New Frontiers: The Evolving Content and Geography of New Work in the 20th Century [*Extended Abstract*]

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> "[M]achinery constantly supplants and renders unnecessary that purely manual skill, the attainment of which was, even up to Adam Smith's time, the chief advantage of division of [labor]. But this influence is more than countervailed by its tendency to increase the scale of manufactures and to make them more complex; and therefore to increase the opportunities for division of [labor] of all kinds." (Marshall, 1890, p. 112)

Introduction

'Middle skill' occupations—encompassing routine production, operative, clerical, and administrative support tasks—are in decline throughout the developed world (Acemoglu and Autor, 2011; Goos et al., 2014; Autor, n.d.). The contraction of these broad occupational categories may suggest that labor is destined to perform an ever-narrower set of tasks (Frey and Osborne, n.d.; Susskind, n.d.). But recent theory and evidence stresses that automation displaces labor from existing tasks and generates new labor-demanding tasks simultaneously (Goldin and Katz, n.d.; Lin, 2011; Acemoglu and Restrepo, 2018, n.d.; Atack et al., n.d.). To date, we know little about how these newly generated labor-using tasks compare to those that are automated, and what this implies for the evolving task content, skill requirements, and wage levels of remaining work. In their model of the race between man and machine model, Acemoglu and Restrepo (2018) posit that automation eliminates tasks that use low-skill labor and generates new tasks that demand high-skill labor, a view that is supported by the evidence in Lin (2011). By contrast, Atack et al. (n.d.) document a dramatic narrowing of the scope of work performed by production workers in the late nineteenth century as factories switched from artisanal craft work to mass production, which the authors characterize as deskilling. Studying factory automation in the early twentieth century, however, Goldin and Katz (n.d.) find that an initial phase of skill-replacing automation gave way to an era of cognitive skill demands, as workers were tasked with overseeing continuous batch manufacturing processes and tending sophisticated machines. This body of evidence highlights suggests that the nature of task substitution and reinstatement may differ over time and among settings, with potentially

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distinct implications for the evolution of skill demands across the occupational spectrum and skill distribution.

We will explore the evolution of new work—its task content, skill demands, and wage levels—using consistent historical data for the United States for the 115 year period between 1900 and 2015. Our analysis draws on three sources: successive volumes of the Census Classified Index of Occupations from 1910 through 2016 released with each decennial Census or American Community Survey (ACS); job descriptions from the Dictionary of Occupational Titles (DOT) for the years 1938 through 1991 and the Occupational Information Network (O*NET) for 2000 to present; and Census Complete Count files for 1900 through 1940, which provide highly granular occupational titles that are currently confidential in subsequent Census years. Our work builds on the approach pioneered by Lin (2011), who studied the period 1970 through 2000. Distinct from Lin, our historical data will allow us to observe the demographic characteristics of workers performing new work (education, sex, race, age), and to leverage textual descriptions from DOT and O*NET to better classify the task content of new work. We will apply both conventional hand-coding and automated machine-learning approaches to parse these job titles and classify them within interpretable categories.

Initial descriptive results

Our preliminary work, using a combination of Dictionary of Occupational Titles and Census Classified Index of Occupations volumes for 1970–2016 paired with Census of Population and American Community Survey data for corresponding years, explores three broad classes of new jobs emerging from the interplay of changing technology, shifting tastes, and rising incomes. We label these frontier work, last-mile work, and wealth work.[1] Frontier work involves directly producing, installing, maintaining, and deploying novel technologies. Recent examples are robot integration, search engine optimization, and radiological medicine. Last-mile work, on the other hand, involves carrying out nearly-automated tasks that retain only a residual set of human components. Last-mile tasks typically do not require high levels of technology-specific expertise. Examples include call-center operators, order fulfillment workers, and data entry clerks. Finally, we classify new jobs that appear to arise as novel consumer luxuries as wealth work. Wealth work occupations perform in-person services for affluent consumers: nail technicians, dog groomers, and many forms of personal training and counseling. Table 1 shows specific examples of new occupational titles added by decade, separately for each of these three job categories.

[1] We note that these three broad categories were chosen based on hand inspection of lists of new occupational titles. Our future work will improve this informal classification scheme.

