Automation and the Future of Young Workers: Evidence from Telephone Operation in the Early 20th Century

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Motivation: What happens when technology replaces an entire, major entry-level occupation?

- "Automation anxiety"—i.e., concern about widespread technological unemployment—has made a roaring comeback
- An economics literature is emerging on the pace of automation, its effects on workers, how the economy adjusts
- The possibility that automation might replace common entry-level jobs presents a serious concern: what happens when you automate young adults' pathway into the labor force?
  - Jobs like customer service reps, cashiers, exec. assistants: all being automated or at high risk, according to BLS

Motivation (cont'd)

- Existing research on the labor market effects of automation and SBTC is often imperfectly-suited to studying this question
  - Typically takes a high-level view, and/or studies gradual changes in employment distributions over long horizons
  - Few examples of major occupations abruptly disappearing
- In this paper, we take a deep dive into a single, large, and historically important occupation which was a major employer of young women and was decimated by automation in the 20th century: **telephone operation**

Background

- Refresher: 100 years ago, telephone calls were connected by operators at telephone company switchboards

Telephone operators in Montreal, QC



Telephone operators in Salt Lake City, UT



Telephone operators in Washington, DC



Background

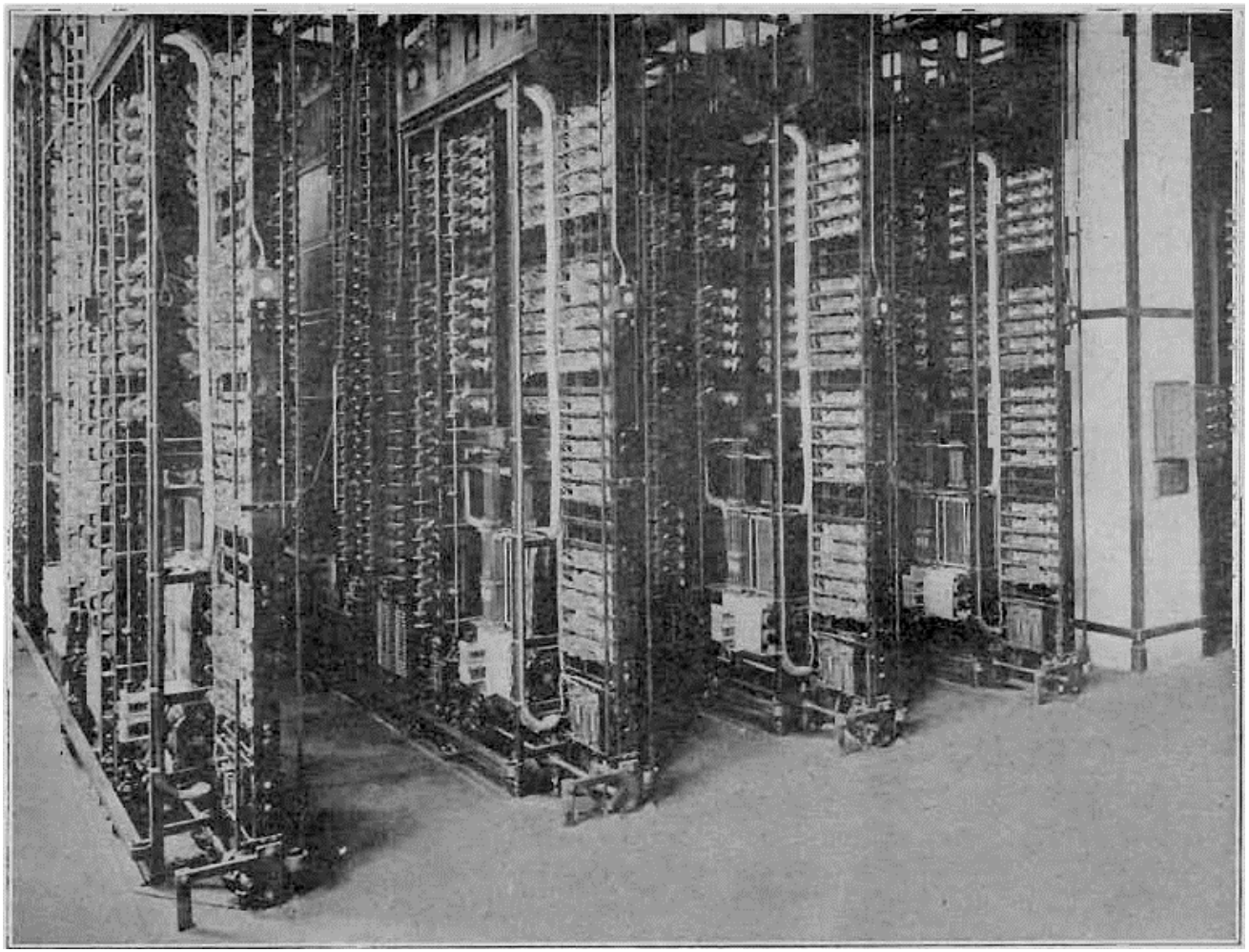
- Refresher: 100 years ago, telephone calls were connected by operators at telephone company switchboards

