones at the 25th and 75th percentiles was 3.2 percentage points. Therefore, commuting zones at the 25th percentile of the routine employment change distribution experienced a 1.6 percentage point larger decline in the prime-age labor force participation rate between 1990 and 2016 than commuting zones at the 75th percentile of the routine employment change distribution (top panel).[4] Similarly, commuting zones at the 25th percentile experienced a 2 percentage point larger decline in the prime-age employment-to-population ratio than commuting zones at the 75th percentile

[4] The calculation is 0.505x0.032x100.

(bottom panel). Summary statistics and the results for the unweighted versions of these regressions, which yield to similar results, are provided in the Appendix.

Table 5: 2SLS Regression of Changes in the Labor Market Outcomes on Changes in Routine Employment, 1990-2016

	Δ Labor Force Participation Rate				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Employment	0.939***	0.764***	0.928***	0.939***	0.505***
	(0.156)	(0.100)	(0.147)	(0.185)	(0.141)
Share of College-Educated$_t$		0.055***			0.123***
		(0.016)			(0.022)
Share of Foreign-Born$_t$			0.003		-0.035***
			(0.009)		(0.010)
Female Labor Force Participation Rate$_t$				-0.001	-0.225***
				(0.043)	(0.059)
N	1482	1482	1482	1482	1482
R-squared	0.818	0.821	0.818	0.818	0.802
	Δ Employment-to-Population Ratio				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Employment	1.072***	0.892***	1.053***	1.070***	0.622***
	(0.168)	(0.115)	(0.154)	(0.197)	(0.155)
Share of College-Educated$_t$		0.056***			0.125***
		(0.019)			(0.024)
Share of Foreign-Born$_t$			0.005		-0.034***
			(0.010)		(0.010)
Female Labor Force Participation Rate$_t$				-0.003	-0.232***
				(0.047)	(0.059)
N	1482	1482	1482	1482	1482
R-squared	0.758	0.762	0.759	0.758	0.737

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include time dummies and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Next, I test for the shifts in employment across occupations at the commuting-zone level. For this exercise, I also consider separate time intervals, as there can be differences in changes in employment by occupation in the pre- and post-2000 periods. Table 6 shows that commuting zones with larger declines in routine employment experienced larger shifts toward non-routine occupations.

Table 6: 2SLS Regression of Changes in the Labor Market Outcomes on Changes in Routine Employment, by Major Occupations and Time Periods, 1990-2016

	Δ Employment-to-Population Ratio								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1990-2000									
Δ Share in Routine Employment	-0.024	-0.181***	-0.283***	-0.223***	0.210***	-0.103*	-0.009	1.052***	0.073**
	(0.080)	(0.069)	(0.070)	(0.080)	(0.054)	(0.055)	(0.027)	(0.110)	(0.033)
2000-2016									
Δ Share in Routine Employment	-0.088	-0.228***	-0.163***	-0.044	0.028	0.022	0.114***	0.871***	0.009
	(0.058)	(0.088)	(0.052)	(0.039)	(0.058)	(0.052)	(0.020)	(0.099)	(0.031)
1990-2016 Stacked									
Δ Share in Routine Employment	0.000	-0.182**	-0.197***	-0.087**	0.119**	0.039	0.067***	0.828***	0.033
	(0.052)	(0.078)	(0.060)	(0.041)	(0.051)	(0.053)	(0.012)	(0.117)	(0.024)

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include the initial share of the prime-age population with a bachelor's degree or higher, initial share of population that is foreign-born, initial prime-age female labor force participation rate, time dummies, and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses. The columns correspond to nine major occupations:
(1) Management and Business Operations & Finance
(2) Professional: Computer & Mathematics, Architecture & Engineering, Life Physical & Social Science, Community & Social Services, Legal, Education, Training & Library, Arts, Entertainment & Sports, and Healthcare Practitioners
(3) Service: Healthcare Support, Protective Service, Food Preparation & Serving, Cleaning & Maintenance, and Personal Care
(4) Sales
(5) Office & Administrative Support
(6) Construction Trades & Extraction
(7) Installation, Maintenance & Repair
(8) Production
(9) Transportation & Material Moving

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

In all time periods (1990-2000, 2000-2016, and stacked), there have been large employment losses in routine occupations and mostly in production occupations (column 8). The declines in routine, office and administrative occupations (column 5) were more evident in the 1990-2000 period, while the declines in routine, installation, maintenance and repair occupations (column 7) were concentrated in the 2000-2016 period. In all time periods considered, employment increased in non-routine occupations, both in high-skill professional occupations (column 2) and in low-skill service occupations (column 3).

The employment shifts from routine or middle-skill occupations toward non-routine, high- and low-skill occupations at the commuting-zone level are in line with the aggregate evidence provided in the previous section using the CPS data. My analyses reveal that these employment shifts were not sufficient to fully offset the employment losses due to disappearance of routine occupations and resulted in lower prime-age labor force participation rates and lower prime-age employment-to-population ratios across local labor markets in the United States.

3.3 Heterogenous Effects by Demographic Groups

The patterns in the prime-age labor force participation rate differed for gender groups prior to the 2000s, but since then, the labor market outcomes of prime-age men and women have shown similar trends. The labor force participation rate of prime-age men in the United States has been declining since the 1960s, but the decline has accelerated more recently as seen in Figure 8. Table 7 shows that the share of prime-age men either working or actively looking for work decreased from 93.4 percent in 1990 to 88.3 percent in 2015. Similarly, the employment-to-population ratio of prime-age men declined from 89.1 percent in 1990 to 84.3 percent in 2015. While the labor force participation rate and the employment-to-population ratio of prime-age men increased slightly by 2018, they remain well below the 1990 levels.

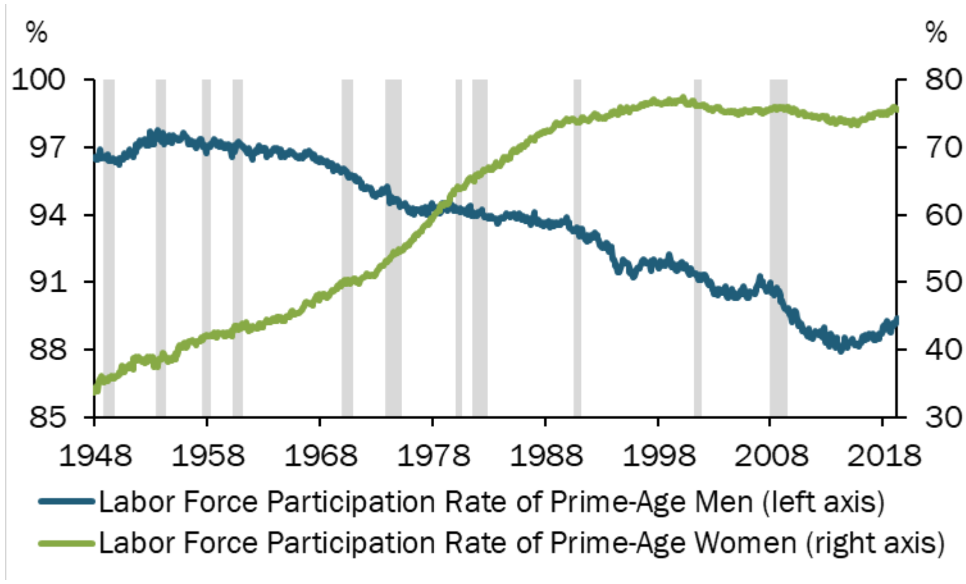


Figure 8: Labor Force Participation Rates of Prime-Age Men and Women, 1948-2018

Notes: BLS, Haver Analytics. Data are monthly and seasonally adjusted.