Table 1: Examples of New Job Titles by New Work Category and Decade

	Frontier work	Last Mile Work	Wealth Work
1980	Supervisor, Word Processing	Check Writer	Hypnotherapist
	Controller, Remotely-Piloted Vehicle	Tamale-Machine Feeder	Gift Wrapper
1990	Circuit Layout Designer	Vending-Machine Attendant	Dance Therapist
	Robotic Machine Operator	Film Touch-Up Inspector	Singing Messenger
2000	Artificial Intelligence Specialist	Chat Room Host/Monitor	Counselor, Marriage-Family
	Echocardiographer	Bicycle Messenger	Employee Wellness Crdnr
2010	Technician, Wind Turbine	Underground Utility Cable Locator	Exercise physiologist
	Intelligence Analyst	Technician, Prepress	Sommelier

Table reports examples of new job titles added to the 1977 and 1991 Dictionary of Occupational Titles, and the 2000 and 2010 Census Classified Indices of Occupations.

Using pooled American Community Survey (ACS) data for 2014 - 2016, Table 2 presents summary statistics for employed working-age adults ages 18 - 64 by occupational categories corresponding to our three part scheme. Applying ACS population weights and limiting the sample to those currently employed, we find that 44 percent of workers in 2015 are women, 35 percent are college graduates, another 32 percent have some college, 26 percent have exactly a high school degree, and 7 percent have not completed high school. We estimate that 13.1 percent of all workers in 2015 are employed in new jobs, meaning they work in occupational titles that have emerged since 1970. As compared to average workers, workers in new jobs earn approximately 10 percent higher wages on average, are slightly more likely to be female, and are 8 percentage points more likely to have some-college or greater education, and are correspondingly less likely to have high school or lower education.

However, these new-work averages conceal substantial heterogeneity in worker characteristics and earnings across different new work categories. Workers employed in frontier jobs earn more than 30 percent above the average worker, and are disproportionately male and college-educated. Conversely, workers employed in last-mile jobs earn 20 percent below average, are disproportionately likely to have no college education (48 percent among last-mile workers versus 33 percent overall), and are as likely to be male as is the typical worker. Finally, wealth workers are far more likely than average workers to be women (62 versus 44 percent, respectively) and somewhat more likely than average to be college-educated (41 versus 35 percent), and yet mean earnings in wealth work is almost identical to average earnings. Perhaps most surprisingly, wealth work accounts for an outsized share of new work—52 percent—relative to 39 percent for frontier work and 9.4 percent for last-mile work.

Table 2: Demographic Characteristics and Average Log Hourly Wages of Workers Employed in All Occupations and in New Work in 2015

	All Jobs (1)	All New Work (2)	Frontier Work (3)	Last Mile Work (4)	Wealth Work (5)
Share of employment	1.000	0.131	0.051	0.012	0.068
Share of new work	.	1.000	0.388	0.094	0.518
Mean log wage	2.93	3.04	3.29	2.73	2.92
Female share	0.44	0.47	0.28	0.43	0.62
College grad share	0.35	0.42	0.50	0.15	0.41
Some college share	0.32	0.33	0.31	0.36	0.33
High school share	0.26	0.21	0.16	0.38	0.21
< High school share	0.07	0.05	0.03	0.10	0.05

Table reports demographic characteristics of working-age adults ages 18-64 in 2015 by occupational category. Source: American Community Survey (ACS) data for years 2014 through 2016, sourced from IPUMS Ruggles et al. (2018). Earnings are reported in real 2015$, deflated using Personal Consumption Expenditure Deflator.

As demonstrated by Lin (2011), new work opportunities are unevenly distributed across space, and any such spatial pattern may further change over time. Figure 1 adds both a temporal and geographic dimension to the descriptive statistics in Table 2 by reporting the share of employment in each of these categories by commuting zone for the years 1980 through 2015 among working-age adults ages 18-64.[2] Commuting zones are ordered from lowest to highest population density, with rural areas on the left-side of each panel, followed by suburbs, metro areas, and cities as one moves rightward. Each plotted point in the figure represents approximately 3.3 percent of working-age adults in the relevant year.[3]

[2]Panels report the cumulative share of employment in each occupational category from 1970 to the relevant year.

[3]We used fixed 1970 CZ population densities so that the ordering of CZs remains constant and hence comparable across panels. However, the inter-decadal correlation of CZ population densities exceeds 0.9 across many decades, so allowing CZ densities to differ by decade would have minimal effects on these plots.