- This was one of the top occupations for young women
  - In 1920 census, employed 4% of the nearly 3 MM young, white, American-born women in the labor force and was the single largest occupation-industry pair for women $\leq$20
  - As much as 10-15% of peak cohorts was *ever* an operator

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  - As much as 10-15% of peak cohorts was *ever* an operator
- In 1919, AT&T began adopting mechanical switching, replacing most functions of local telephone operators
  - By 1940, over 60% of subscribers were on dial service

Telephone operators after mechanization

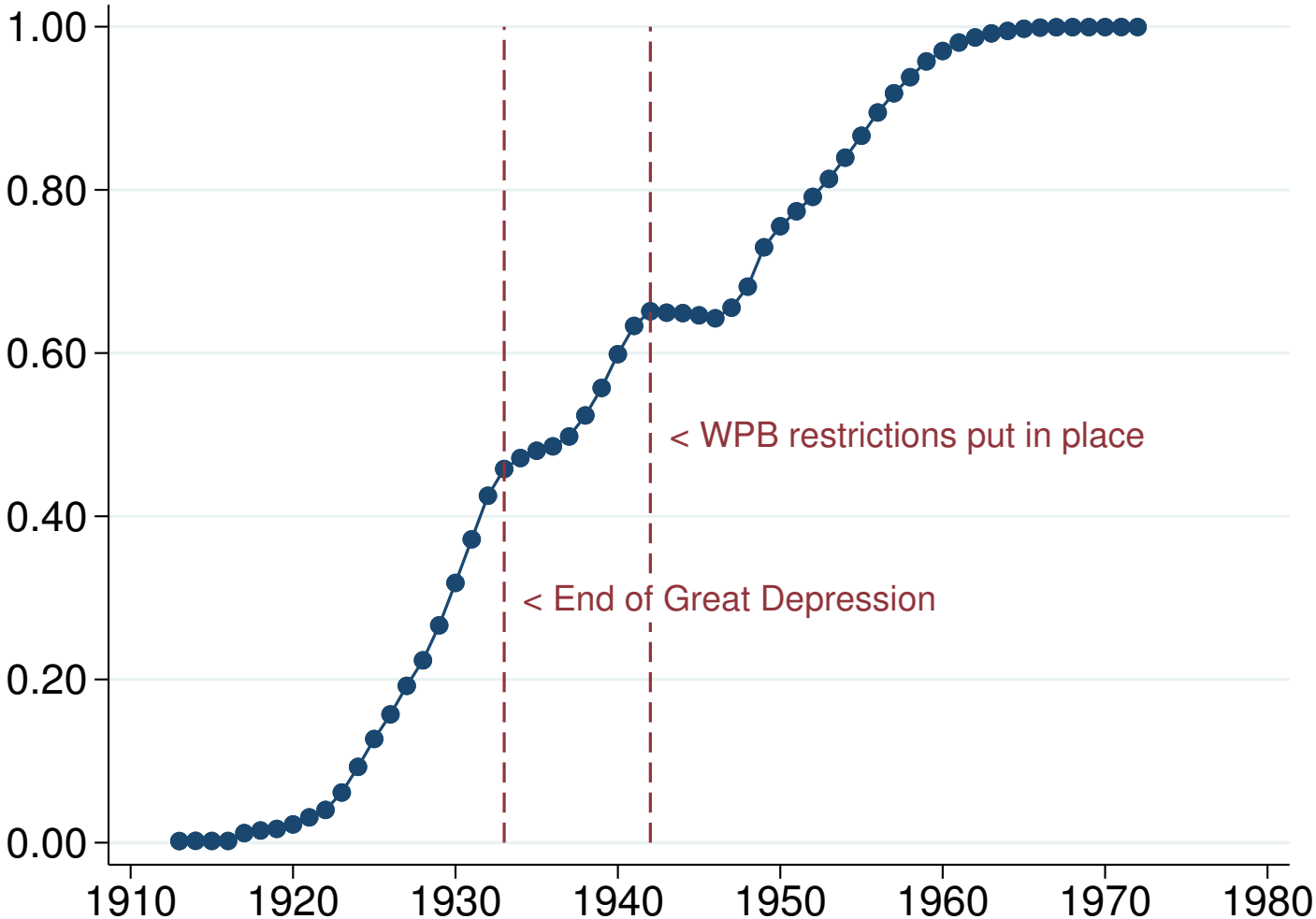


Two questions, two strategies

Measuring the shock: We use AT&T records and data from thousands of local newspaper articles to identify automation timing by city

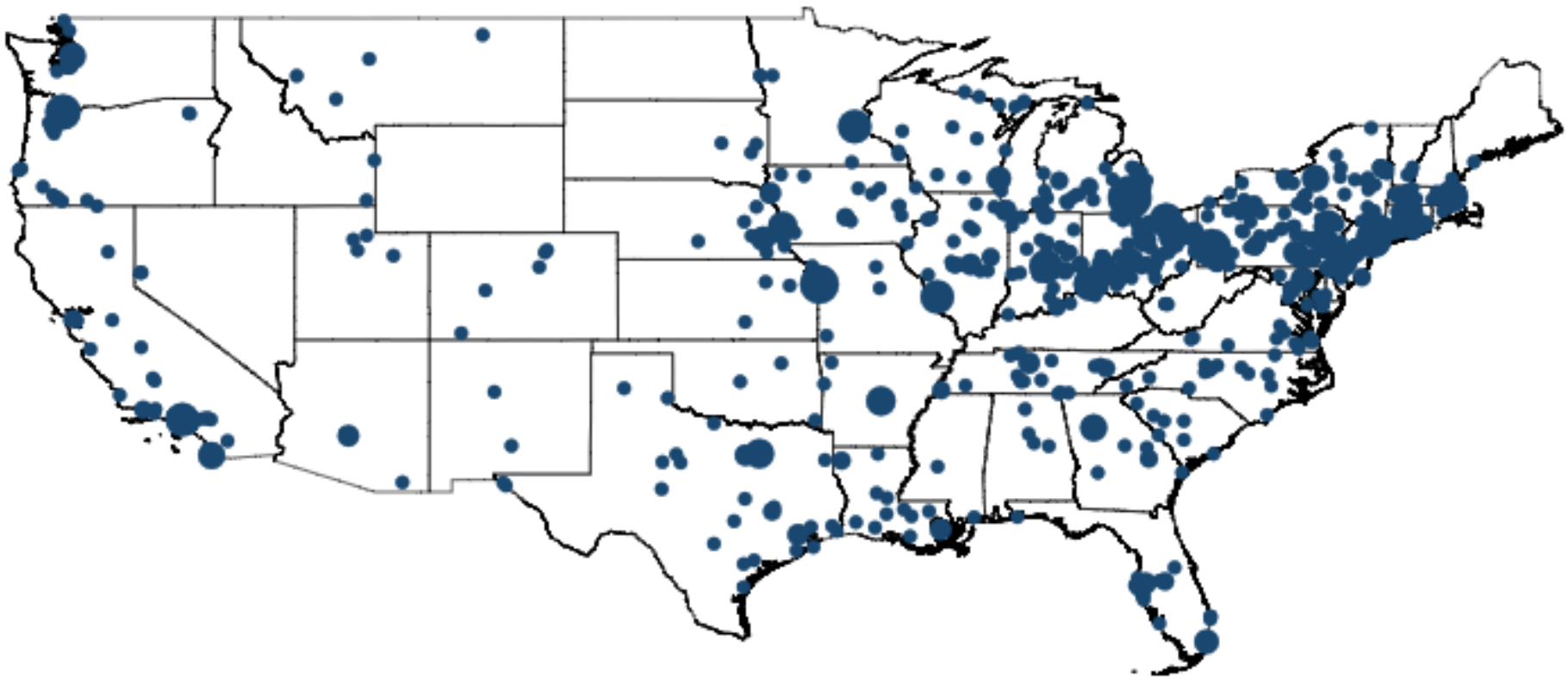
1. What were the effects of automating a major entry-level occupation on future generations of young women?
   - Aggregate complete count census data from 1910 to 1940 to study the effects on successive generations of young women
2. What were the effects on incumbent telephone operators?
   - Develop + apply exciting new census linking methods using genealogical data to track individuals over time