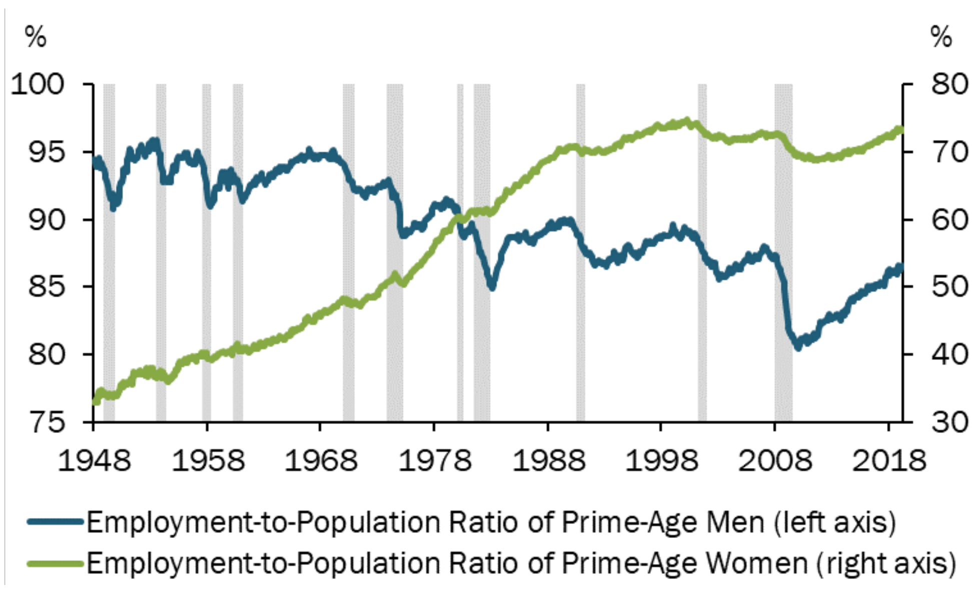


Figure 9: Employment-to-Population Ratios of Prime-Age Men and Women, 1948-2018

Notes: BLS, Haver Analytics. Data are monthly and seasonally adjusted.

Turning to prime-age women, their labor force participation rate increased substantially over the second half of the 20th century, but this growth stagnated and reversed since 2000 as seen in Figure 8. The labor force participation rate of prime-age women rose from 74.0 percent in 1990 to 76.8 percent in 2000, but declined to 73.9 percent in 2015 (Table 7).

Similarly, the employment-to-population ratio of prime-age women rose from 70.5 percent in 1990 to 74.3 percent in 2000, but then declined to 70.5 percent in 2015. Although the labor force participation rate and the employment-to-population of prime-age women increased slightly by 2018, they remain well below the 2000 levels. Therefore, beginning in 2000, there was a stark change in the trajectory of prime-age women's labor market outcomes, with their labor force participation rate and employment-to-population ratio beginning to decline in parallel with prime-age men's labor market outcomes and remaining at lower levels than men's as seen in Figure 9.

These recent patterns in the labor market outcomes of prime-age men and women, however, mask important heterogeneity across different education groups as individuals with lower educational attainment tend to have lower participation rates than their more-educated counterparts. To account for these differences, I compare changes in the labor market outcomes across both gender and education groups. To facilitate comparison, I group prime-age individuals into one of four groups: men with less than a bachelor's degree (non-college men), men with a bachelor's degree or higher (college men), women with less than a bachelor's degree (non-college women), and women with a bachelor's degree or higher (college women).

Three observations emerge from comparing changes in the labor market outcomes of these four demographic groups. First, among all prime-age individuals, college-educated men had the highest labor force participation rate and employment-to-population ratio in 1990, followed by men with less education, and the labor market outcomes of all men declined steadily until 2015 (Table 7). More specifically, the labor force participation rate of college-educated men declined from 96.8 percent in 1990 to 93.9 percent in 2015, while that for prime-age men without a bachelor's degree declined from 92.1 percent in 1990 to 85.5 percent in 2015. Similarly, the employment-to-population ratio of college-educated men declined from 94.8 percent in 1990 to 91.8 percent in 2015, while that for prime-age men without a bachelor's degree declined from 87.0 percent in 1990 to 80.6 percent in 2015. Second, the labor market outcomes of college-educated prime-age women declined since 1990, while those for women without a bachelor's degree increased between 1990 and 2000, but declined afterwards. 83.8 percent of college-educated prime-age women participated in the labor force in 1990, but this share was 82.4 percent in 2015, remaining below those of their male-counterparts. Third, although there have been slight improvements in the labor market outcomes since 2015, the labor force participation rates and the employment-to-population ratios in 2018 remain below the 1990 levels for all four demographic groups.

Table 7: Prime-Age Labor Market Outcomes by Gender and Education Groups

		Labor Force Participation Rate (percent)	Employment-to-Population Ratio (percent)
Prime-Age Men	1990	93.39	89.12
	2000	91.65	88.99
	2015	88.28	84.34
	2018	89.07	86.19
Prime-Age Women	1990	73.95	70.54
	2000	76.79	74.26
	2015	73.88	70.48
	2018	75.69	73.12
Non-College Men	1990	92.11	87.01
	2000	89.86	86.68
	2015	85.47	80.62
	2018	86.21	82.80
College Men	1990	96.81	94.78
	2000	95.88	94.44
	2015	93.88	91.77
	2018	94.24	92.33
Non-College Women	1990	71.07	67.25
	2000	74.32	71.38
	2015	68.68	64.52
	2018	70.23	67.08
College Women	1990	83.79	81.79
	2000	83.00	81.49
	2015	82.43	80.28
	2018	83.51	81.75

Notes: CPS data, author's calculations.

Another important observation is that routine employment declined for all four demographic groups since 1990 as shown in Table 8. First, routine employment has been more common among prime-age men and women without a bachelor's degree. Second, men worked mostly in routine manual jobs, such as blue-collar production occupations, while women worked mostly in routine cognitive jobs, such as white-collar office and administrative support occupations. Third, the share in routine occupations declined the most for prime-age men and women without a bachelor's degree, and employment losses were concentrated in routine manual jobs for men and routine cognitive jobs for women. More specifically, while 61.6 percent of prime-age men without a bachelor's degree worked in a routine job in 1990 and this share declined to 52.1 percent in 2015, due to employment losses in routine manual occupations. Similarly, 38.4 percent of prime-age women without a college degree worked in routine occupations and this share declined to 28.6 percent in 2015, due to employment losses in routine cognitive occupations. Lastly, although lower shares of college-educated prime-age men and women were employed in routine occupations in 1990, they also faced employment losses in routine occupations by 2015. Since 2015, there have been only slight increases in routine employment among prime-age individuals due to a cyclical rebound in transportation and construction occupations.

Table 8: Share of Prime-Age Population Employed in Routine Occupations

		Routine (percent)	Routine Manual (percent)	Routine Cognitive (percent)
Non-College Men	1990	61.58	48.28	13.29
	2000	59.71	46.29	13.42
	2015	52.07	39.71	12.36
	2018	53.42	40.75	12.67
College Men	1990	24.31	8.07	16.24
	2000	23.09	7.72	15.37
	2015	20.89	7.61	13.28
	2018	20.39	7.69	12.70
Non-College Women	1990	38.40	9.67	28.73
	2000	36.76	8.87	27.88
	2015	28.55	6.03	22.52
	2018	29.33	7.01	22.32
College Women	1990	17.28	1.36	15.92
	2000	14.84	1.50	13.34
	2015	14.94	1.32	13.62
	2018	14.53	1.55	12.98

Notes: CPS data, author's calculations. People who are in farming and armed forces occupations and industries and people who are self-employed or working without pay are excluded.

These patterns suggest that prime-age men and women without a bachelor's degree faced larger declines in routine employment and also experienced more dramatic deteriorations in their labor market outcomes than their college-educated counterparts. To further explore this heterogeneity in the labor market outcomes, I repeat the state-level and commuting-zone-level estimations for these four demographic groups.