Figure 1: Employment Shares in Three Categories of New Work by Commuting Zone, 1980 – 2015, among Working-Age Adults

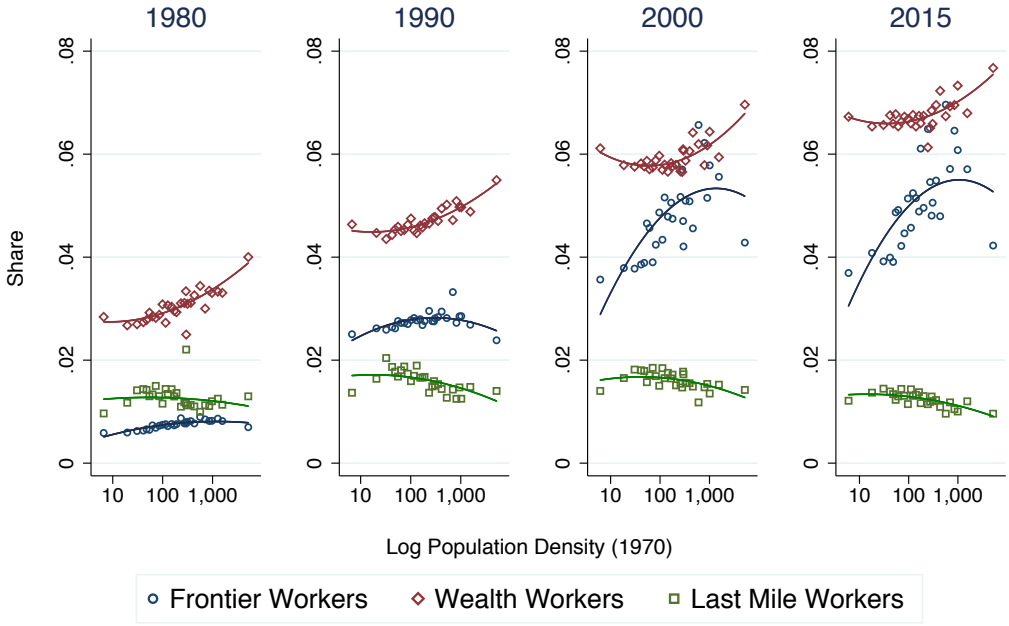
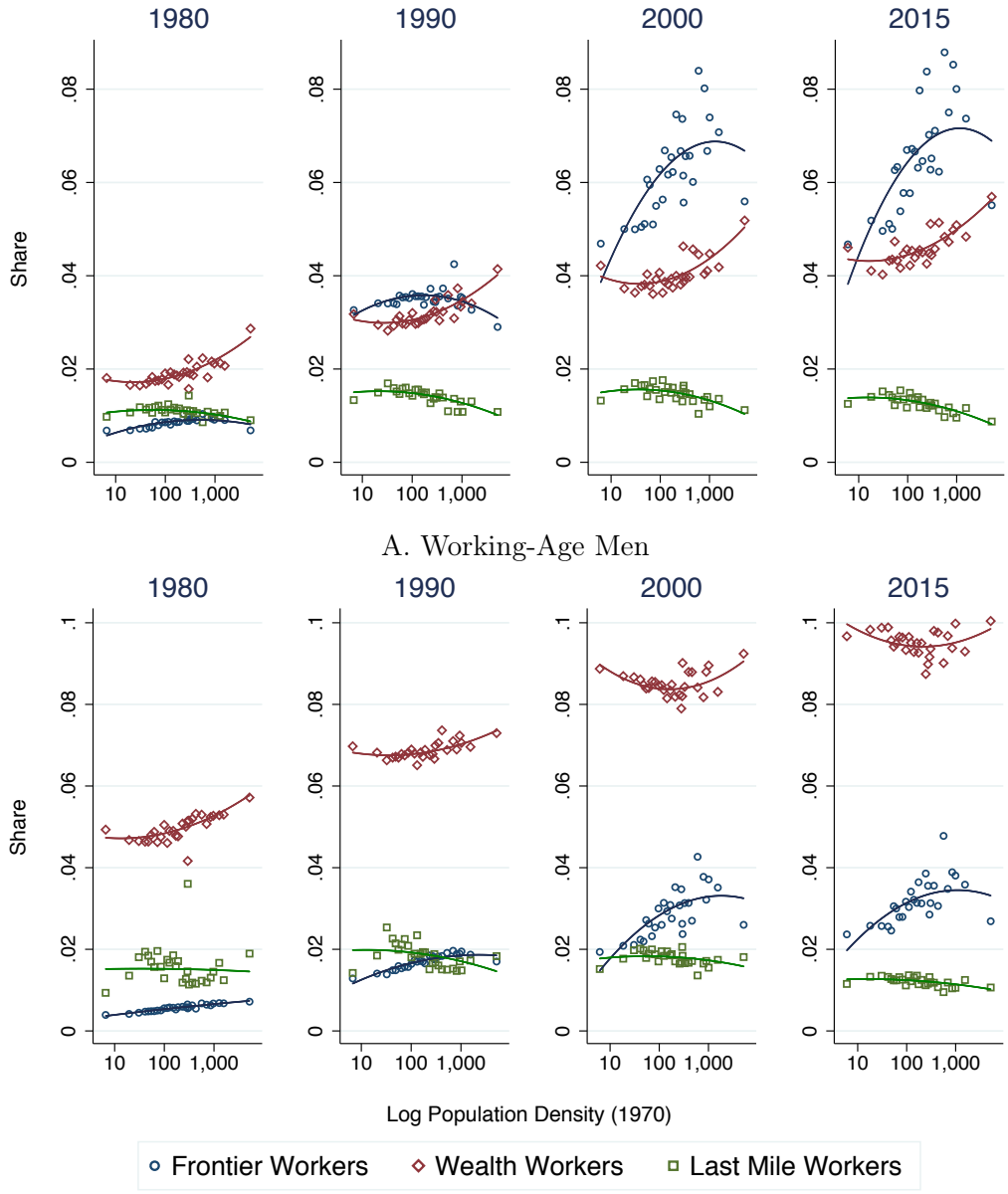