Aggregate diffusion across the AT&T system: percent of subscribers on dial, 1913-1972



Cities cut over to dial service by 1940

source: AT&T records and data collected from newspapers



Empirical approach

▸ More motivation

- Unit of analysis: U.S. cities x year
  - Begin w/ balanced panel of ≈3k cities from 1910 to 1940
  - Focus on white, US-born women age 16-25

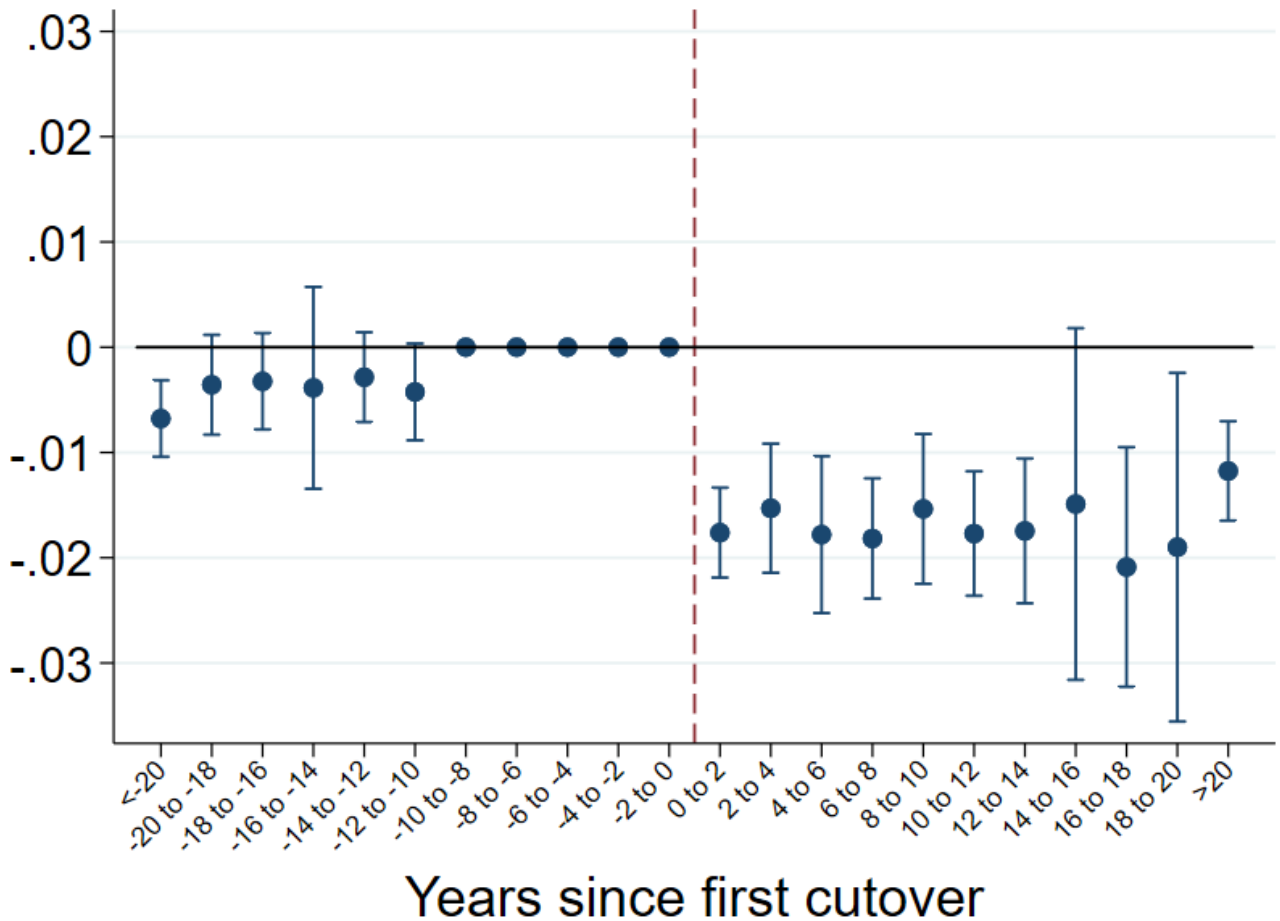
- Exploit the staggered adoption of dial operation across the U.S. to estimate its effects on young workers
  - DID/event studies in smaller cities ($\leq$100k in 1920), where conversion to dial typically completed in one day