Starting with estimating Equation 1 and using state-level data from the CPS, I find positive and statistically significant correlations between each group's labor force participation rate and the share of prime-age individuals employed in routine occupations as shown in Table 9.

The correlations are the largest for prime-age men and women without a bachelor's degree. On average, a 10 percentage point lower prime-age routine employment is associated with a 4 percentage point lower participation rate among men without a bachelor's degree and a 5.1 percentage point lower participation rate among women without a bachelor's degree. The correlations are statistically different and larger for women's participation rates compared to men's. Turning to college-educated men and women, the correlations are much smaller in magnitude than non-college men and women. On average, a 10 percentage point lower prime-age routine employment is associated with a 0.5 percentage point lower participation rate for college-educated men and a 2.0 percentage point lower participation rate for college-educated women. Again, the correlations are statistically different and larger for women's participation rates compared to men's. I find similar results when I estimate the correlations between each group's employment-to-population ratio and the share of prime-age individuals employed in routine occupations at the state level.

Table 9: Panel Regression of the Labor Market Outcomes on the Prime-Age Routine Employment, by Gender and Education, 1994-2018

	Labor Force Participation Rate				
	All	Non-College Men	College Men	Non-College Women	College Women
Share in Routine Employment	0.375***	0.398***	0.051**	0.505***	0.195***
	(0.019)	(0.028)	(0.020)	(0.032)	(0.028)
	Employment-to-Population Ratio				
	All	Non-College Men	College Men	Non-College Women	College Women
Share in Routine Employment	0.357***	0.407***	0.010	0.484***	0.146***
	(0.018)	(0.028)	(0.021)	(0.033)	(0.032)

Notes: CPS state-level panel data from 1994 to 2018. Each variable is constructed at monthly level and state level. All regressions include share of the prime-age population with a bachelor's degree or higher, share of prime-age population that is foreign-born, share of prime-age population employed in manufacturing, and prime-age unemployment rate at the state level. Time and state fixed effects are also included. Each observation is weighted by the state's prime-age population in 1994. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Given the differences in the types of routine employment losses among prime-age individuals, I breakdown the regressor in Equation 1 into routine manual and routine cognitive employment components. Table 10 shows that the labor force participation rate of prime-age men without a bachelor's degree has a larger positive correlation with routine manual employment than routine cognitive employment, while the labor force participation rate of prime-age women without a bachelor's degree has a larger positive correlation with routine cognitive employment than routine manual employment, in line with the results presented earlier. Turning to college-educated prime-age individuals, female labor force participation rate has positive and statistically significant correlations with both types of routine employment, while male labor force participation rate has a small, positive significant correlation with only routine cognitive employment.

Table 10: Panel Regression of Labor Market Outcomes on Prime-Age Manual and Cognitive Routine Employment Rates, by Gender and Education, 1994-2018

	Labor Force Participation Rate				
	All	Non-College Men	College Men	Non-College Women	College Women
Share in Routine Manual Employment	0.417***	0.555***	0.052	0.415***	0.219***
	(0.027)	(0.039)	(0.033)	(0.053)	(0.051)
Share in Routine Cognitive Employment	0.339***	0.264***	0.050**	0.582***	0.175***
	(0.019)	(0.026)	(0.020)	(0.031)	(0.029)
	Employment-to-Population Ratio				
	All	Non-College Men	College Men	Non-College Women	College Women
Share in Routine Manual Employment	0.397***	0.602***	-0.002	0.364***	0.146***
	(0.026)	(0.040)	(0.034)	(0.053)	(0.052)
Share in Routine Cognitive Employment	0.323***	0.242***	0.020	0.586***	0.146***
	(0.018)	(0.025)	(0.025)	(0.032)	(0.036)

Note: CPS state-level panel data from 1994 to 2018. Each variable is constructed at monthly level and state level. All regressions include share of the prime-age population with a bachelor's degree or higher, share of prime-age population that is foreign-born, share of prime-age population employed in manufacturing, and prime-age unemployment rate at the state level. Time and state fixed effects are also included. Each observation is weighted by the state's prime-age population in 1994. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Next, I use the commuting-zone-level data from the Census and the ACS and repeat the instrumental variable estimation of Equation 2. Table 11 shows that the decline in prime-age routine employment resulted in lower labor force participation rates and employment-to-population ratios for prime-age men and women without a bachelor's degree. Between 1990 and 2016, commuting zones at the 25th percentile of the routine employment rate change distribution experienced a 1.7 percentage point larger decline in the labor force participation rate of men without a bachelor's degree and a 2.2 percentage point larger decline in the labor force participation rate of women without a bachelor's degree than commuting zones at the 75th percentile of the routine employment rate change distribution. When the outcome variable is the employment-to-population ratio, I find that commuting zones at the 25th percentile experienced a 2.2 percentage point larger decline in the employment-to-population ratio of men without a bachelor's degree and a 2.7 percentage point larger decline in the employment-to-population ratio of women without a bachelor's degree than commuting zones at the 75th percentile. In contrast, the coefficients for college-educated prime-age men and women turn out to be mostly insignificant in these estimations.

Table 11: 2SLS Regression of Changes in the Labor Market Outcomes on Changes in the Routine Employment Rates, by Gender and Education, 1990-2016

	Δ Labor Force Participation Rate				
	All	Non-College Men	College Men	Non-College Women	College Women
Δ Share in Routine Employment	0.505***	0.520**	0.071	0.672***	0.108
	(0.141)	(0.204)	(0.109)	(0.156)	(0.104)
	Δ Employment-to-Population Ratio				
	All	Non-College Men	College Men	Non-College Women	College Women
Δ Share in Routine Employment	0.622***	0.677***	0.079	0.830***	0.164*
	(0.155)	(0.218)	(0.106)	(0.178)	(0.093)

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include the initial share of the prime-age population with a bachelor's degree or higher, initial share of population that is foreign-born, initial prime-age female labor force participation rate, time dummies, and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Turning to shifts in employment across occupations, Table 12 shows that commuting zones with larger routine employment losses experienced larger employment declines among prime-age men and women without a bachelor's degree in production occupations (column 8), installation, maintenance, and repair occupations (column 7), and office and administrative support occupations (column 5).

Table 12: 2SLS Regression of Changes in Labor Market Outcomes on Changes in Routine Employment Rates for Prime-Age Men, by Major Occupations, Education Groups, and Time Periods, 1990-2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Δ Non-College Male Employment-to-Population Ratio								
Δ Share in Routine Employment	0.027	0.032	-0.136*	-0.080	0.161***	0.002	0.107***	0.615***	-0.052
	(0.036)	(0.031)	(0.081)	(0.050)	(0.051)	(0.137)	(0.035)	(0.076)	(0.063)
	Δ College Male Employment-to-Population Ratio								
Δ Share in Routine Employment	0.162*	-0.493***	-0.004	0.071	0.138**	0.050	0.052	0.096***	0.025
	(0.094)	(0.171)	(0.065)	(0.112)	(0.055)	(0.047)	(0.034)	(0.036)	(0.036)
	Δ Non-College Female Employment-to-Population Ratio								
Δ Share in Routine Employment	-0.014	-0.103*	-0.364***	-0.128**	0.203*	0.013**	0.024***	1.162***	0.039*
	(0.047)	(0.054)	(0.119)	(0.063)	(0.116)	(0.006)	(0.005)	(0.187)	(0.022)
	Δ College Female Employment-to-Population Ratio								
Δ Share in Routine Employment	0.090	-0.284**	0.057	0.010	0.222***	-0.013	-0.005	0.028	0.023**
	(0.068)	(0.137)	(0.038)	(0.039)	(0.061)	(0.008)	(0.009)	(0.020)	(0.011)