Figure plots employment shares of working-age adults ages 18-64 in 1980, 1990, 2000, and 2015 by commuting zone (CZ), where CZ's are ordered by population density in 1970. Source: U.S. Census of Population data for 1980, 1990, and 2000, and pooled American Community Survey (ACS) data for years 2014 through 2016, sourced from IPUMS Ruggles et al. (2018). Each plotted point represents approximately 3.3 percent of the working age population in the corresponding year.

Three salient points emerge from this figure. First, both frontier and wealth work categories rise quickly after 1980, with faster growth in frontier than wealth work after 1990, but with a higher *level* of wealth work in all decades. Last-mile work, on the other hand, represents a relatively constant share of employment over time even though new last-mile categories are added decade by decade, suggesting some of these jobs may experience further automation. Second, both frontier and wealth work are more prevalent in denser labor markets. In the case of frontier work, this pattern likely contributes to the well-known geographic agglomeration of high skill work (Glaeser and Mare, 2001; Glaeser and Resseger, 2010). In the case of wealth work, it may reflect the amenity choices of high-income consumers who are overrepresented in cities (Glaeser et al., n.d.), many of whom may themselves be frontier workers. Third, last mile work is actually somewhat less prevalent in urban than non-urban areas. This latter pattern likely stems from the fact that many last-mile jobs do not demand face-to-face interaction (e.g., call center workers, data entry operators) and hence can be performed outside of expensive cities.

Figure 2: Employment Shares in Three Categories of New Work by Commuting Zone, 1980 – 2015, among Working-Age Men and Women



A. Working-Age Men

A. Working-Age Women

Figure plots employment shares of working-age men (panel A) and women (panel b) in 1980, 1990, 2000, and 2015 by commuting zone (CZ), where CZ's are ordered by population density in 1970. Source: U.S. Census of Population data for 1980, 1990, and 2000, and pooled American Community Survey (ACS) data for years 2014 through 2016, sourced from IPUMS Ruggles et al. (2018). Each plotted point represents approximately 3.3 percent of the working age population by sex in the corresponding year.

Figure 2 reports the evolution of new work over time and across locations by gender, showing that the spatial shifts highlighted above are found for both men and women. Further, in all decades, women are approximately twice as likely as men to be employed in wealth work while, conversely, men

are roughly twice as likely to be employed in frontier work. That is, the sharp gender differences in the distribution of new work categories shown in Table 2 are broadly constant over this time period.