Summary of what we find

- Immediate, permanent 50-80% decline in young operators
  - ≈2% of young, white, American-born women's employment
  - Given turnover rates, we estimate roughly 3-4x as many women were directly affected (likely to *ever* be an operator)

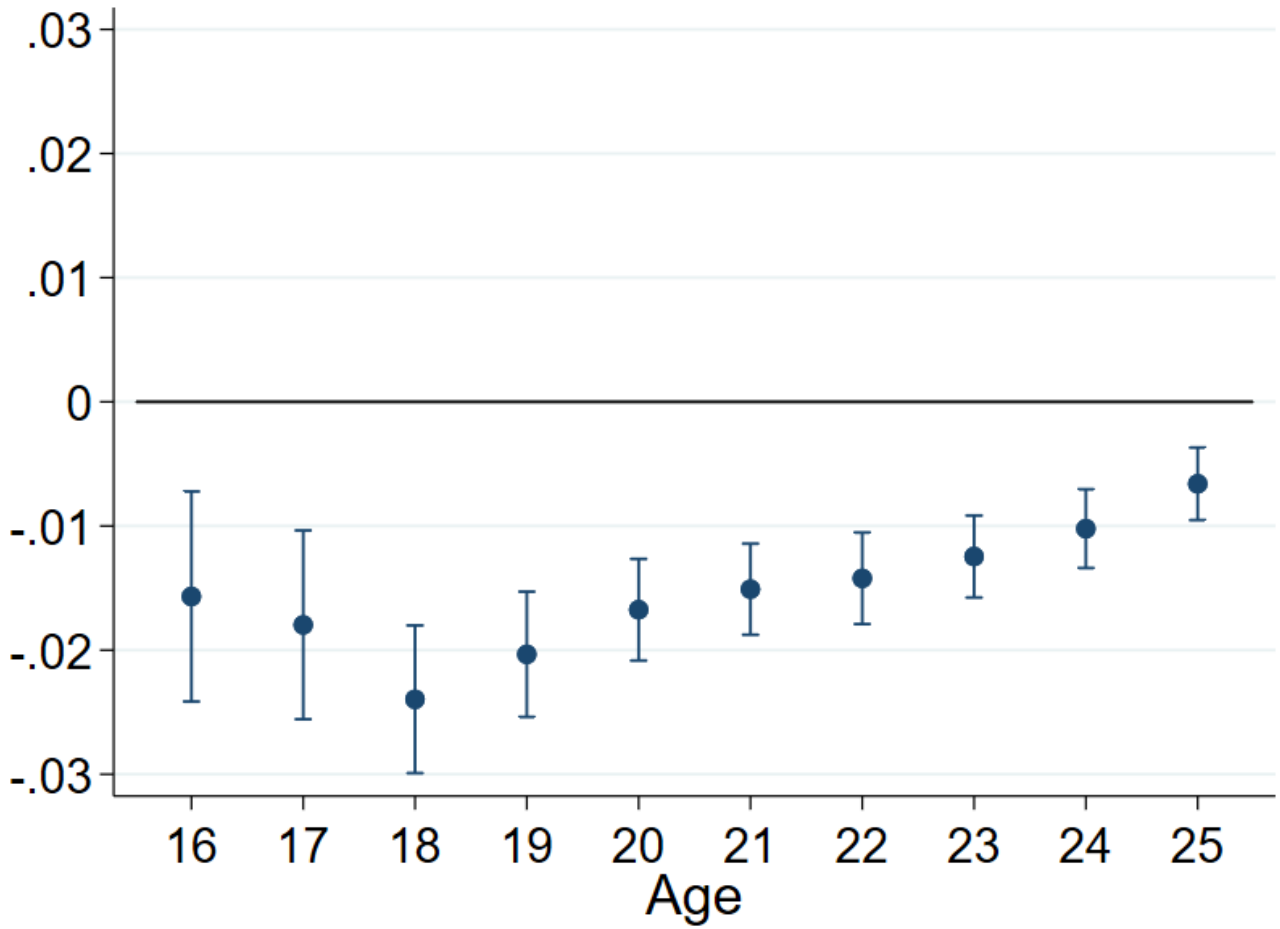
Effects on pct. who are operators: Event Study