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include the initial share of the prime-age population with a bachelor's degree or higher, initial share of population that is foreign-born, initial prime-age female labor force participation rate, time dummies, and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses. The columns correspond to nine major occupations:
(1) Management and Business Operations & Finance
(2) Professional: Computer & Mathematics, Architecture & Engineering, Life Physical & Social Science, Community & Social Services, Legal, Education, Training & Library, Arts, Entertainment & Sports, and Healthcare Practitioners
(3) Service: Healthcare Support, Protective Service, Food Preparation & Serving, Cleaning & Maintenance, and Personal Care
(4) Sales
(5) Office & Administrative Support
(6) Construction Trades & Extraction
(7) Installation, Maintenance & Repair
(8) Production
(9) Transportation & Material Moving

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

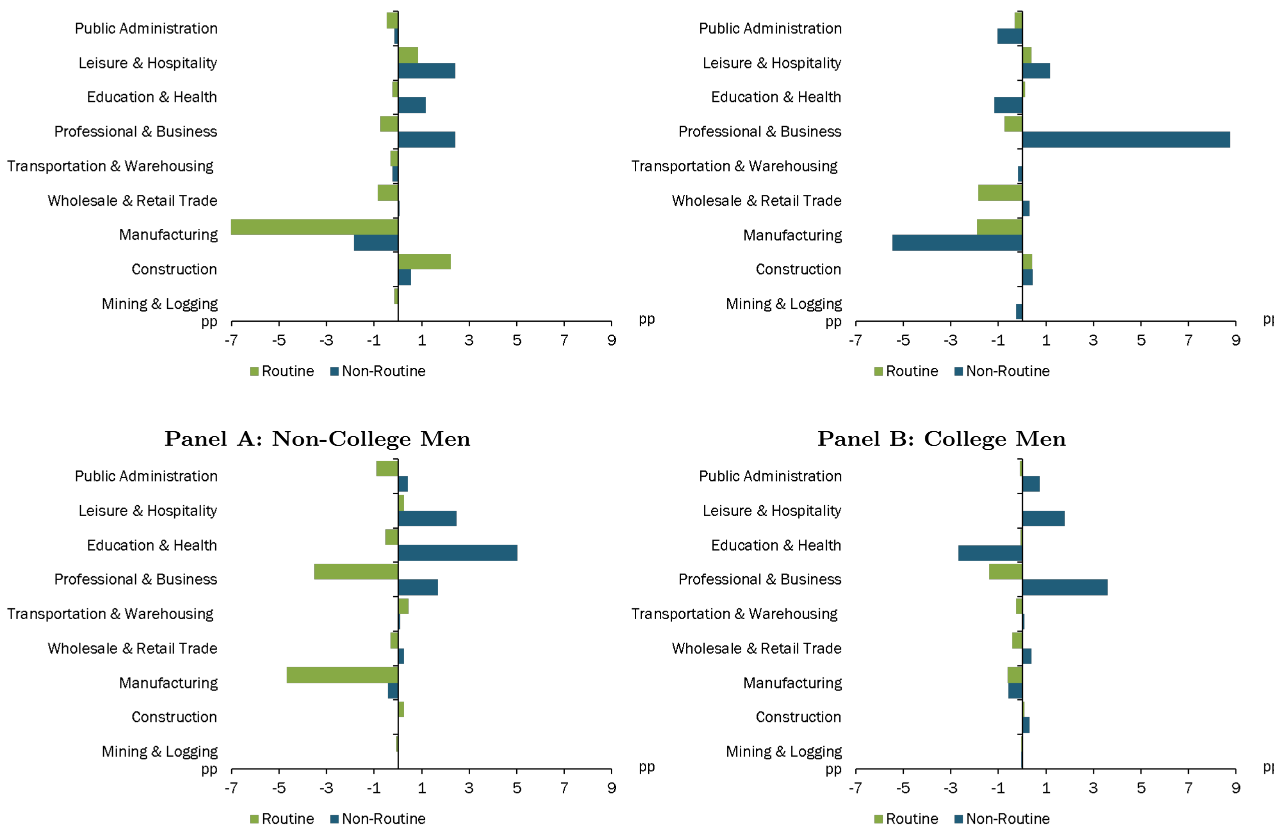
Interestingly, declines in production employment were more pronounced for prime-age women and they also experienced small employment losses in construction occupations (column 6) and transportation and material moving occupations (column 9). The differential reallocation of non-college labor into low-skill service occupations (column 3) was more pronounced for women than men. Surprisingly, there were some employment gains in sales and professional occupations for prime-age women without a bachelor's degree.

In the case of college-educated prime-age men, employment declined in routine office and administrative jobs (column 5) as well as in production jobs. Similarly, college-educated prime-age women experienced job losses in routine office and administrative occupations (column 5) as well as in transportation occupations (column 9). The differential reallocation of college-educated labor into high-skill professional occupations (column 2) has been similar for men and women.

3.4 Declining Manufacturing Employment and Routine Employment Losses Across Industries

One common assumption is that the disappearance of routine occupations has been driven mainly by contractions in manufacturing, where a large share of jobs was in the routine category. For example, Valetta (2019) uses state-level panel data to show that the decline in blue-collar (routine manual) manufacturing employment had a meaningful contribution to the decline in the prime-age labor force participation rate in the past two decades. However, did job losses in routine occupations take place only in the manufacturing industries?

To answer this question, I first use the CPS data to compute changes in prime-age employment in routine and non-routine occupations across major industries. Figure 10 shows that routine employment declined in most major industries and employment shifted from manufacturing to non-manufacturing industries. In the case of prime-age men without a bachelor's degree, the majority of the decline in employment was in routine, blue-collar production occupations that were concentrated in the manufacturing industries, but declines in routine employment were broad based. Part of the decline in routine employment in manufacturing was offset by an increase in routine employment in construction, in line with the findings in Charles et al. (2016) that increases in employment in construction during the housing boom masked part of the employment losses in manufacturing for less educated workers. These men also experienced employment losses in non-routine occupations in the manufacturing industries. In the case of college-educated prime-age men, routine employment losses were observed across several industries, but in smaller magnitudes than their less-educated counterparts. This group experienced large increases in non-routine employment in professional and business services, which offset the decline in non-routine employment in manufacturing.



Panel A: Non-College Men

Panel B: College Men

Panel C: Non-College Women

Panel D: College Women

Figure 10: Changes in Prime-Age Employment by Major Industries and Routine Classifications, 1990-2018

Notes: BLS, Haver Analytics.

Turning to prime-age women without a bachelor's degree, there were large employment losses in routine occupations in manufacturing, but comparable declines in routine employment were observed in other industries, especially in professional and business services. In the case of college-educated prime-age women, there were smaller routine employment losses and larger increases in non-routine employment in professional and business services than less educated women. To summarize, while there were large routine employment losses in the manufacturing industries for prime-age men and women without a bachelor's degree, declines in routine employment were broad based for all prime-age individuals.

Data from the Census and ACS also indicate employment losses in manufacturing and employment shifts toward non-manufacturing industries. Table 13 reports that 14.6 percent of all prime-age individuals were employed in the manufacturing industries in 1990, this share declined slightly to 12.5 percent by 2000 and declined sharply to around 8.9 percent by 2016. At the same time prime-age employment in non-manufacturing industries rose from 63.0 percent in 1990 to 67.7 percent in 2016. Similar shifts were experienced by all demographic groups.

Table 13: Prime-Age Employment in Manufacturing and Non-Manufacturing Industries in 1990, 2000, and 2016

		Manufacturing Employment/Population	Non-Manufacturing Employment/Population
All Prime-Age	1990	14.59	62.95
	2000	12.49	62.86
	2016	8.87	67.72
Non-College Men	1990	22.66	62.00
	2000	19.24	59.72
	2016	13.84	65.11
College Men	1990	16.41	77.50
	2000	14.72	77.00
	2016	11.53	80.37
Non-College Women	1990	10.09	55.65
	2000	8.55	56.46
	2016	5.32	59.43
College Women	1990	4.71	76.55
	2000	4.89	74.63
	2016	4.37	77.06

Source: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Author's calculations.