Figure 3: Log Real Hourly Wages in New Work and All Work, 1980–2015, by Commuting Zone

Figure plots mean log real hourly wages among working-age adults ages 18-64 in 1980, 1990, 2000, and 2015 by commuting zone (CZ) and occupational category (all work, frontier work, wealth work, and last-mile work), where CZ's are ordered by population density in 1970. Source: U.S. Census of Population data for 1980, 1990, and 2000, and pooled American Community Survey (ACS) data for years 2014 through 2016, sourced from IPUMS Ruggles et al. (2018). Each plotted point represents approximately 3.3 percent of the working age population in the corresponding year.

A theme that emerges from current literature is that new work is, depending on the time period, either uniformly skill-replacing or uniformly skill-demanding. The simple tabulations above suggest otherwise. New work appears non-homogeneous in its skill demands, at least in recent decades. Unlike the middle-skilled routine work it is potentially replacing, new work appears distinctly 'polarized' in that it draws heavily from both the upper and lower tails of the education distribution. As such, the emergence of new jobs would contribute to job polarization. Figure 3, which plots real log wages by occupational category by CZ and decade, reinforces this impression. Wages in frontier work lie well above overall average wage levels while those in last-mile jobs are well below average. These differences have grown noticeably more pronounced across successive decades, particularly in urban CZs. The category of wealth work deviates slightly from this overall pattern in that wages in wealth work are generally close to the grand mean and, if anything, have converged from below towards this grand mean in recent decades. Since wealth work accounts for a bare majority of all

new work according to our metric, this may suggest that the modal new occupation is in some sense middle skilled—though it also bears note that the workers occupying these jobs are more educated than average and disproportionately likely to be women.

Next steps

Our ongoing work extends this analysis backward in time to the beginning of the twentieth century. This long-run perspective will allow us to shed light on any changes in the nature of new jobs—that is, we can consider whether "this time is different"'. Simultaneously, we will enrich the data by parsing occupational descriptors from DOT and O*NET. Additionally, exploiting Census Complete Count occupational data for 1900 through 1940 will enable us to observe demographics, earnings, and locations of workers employed in new job titles, something that is not directly feasible in recent decades.[4] With these unique data, we will explore the following questions:

1. How have the broad 'types' of new work changed over time (i.e., is the frontier, last-mile, wealth work trichotomy sufficient to capture the relevant variation across decades)?

2. Has new work become more or less complementary with specific skill groups over time? For example, was a larger share of frontier work intensive in high school educated labor in earlier decades—distinct from the current era where frontier work is concentrated among those with college degrees?

3. Has the geography of new work contributed to rising inequality in urban labor markets? Recent work by Baum-Snow et al. (2018) and Autor (n.d.) documents that the urban wage gradient among college-educated workers has grown steeper in the U.S. between 1980 and the present while the urban wage gradient for non-college workers has attenuated substantially. In this same time period, the occupational distribution of urban non-college workers has hollowed out, as they have exited from middle-skill production and office work and increasingly concentrated in traditionally low-education, low-wage service occupations (cleaning, food service, security, personal care, transportation). We hypothesize that this pattern may in part be driven by a growing 'skill bias' in new work, which may at one time have complemented non-college urban workers but at present appears to strongly favor the college-educated.

4. Is advancing technology changing jobs more rapidly at present than in the past? Recent work suggests that, at present, technology-intensive jobs experience rapid skill depreciation (Deming and Noray, 2018). Exploiting the historical dimension of our data, we will examine whether wage premiums for older vintages of frontier work are fading more rapidly over time, and how the self-selection of workers into these technology-dependent jobs is evolving.

[4]New job titles correspond to newly enumerated detailed occupation categories within larger Census occupation aggregates. These larger aggregates appear in public use data but not the underlying detailed categories. Researchers studying these new occupations have therefore followed Lin (2011) in imputing these new categories into broader public use aggregates by assuming that employment in new work is proportional to the share of detailed titles that are new within the total set of titles represented in the overarching Census occupation category.

Conclusion

Armed with a century-long inventory of new jobs linked to Census microdata, we will provide comprehensive descriptive evidence on the emergence of new work by occupation, industry, and region; how new work compares to existing jobs in terms of wages and worker characteristics; and how all this has evolved over the past century. Where possible, we will document the task content of new jobs using Dictionary of Occupational Titles and Occupational Information Network data. Preliminary results suggest that the relative wages of these three types of new work and their geographical concentration have changed in important ways over time, contributing to overall inequality changes in the United States.

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