focal demographic: female, US-born, white, young



Effects on pct. who are operators: DID, by age

focal demographic: female, US-born, white, young



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- How did future cohorts adjust?
  - Shock did not reduce later cohorts' overall employment; no substitution into education, marriage, or child-bearing
  - Instead, automation was counteracted by:
    1. Growth in employment in comparable middle-skill white-collar jobs (secretarial work) for ca. 19-22 year-olds
    2. Growth in low-skill service jobs for 16-18 year-olds

Fraction of young women ages **19 to 22** who are working / in school / married / with children

	White, American-born women ages 19 to 22				
	Fraction of the group that is:				
	Tel. oper.	Working	In school	Married	Has children
Post-cutover	-0.008***	-0.002	-0.001	0.003	0.004
	(0.001)	(0.006)	(0.003)	(0.004)	(0.003)
N	11656	11656	11656	11656	11656
R^2	0.51	0.81	0.79	0.84	0.79
Cities	2914	2914	2914	2914	2914
Cut over	261	261	261	261	261
Y Mean	0.01	0.48	0.11	0.36	0.19

Employment shares of working young women ages **19 to 22** in select occupations

	White, American-born women ages 19 to 22						
	Conditional on working, fraction employed as or in						
	Tel. oper.	Off. mach.	Typist/secr.	Office clerk	Sales clerk	Beautician	Restaurant
Post-cutover	-0.017***	0.000	0.009***	-0.003	0.003	0.001	0.006***
	(0.002)	(0.000)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)
N	11642	11642	11642	11642	11642	11642	11642
R^2	0.50	0.55	0.76	0.73	0.57	0.66	0.72
Cities	2914	2914	2914	2914	2914	2914	2914
Cut over	261	261	261	261	261	261	261
Y Mean	0.03	0.00	0.14	0.05	0.10	0.01	0.04

How did automation affect existing operators?