More importantly, employment of prime-age individuals in routine occupations declined in both manufacturing and non-manufacturing industries. Table 14 shows that 11.0 percent prime-age population employed in routine occupations in manufacturing in 1990, and it decreased to 6.0 percent in 2016. Similarly, the share of prime-age individuals employed in routine occupations in non-manufacturing declined from 31.3 percent in 1990 to 27.1 percent in 2016. While the declines in routine employment in manufacturing were primarily post-2000, declines in routine employment in non-manufacturing were evident since the 1990s. Routine employment in both manufacturing and non-manufacturing industries were more common among prime-age men and women without a bachelor's degree than their college-educated counterparts. However, routine employment declined in both sectors and for all four demographic groups.

Table 14: Prime-Age Routine Employment in Manufacturing and Non-Manufacturing Industries in 1990, 2000, and 2016

		Manufacturing Routine Employment/Population	Non-Manufacturing Routine Employment/Population
All Prime-Age	1990	11.03	31.25
	2000	9.07	28.95
	2016	6.01	27.14
Non-College Men	1990	18.90	42.08
	2000	16.13	39.33
	2016	11.63	40.11
College Men	1990	5.06	20.90
	2000	3.78	18.20
	2016	2.99	17.97
Non-College Women	1990	8.80	29.72
	2000	7.36	28.93
	2016	4.48	25.78
College Women	1990	1.78	15.34
	2000	1.61	13.96
	2016	1.28	14.10

Source: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Author's calculations.

To estimate the impact of declining routine occupations on prime-age employment in the manufacturing and non-manufacturing industries, I repeat the 2SLS regressions for the two industry groups separately.

Table 15: 2SLS Regression of Changes in the Labor Market Outcomes on Changes in the Routine Employment, by Gender and Education Groups, Manufacturing, 1990-2016

	Δ Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Manufacturing Employment	1.076***	1.117***	1.107***	1.077***	1.151***
	(0.027)	(0.029)	(0.031)	(0.028)	(0.030)
Share of College-Educated$_t$		-0.017***			-0.022***
		(0.004)			(0.006)
Share of Foreign-Born$_t$			-0.013**		-0.007
			(0.006)		(0.006)
Female Labor Force Participation Rate$_t$				0.005	0.021**
				(0.007)	(0.010)
N	1482	1482	1482	1482	1482
F statistics	47.96	81.73	50.16	49.12	79.74
	Δ Non-College Male Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Manufacturing Employment	1.110***	1.167***	1.085***	1.109***	1.196***
	(0.083)	(0.084)	(0.081)	(0.081)	(0.081)
Share of College-Educated$_t$		-0.023**			-0.053***
		(0.010)			(0.017)
Share of Foreign-Born$_t$			0.011		0.024*
			(0.011)		(0.013)
Female Labor Force Participation Rate$_t$				-0.007	0.052**
				(0.020)	(0.023)
N	1482	1482	1482	1482	1482
F statistics	47.96	81.73	50.16	49.12	79.74
	Δ College Male Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Manufacturing Employment	0.504***	0.690***	0.597***	0.505***	0.819***
	(0.121)	(0.130)	(0.138)	(0.121)	(0.133)
Share of College-Educated$_t$		-0.076***			-0.108***
		(0.019)			(0.024)
Share of Foreign-Born$_t$			-0.039		-0.013
			(0.029)		(0.028)
Female Labor Force Participation Rate$_t$				0.004	0.094**
				(0.030)	(0.042)
N	1479	1479	1479	1479	1479
F statistics	47.96	81.73	50.16	49.12	79.74
	Δ Non-College Female Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Manufacturing Employment	1.216***	1.281***	1.263***	1.212***	1.294***
	(0.043)	(0.039)	(0.037)	(0.042)	(0.039)
Share of College-Educated$_t$		-0.027***			-0.015
		(0.005)			(0.012)
Share of Foreign-Born$_t$			-0.020***		-0.019***
			(0.005)		(0.006)
Female Labor Force Participation Rate$_t$				-0.015	-0.011
				(0.012)	(0.020)
N	1482	1482	1482	1482	1482
F statistics	47.96	81.73	50.16	49.12	79.74
	Δ College Female Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Manufacturing Employment	0.023	0.130***	0.091**	0.024	0.213***
	(0.052)	(0.049)	(0.044)	(0.051)	(0.046)
Share of College-Educated$_t$		-0.044***			-0.059***
		(0.009)			(0.008)
Share of Foreign-Born$_t$			-0.029***		-0.014**
			(0.009)		(0.007)
Female Labor Force Participation Rate$_t$				0.007	0.053***
				(0.009)	(0.011)
N	1462	1462	1462	1462	1462
F statistics	47.96	81.73	50.16	49.12	79.74

Note: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include time dummies and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses.

*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table 16: 2SLS Regression of Changes in Labor Market Outcomes on Changes in Routine Employment Rates, by Gender and Education Groups, Non-Manufacturing, 1990-2016

	Δ Non-Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Non-Manufacturing Employment	0.856***	1.174***	0.870***	0.781***	1.180***
	(0.106)	(0.183)	(0.109)	(0.156)	(0.186)
Share of College-Educated$_t$		0.098**			0.146***
		(0.038)			(0.035)
Share of Foreign-Born$_t$			0.016		-0.027***
			(0.012)		(0.007)
Female Labor Force Participation Rate$_t$				-0.066	-0.111***
				(0.043)	(0.036)
N	1482	1482	1482	1482	1482
F statistics	24.16	33.31	21.49	41.43	32.87

	Δ Non-College Male Non-Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Non-Manufacturing Employment	1.156***	2.034***	1.197***	1.266***	2.051***
	(0.122)	(0.235)	(0.140)	(0.133)	(0.236)
Share of College-Educated$_t$		0.270***			0.254***
		(0.034)			(0.032)
Share of Foreign-Born$_t$			0.045***		-0.001
			(0.015)		(0.008)
Female Labor Force Participation Rate$_t$				0.095**	0.061*
				(0.039)	(0.037)
N	1482	1482	1482	1482	1482
F statistics	24.16	33.31	21.49	41.43	32.87

	Δ College Male Non-Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Non-Manufacturing Employment	0.589**	1.549***	0.609**	0.830**	1.608***
	(0.258)	(0.470)	(0.260)	(0.338)	(0.472)
Share of College-Educated$_t$		0.295***			0.260***
		(0.084)			(0.070)
Share of Foreign-Born$_t$			0.022		-0.014
			(0.027)		(0.020)
Female Labor Force Participation Rate$_t$				0.209**	0.161**
				(0.084)	(0.078)
N	1482	1482	1482	1482	1482
F statistics	24.16	33.31	21.49	41.43	32.87

	Δ Non-College Female Non-Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Non-Manufacturing Employment	0.965***	0.771***	0.961***	0.708***	0.757***
	(0.152)	(0.283)	(0.152)	(0.234)	(0.288)
Share of College-Educated$_t$		-0.060			0.044
		(0.052)			(0.051)
Share of Foreign-Born$_t$			-0.004		-0.043***
			(0.011)		(0.009)
Female Labor Force Participation Rate$_t$				-0.224***	-0.272***
				(0.060)	(0.057)
N	1482	1482	1482	1482	1482
F statistics	24.16	33.31	21.49	41.43	32.87

	Δ College Female Non-Manufacturing Employment				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Non-Manufacturing Employment	-0.223	-0.397	-0.240	-0.430*	-0.387
	(0.149)	(0.261)	(0.152)	(0.228)	(0.282)
Share of College-Educated$_t$		-0.054			0.051
		(0.036)			(0.035)
Share of Foreign-Born$_t$			-0.019*		-0.056***
			(0.011)		(0.015)
Female Labor Force Participation Rate$_t$				-0.180**	-0.243***
				(0.078)	(0.070)
N	1482	1482	1482	1482	1482
F statistics	24.16	33.31	21.49	41.43	32.87

Note: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include time dummies and Census division dummies. Each observation is weighted by initial prime-age population in each commuting zone. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table 15 reports thats commuting zones with larger declines in routine employment in the manufacturing industries experienced larger declines in prime-age employment in the manufacturing industries. While employment among all demographic groups were impacted by the decline in routine employment, the impact was the largest for prime-age men and women without a bachelor's degree.

Similarly, commuting zones with larger declines in routine employment in the non-manufacturing industries experienced larger declines in prime-age employment in the non-manufacturing industries (Table 16). The negative impact has been the largest for prime-age men without a bachelor's degree, followed by college-educated men and women without a bachelor's degree. The estimates for college-educated prime-age women are not statistically significant.

4 Conclusion

In this paper, I study the relationship between disappearing routine occupations and the decline in the labor force participation rate of prime-age individuals since the 1990s. My results indicate that commuting zones with larger declines in routine employment experienced larger declines in the prime-age labor force participation rates. Moreover, disappearing routine employment mostly reduced the labor force participation rates of prime-age men and women without a bachelor's degree. Lastly, I show that declines in routine employment in both manufacturing and non-manufacturing industries contributed to the declines in prime-age employment and the prime-age labor force participation rate.

Skills demanded in the labor market are rapidly changing; automation and trade continue to render the skills of many less-educated workers obsolete. This lack of job opportunities, in turn, is shown to lead to depression, illness, and dependence on pain medication among displaced workers, and these health conditions may become further barriers to their employment (Krueger, 2016). Ending this vicious cycle—and avoiding further decreases in the labor force participation rate of prime-age individuals—will require equipping workers with the new skills and educations that employers are demanding in the face of rapid technological advancements.

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A Consistent Classifications

Table A.1: Consistent Classification of Occupations, 1990-2016

Routine Classification	Detailed Occupations	1990 Occupation Codes	2000 - 2016 Occupation Codes	Consistent Groupings
Non-Routine Cognitive	Management	3-5, 7-19, 473, 475, 476	10-430	1-24
	Business Operations & Finance	23-34, 37, 375	500-950	25-29, 31-48
	Computer and Mathematical	64-68, 213-218, 229	1000-1240	49-56
	Architecture & Engineering	43-63, 866	1300-1560	57-74
	Life, Physical & Social Science	69-83, 166-173, 223-225, 235	1600-1965	75-94
	Community and Social Services	163, 174, 176, 177, 467	2000-2060	95-100
	Legal	178, 179, 234, 314	2100-2160	101
	Education, Training & Library	113-159, 164, 165, 387	2200-2550	102-112
	Arts, Entertainment & Sports	183-199, 228	2600-2920	113-130
	Healthcare Practitioners	84-106, 203-208, 677	3000-3540	131-158
Non-Routine Manual	Healthcare Support	445-447	3600-3655	159-164
	Protective Service	6, 413-427	3700-3955	165-177, 30
	Food Preparation and Serving	404, 433-444	4000-4150	179-190
	Cleaning and Maintenance	405, 407, 448-453, 455, 474, 485, 486	4200-4250	191-196
	Personal Care	175, 406, 456-464, 466, 468, 469, 487, 773	4300-4549, 4551-4650	197-211, 213-217
Routine Cognitive	Sales	243-285	4700-4965	218-235
	Office & Administrative Support	303-313, 315-374, 376-386, 389,877	5000-5940	236-285
Routine Manual	Construction Trades & Extraction	35, 543, 553-576, 579-617, 643, 653, 654, 844, 855, 865, 867, 869	6200-6940	293-324
	Installation, Maintenance & Repair	503-539, 544-549, 577,864	7000-7630	325-356
	Production	233, 403, 633-639, 644-649, 655-676, 678-769, 774-799, 873	7700-8965	357-418
	Transportation & Material Moving	226, 227, 454, 465, 803-843, 845-853, 856-863, 875, 876, 878-889	4550, 9000-9750	419-448, 212

Table A.2: Consistent Classification of Industries, 1990-2016

Major Industries	1990 Industry Codes	2000-2016 Industry Codes
Agriculture	10, 11, 30, 31, 32, 230	170-290
Mining & Logging	40-50	370-490
Construction	60	770
Manufacturing	100-162, 180-222, 231-282, 291-392, 610	1070-3990
Wholesale & Retail Trade	500-602, 611-640, 642-691	4070-5790
Transportation & Warehousing	171, 172, 400-422, 440-470, 472, 732, 800, 852	570-690, 6070-6390, 6470-6780
Professional & Business	12, 20, 432, 471, 700-731, 740-750, 781, 791, 801, 841, 882-892	6870-7190, 7270-7790
Education & Health	812-840, 842-851, 860-863, 870, 871	7860-8470
Leisure & Hospitality	641, 751-762, 771-780, 782, 790, 802, 810, 872-881, 893	8560-8690, 8770-9290
Public Administration	900-932	9370-9590
Armed Forces	940-960	9670-9870

B Summary Statistics

Table B.1: Commuting-Zone-Level Data, 1990-2000

	All CZ	Min	25th	Median	75th	Max
Change in Employment-to-Population Ratio	-2.18	-10.76	-4.36	-2.06	-0.12	13.61
Non-College Men	-5.79	-17.63	-8.24	-5.53	-3.40	13.26
College Men	-2.26	-10.25	-3.28	-2.13	-1.18	6.78
Non-College Women	-0.79	-9.96	-4.09	-0.74	1.99	16.77
College Women	-1.50	-14.67	-3.11	-2.02	0.13	12.52
Change in Labor Force Participation Rate	-3.02	-10.26	-4.87	-2.95	-1.26	10.36
Non-College Men	-7.16	-16.33	-8.98	-6.76	-5.35	5.66
College Men	-2.58	-11.28	-3.41	-2.35	-1.72	5.41
Non-College Women	-1.27	-9.45	-4.05	-1.35	1.08	15.41
College Women	-1.83	-13.47	-3.54	-2.41	-0.41	11.25
Change in Employment-to-Population Ratio						
Construction	-0.22	-3.44	-0.54	-0.18	0.10	5.23
Management	1.12	-3.24	0.53	1.17	1.73	6.10
Office	-1.78	-3.85	-2.57	-1.72	-1.07	3.08
Production	-1.62	-8.57	-2.09	-1.56	-1.09	6.28
Professional	0.99	-6.74	0.43	1.12	1.54	4.96
Repair	-0.12	-2.02	-0.28	-0.15	-0.01	2.59
Sales	-0.18	-3.71	-0.53	-0.24	0.13	4.11
Services	-0.05	-3.50	-0.52	-0.06	0.47	3.72
Transportation	-0.32	-4.82	-0.60	-0.35	-0.14	2.75
Change in Manufacturing Employment-to-Population Ratio	-1.99	-19.66	-3.11	-1.91	-0.89	10.46
Non-College Men	-3.23	-21.76	-5.16	-3.27	-1.81	16.65
College Men	-1.55	-24.46	-3.46	-1.63	0.23	15.92
Non-College Women	-1.48	-18.29	-2.78	-1.34	-0.28	8.37
College Women	0.26	-8.28	-0.54	0.23	0.86	9.41
Change in Non-Manufacturing Employment-to-Population Ratio	-0.19	-9.12	-2.24	-0.09	1.91	11.74
Non-College Men	-2.55	-16.18	-4.96	-2.73	-0.04	15.31
College Men	-0.71	-18.43	-2.59	-1.04	1.31	21.78
Non-College Women	0.69	-6.86	-1.88	0.74	2.90	12.28
College Women	-1.77	-13.41	-3.42	-2.14	-0.10	14.32
Covariates:						
Percentage of College	23.82	7.32	19.18	23.45	28.60	40.64
Percentage of Foreign-Born	10.68	0.28	2.79	5.96	15.75	41.12
Female Labor Force Participation Rate	73.06	41.55	69.97	73.89	76.36	83.40
Change in Routine Employment	-4.25	-13.95	-6.00	-4.66	-2.84	11.90
Manufacturing	-1.86	-16.29	-2.62	-1.83	-1.11	9.28
Non-Manufacturing	-2.39	-8.37	-3.85	-2.45	-0.91	8.35
Predicted Change in Routine Employment	-4.16	-9.55	-4.36	-3.99	-3.79	-2.45
Manufacturing	-1.91	-8.19	-2.32	-1.68	-1.25	-0.11
Non-Manufacturing	-2.24	-4.73	-2.44	-2.22	-1.97	-1.03

Notes: Census data for 1990 and 2000. Means are weighted by initial prime-age population in each commuting zone.