- To understand effects on existing, potentially displaced operators, we need to track these women over time

- This is close to a Herculean task:
  1. Linking males across census waves is hard (but doable for subsets of the population—disambiguated linking rates w/ state-of-the-art methods are ≈30-40%)
  2. Linking *women* is even harder
  3. Linking *young women* is close to impossible

  (reason: surnames change at marriage)

Approaches to linking women across censuses

- What can be done?
  1. Collect marriage records? Scattershot records with inconsistent coverage, 50-state effort, lots of other problems
  2. Historical SS registration records? We tried—a real mess Duplicate registrations, selection into registration, etc.
  3. FamilySearch.org: genealogy tool hosted by the Church of the LDS, where people can build their own family trees, linking to census records—and all trees are public

- We rely on genealogists + descendants to tell us which census records represent the same person over time

Our FamilySearch-based linking procedure

- Specifically, we:
  1. Identify all women in the census data who were telephone operators in the telephone industry in 1920 and 1930
  2. Look for them on the tree in that year
  3. Let the tree tell us who they were in other years
  4. Retrieve their census data for those years
  5. Do the same for their demographically-similar neighbors, whom we can leverage as a control group

- Caveat: Still subject to selection (vis-à-vis who's on the tree)
  - Adjust for this with propensity weights (Bailey et al. 2020)

Characteristics of linked sample of operators + control group women

- Link rates (to tree, and across it) relatively good
  - We find 30.4% (32.3%) of operators in 1920 (1930) in FS
  - Of these, we link 42.4% (44.7%) to the next decade
  - This yields: 12,900 operators linked from 1920 to 1930, and another 8,955 linked from 1930 to 1940

- Control group: women from the same census enumeration district (neighborhood) matched on age (± 3), race, nativity, parental nativity, marital status, children, and working
  - This yields matched controls for about 2/3 of operators, with approx. 4 control women for each operator

How did automation affect existing operators?

- We focus on operators each decade in cities *not yet cut over*
  - ... and ask what they were doing ten years later, as a function of whether their city was cut over to dial in between:

$$\mathrm{Y}_{ict}^{t+10} = \beta \cdot \mathbb{1}(\mathrm{Cutover})_{ct} + \delta_{ct} + X_i\phi + \varepsilon_{ict}$$

- What we find:
  - Pr(Still a tel. operator in tel. industry): $\downarrow\downarrow\downarrow$
  - Pr(Other job in tel. industry): $\uparrow$ (for younger workers)
  - Pr(Operator in other industry): $\uparrow$ (for younger workers)
  - Pr(Still working): $\downarrow$ (for older workers)
  - Pr(Married/kids): $\uparrow$ (for older workers)
  - Pr(Reduction in occupation score decile): $\uparrow$

Recap of what we have seen

- In 1920, telephone operation was one of the most common jobs for young American women: upwards of 10-15% of women were ever an operator at some point as a young adult
- Between 1920 and 1940, this job was widely automated
  - Collapse in entry-level hiring of telephone industry operators; $\approx$2% of jobs for these young women eliminated
- No discernable effects on future cohorts' employment
  - Shock offset by demand growth in other middle-skill jobs (e.g., secretaries) and lower-skill service jobs
- Incumbent operators bore the brunt of the shock: subsequently less likely to be working or in lower-paying occupations

What to make of these results?

- Why did other jobs grow to offset jobs lost to automation?
- One possibility: technology destroyed some jobs, but created demand for types of workers that compensated
  - May have created a few jobs for women (e.g., secretaries to dial calls) but likely very inframarginal
- Another: Under the right conditions, new jobs will be created in other sectors and economies will adjust (A&R 2018)
  - What conditions? Requires further study on e.g. technological, institutional, economic context of automation
  - Exceptions may prove the rule: e.g., in cities where GD was most severe, automation had detectable negative effects on the employment rates of young women