Table B.2: Commuting-Zone-Level Data, 2000-2016

	All CZ	Min	25th	Median	75th	Max
Change in Employment-to-Population Ratio	1.20	-9.91	-0.74	0.63	3.03	11.06
Non-College Men	-0.04	-12.50	-3.30	-1.07	4.03	11.29
College Men	0.00	-14.39	-0.85	0.32	1.02	12.84
Non-College Women	-0.02	-13.31	-2.22	-0.58	1.60	13.42
College Women	1.88	-13.94	0.85	2.18	3.35	13.38
Change in Labor Force Participation Rate	2.24	-6.38	0.37	1.76	4.31	10.78
Non-College Men	1.36	-10.99	-1.64	0.67	4.95	8.82
College Men	0.83	-13.08	0.11	0.96	1.84	13.67
Non-College Women	1.32	-10.79	-0.35	1.00	2.92	12.25
College Women	2.72	-12.82	1.79	3.32	4.06	14.11
Change in Employment-to-Population Ratio						
Construction	0.03	-3.49	-0.43	0.02	0.59	5.43
Management	1.19	-1.99	0.66	1.19	1.69	4.86
Office	-2.12	-5.26	-2.86	-2.24	-1.53	3.29
Production	-2.10	-10.26	-2.64	-1.86	-1.28	1.92
Professional	1.83	-4.48	1.22	2.02	2.56	8.28
Repair	-0.69	-2.69	-0.82	-0.64	-0.50	1.50
Sales	-0.05	-3.58	-0.40	-0.11	0.35	3.47
Services	3.01	-2.82	2.45	3.13	3.70	9.57
Transportation	0.10	-2.88	-0.25	0.09	0.55	3.08
Change in Manufacturing Employment-to-Population Ratio	-3.41	-15.96	-4.35	-2.91	-2.00	3.11
Non-College Men	-4.98	-20.29	-6.90	-4.58	-2.89	4.71
College Men	-2.86	-20.23	-4.18	-2.94	-1.42	15.22
Non-College Women	-3.08	-17.95	-3.91	-2.53	-1.94	5.12
College Women	-0.42	-6.46	-0.82	-0.50	0.16	7.67
Change in Non-Manufacturing Employment-to-Population Ratio	4.61	-11.83	2.86	4.21	6.14	14.58
Non-College Men	4.94	-11.16	2.41	4.50	8.15	15.91
College Men	2.86	-16.09	1.17	3.31	4.77	17.31
Non-College Women	3.05	-13.20	1.01	2.67	4.43	16.46
College Women	2.30	-15.63	1.00	2.70	3.76	13.82
Covariates:						
Percentage of College	27.39	8.79	22.46	26.98	32.72	45.05
Percentage of Foreign-Born	15.69	0.47	5.09	9.42	23.88	50.41
Female Labor Force Participation Rate	72.28	50.39	69.47	72.36	75.82	86.22
Change in Routine Employment	-4.83	-14.03	-6.43	-5.10	-3.42	7.72
Manufacturing	-2.89	-15.14	-3.73	-2.41	-1.70	2.50
Non-Manufacturing	-1.94	-8.09	-3.07	-2.26	-0.85	9.74
Predicted Change in Routine Employment	-4.76	-10.52	-5.31	-4.61	-4.04	0.21
Manufacturing	-3.01	-10.55	-3.79	-2.70	-1.98	-0.16
Non-Manufacturing	-1.76	-3.33	-2.01	-1.80	-1.57	2.04

Notes: Census data for 2000 and pooled ACS data for 2014-2016. Means are weighted by initial prime-age population in each commuting zone.

Table B.3: Commuting-Zone-Level Data, 1990-2016

	All CZ	Min	25th	Median	75th	Max
Change in Employment-to-Population Ratio	-0.75	-10.76	-3.04	-0.76	1.05	13.61
Non-College Men	-3.36	-17.63	-6.29	-3.87	-1.12	13.26
College Men	-1.31	-14.39	-2.49	-1.26	0.31	12.84
Non-College Women	-0.47	-13.31	-2.88	-0.71	1.82	16.77
College Women	-0.07	-14.67	-2.57	0.10	2.20	13.38
Change in Labor Force Participation Rate	-0.80	-10.26	-3.53	-1.03	1.51	10.78
Non-College Men	-3.56	-16.33	-6.98	-4.58	-0.24	8.82
College Men	-1.14	-13.08	-2.67	-1.50	0.75	13.67
Non-College Women	-0.18	-10.79	-2.91	-0.10	2.09	15.41
College Women	0.09	-13.47	-2.82	0.09	3.23	14.11
Change in Employment-to-Population Ratio						
Construction	-0.12	-3.49	-0.50	-0.12	0.25	5.43
Management	1.15	-3.24	0.57	1.18	1.73	6.10
Office	-1.92	-5.26	-2.67	-2.04	-1.23	3.29
Production	-1.82	-10.26	-2.19	-1.74	-1.15	6.28
Professional	1.35	-6.74	0.66	1.41	2.05	8.28
Repair	-0.36	-2.69	-0.60	-0.33	-0.12	2.59
Sales	-0.12	-3.71	-0.50	-0.17	0.21	4.11
Services	1.24	-3.50	-0.25	0.54	2.95	9.57
Transportation	-0.14	-4.82	-0.46	-0.20	0.17	3.08
Change in Manufacturing Employment-to-Population Ratio	-2.59	-19.66	-3.61	-2.38	-1.25	10.46
Non-College Men	-3.97	-21.76	-5.49	-3.77	-2.48	16.65
College Men	-2.10	-24.46	-3.86	-2.13	-0.37	15.92
Non-College Women	-2.15	-18.29	-2.95	-2.00	-0.69	8.37
College Women	-0.03	-8.28	-0.74	-0.06	0.66	9.41
Change in Non-Manufacturing Employment-to-Population Ratio	1.83	-11.83	-1.12	2.03	4.13	14.58
Non-College Men	0.61	-16.18	-3.54	0.38	3.88	15.91
College Men	0.80	-18.43	-1.51	0.94	3.56	21.78
Non-College Women	1.69	-13.20	-0.89	1.78	3.84	16.46
College Women	-0.05	-15.63	-2.55	-0.05	2.67	14.32
Covariates:						
Percentage of College	25.33	7.32	20.49	25.00	30.04	45.05
Percentage of Foreign-Born	12.79	0.28	3.57	7.16	17.81	50.41
Female Labor Force Participation Rate	72.73	41.55	69.79	73.31	76.05	86.22
Change in Routine Employment	-4.49	-14.03	-6.17	-4.81	-2.96	11.90
Manufacturing	-2.29	-16.29	-2.98	-2.08	-1.32	9.28
Non-Manufacturing	-2.20	-8.37	-3.73	-2.36	-0.88	9.74
Predicted Change in Routine Employment	-4.41	-10.52	-4.79	-4.14	-3.82	0.21
Manufacturing	-2.37	-10.55	-2.91	-2.01	-1.47	-0.11
Non-Manufacturing	-2.04	-4.73	-2.31	-2.02	-1.79	2.04

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Means are weighted by initial prime-age population in each commuting zone.

Table B.4: State-Level Data, 1994

	All States	Min	25th	Median	75th	Max
Employment-to-Population Ratio	77.17	64.06	74.17	77.25	79.46	88.79
Non-College Men	82.91	68.16	79.60	83.07	85.91	96.92
College Men	93.29	82.46	91.45	93.29	95.16	100.00
Non-College Women	66.09	50.52	61.98	65.96	69.09	84.42
College Women	81.10	65.06	78.40	80.61	83.27	96.24
Labor Force Participation Rate	81.45	70.10	79.17	81.58	83.16	91.17
Non-College Men	88.53	75.04	86.75	88.54	90.47	98.13
College Men	95.71	84.38	94.39	95.86	97.09	100.00
Non-College Women	70.40	54.51	66.44	70.35	73.39	86.16
College Women	83.52	65.06	81.32	83.10	85.17	96.57
Covariates:						
Share of College-Educated	25.22	11.02	22.90	25.00	27.63	41.72
Share of Foreign-Born	11.03	0.21	2.74	7.70	17.79	33.01
Manufacturing Employment-to-Population Ratio	5.29	1.27	4.17	5.18	6.29	11.79
Unemployment Rate	13.84	0.38	11.00	12.98	16.59	26.79
Routine Employment	40.39	22.86	36.82	40.68	42.89	52.57
Routine Manual	20.51	7.00	17.48	20.04	22.88	32.18
Routine Cognitive	19.88	13.89	18.57	19.70	20.95	26.82

Notes: CPS data. Means are weighted by the state's prime-age population in 1994.

Table B.5: State-Level Data, 2000

	All States	Min	25th	Median	75th	Max
Employment-to-Population Ratio	79.75	70.02	77.02	79.83	81.46	89.70
Non-College Men	85.15	71.36	83.56	85.44	87.11	94.96
College Men	93.79	82.69	92.11	93.83	95.54	100.00
Non-College Women	69.81	54.35	66.18	69.83	72.70	86.57
College Women	80.20	59.76	77.46	79.54	82.66	95.84
Labor Force Participation Rate	82.38	73.01	79.99	82.24	83.89	91.64
Non-College Men	88.40	76.16	87.12	88.64	89.96	95.28
College Men	95.27	83.30	93.78	95.25	96.74	100.00
Non-College Women	72.74	58.88	69.22	72.78	75.31	88.38
College Women	81.71	62.92	78.89	81.19	84.27	95.84
Covariates:						
Share of College-Educated	28.87	16.66	26.20	28.56	31.08	46.59
Share of Foreign-Born	14.01	0.50	4.87	10.72	21.61	36.01
Manufacturing Employment-to-Population Ratio	3.21	0.51	2.54	3.19	3.85	9.58
Unemployment Rate	12.82	0.28	10.19	12.22	15.33	25.23
Routine Employment	39.21	23.50	36.48	39.44	41.02	49.50
Routine Manual	20.08	8.09	17.70	19.81	21.98	30.30
Routine Cognitive	19.13	13.14	18.02	18.95	19.98	25.73

Notes: CPS data. Means are weighted by the state's prime-age population in 1994.

Table B.6: State-Level Data, 2018

	All States	Min	25th	Median	75th	Max
Employment-to-Population Ratio	78.07	66.14	76.18	77.63	79.98	88.41
Non-College Men	80.90	61.19	78.29	80.89	83.42	95.25
College Men	91.74	79.95	89.90	91.62	93.59	99.18
Non-College Women	65.72	40.93	62.59	64.99	68.22	82.45
College Women	80.77	60.29	77.64	80.45	83.60	93.58
Labor Force Participation Rate	80.81	71.21	78.95	80.28	82.82	90.23
Non-College Men	84.43	69.54	82.19	84.46	86.81	96.48
College Men	93.65	82.19	92.24	93.74	95.17	100.00
Non-College Women	68.82	54.04	66.15	68.11	71.38	85.15
College Women	82.53	64.25	79.69	82.27	85.16	94.71
Covariates:						
Share of College-Educated	38.80	21.07	34.88	38.74	42.05	75.66
Share of Foreign-Born	19.68	0.89	10.28	20.87	28.16	36.88
Manufacturing Employment-to-Population Ratio	3.40	0.62	2.86	3.44	3.90	8.64
Unemployment Rate	8.58	0.54	6.19	7.80	10.60	19.39
Routine Employment	31.94	10.83	29.78	31.81	34.28	42.39
Routine Manual	16.32	2.34	14.32	15.99	18.38	26.39
Routine Cognitive	15.63	7.58	14.61	15.54	16.44	22.30

Notes: CPS data. Means are weighted by the state's prime-age population in 1994.

C Unweighted Regressions

Table C.1: Unweighted Panel Regression of Labor Market Outcomes on Prime-Age Routine Employment Rate, 1994-2018

	Labor Force Participation Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Share in Routine Employment	0.239***	0.339***	0.238***	0.221***	0.247***	0.357***
	(0.016)	(0.015)	(0.016)	(0.020)	(0.019)	(0.015)
Share of College-Educated		0.233***				0.253***
		(0.024)				(0.022)
Share of Foreign-Born			-0.011			-0.036*
			(0.023)			(0.019)
Share in Manufacturing Employment				0.063		0.059**
				(0.044)		(0.028)
Unemployment Rate					0.048	0.170***
					(0.034)	(0.026)
N	15300	15300	15297	15294	15300	15291
R-squared	0.381	0.455	0.381	0.383	0.381	0.466
	Employment-to-Population Ratio					
	(1)	(2)	(3)	(4)	(5)	(6)
Share in Routine Employment	0.363***	0.497***	0.361***	0.329***	0.235***	0.339***
	(0.020)	(0.018)	(0.020)	(0.026)	(0.018)	(0.014)
Share of College-Educated		0.311***				0.240***
		(0.024)				(0.020)
Share of Foreign-Born			-0.031			-0.035*
			(0.027)			(0.018)
Share in Manufacturing Employment				0.121**		0.055**
				(0.057)		(0.026)
Unemployment Rate					-0.762***	-0.646***
					(0.033)	(0.025)
N	15300	15300	15297	15294	15300	15291
R-squared	0.595	0.666	0.596	0.601	0.701	0.742

Notes: CPS state-level panel data from 1994 to 2018. Each variable is constructed at monthly level and state level. All regressions include time fixed effects and state fixed effects. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Table C.2: Unweighted 2SLS Regression of Changes in Labor Market Outcomes on Changes in Routine Employment Rates, 1990-2016

	Δ Labor Force Participation Rate				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Employment	0.576***	0.557***	0.549***	0.488***	0.371***
	(0.053)	(0.055)	(0.059)	(0.057)	(0.058)
Share of College-Educated$_t$		0.038***			0.108***
		(0.012)			(0.014)
Share of Foreign-Born$_t$			0.036***		-0.002
			(0.012)		(0.011)
Female Labor Force Participation Rate$_t$				-0.102***	-0.178***
				(0.024)	(0.029)
N	1482	1482	1482	1482	1482
R-squared	0.478	0.483	0.482	0.500	0.505
	Δ Employment-to-Population Ratio				
	(1)	(2)	(3)	(4)	(5)
Δ Share in Routine Employment	0.713***	0.701***	0.695***	0.640***	0.555***
	(0.058)	(0.061)	(0.065)	(0.056)	(0.059)
Share of College-Educated$_t$		0.024*			0.081***
		(0.014)			(0.016)
Share of Foreign-Born$_t$			0.024*		-0.005
			(0.014)		(0.012)
Female Labor Force Participation Rate$_t$				-0.086***	-0.142***
				(0.022)	(0.026)
N	1482	1482	1482	1482	1482
R-squared	0.567	0.569	0.569	0.579	0.580

Notes: Census data for 1990 and 2000 and pooled ACS data for 2014-2016. Each variable is constructed at the commuting-zone level. All regressions include time dummies and Census division dummies. Robust standard errors clustered at the state level are shown in parentheses.
*** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level