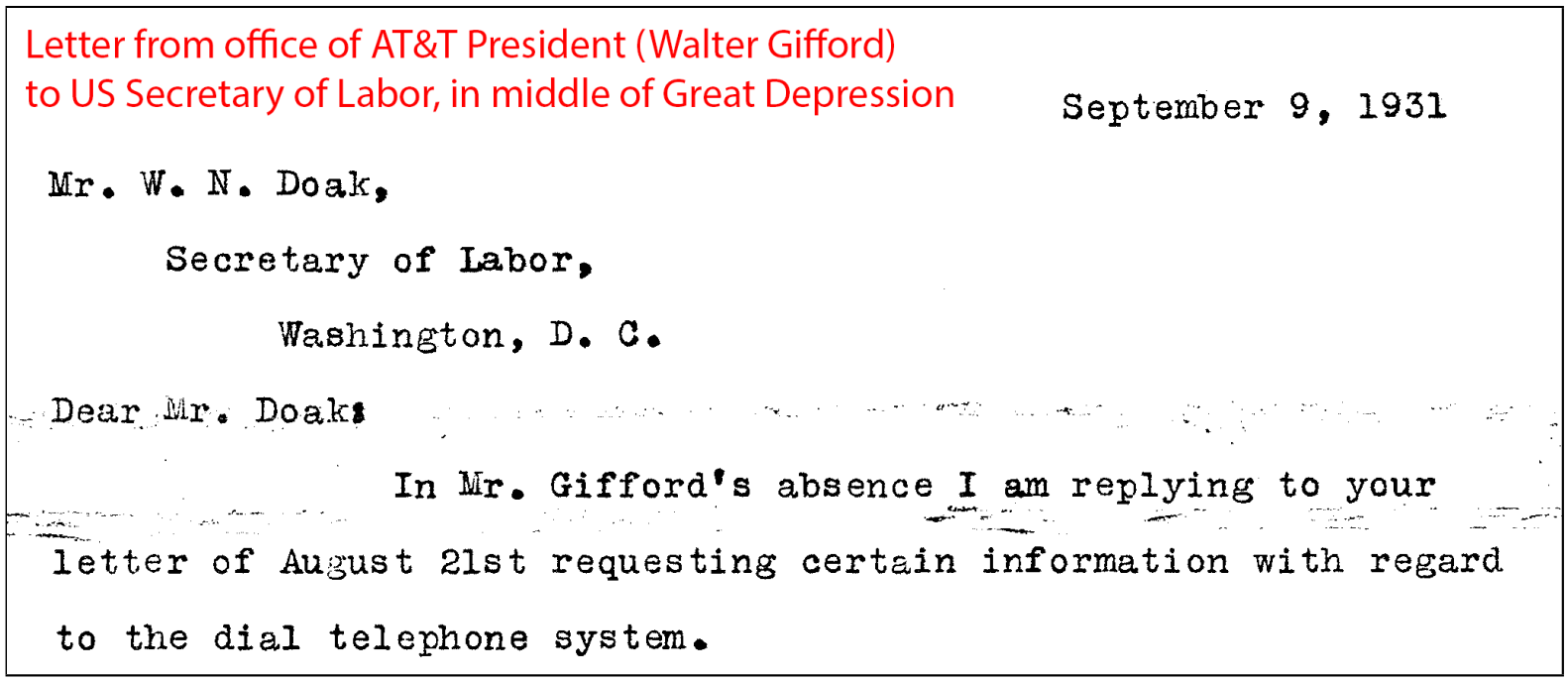
Additional reflections

- AT&T is distinctive: is this feature or bug?
  - Largest U.S. employer for most of 20th century
    - Large enough to have aggregate effects
    - Geographic variation, automation well-documented
  - Modern parallels in e.g. Amazon, Walmart
- Should we be worried that this was just a special time in U.S. history? Is this time intrinsically different?
  - Rapid changes in women's education and LFP
- Another potential mechanism: Advance notice
  - Cutovers were planned events (2+ years). But, are automation threats today playing out faster? (Probably not.)

Appendix

What drove AT&T to automate its biggest job?

- Rich narrative evidence from internal company documents, including correspondence between executives and between AT&T VP and U.S. Secretary of Labor



Letter from office of AT&T President (Walter Gifford)
to US Secretary of Labor, in middle of Great Depression

September 9, 1931

Mr. W. N. Doak,

Secretary of Labor,

Washington, D. C.

Dear Mr. Doak:

In Mr. Gifford's absence I am replying to your letter of August 21st requesting certain information with regard to the dial telephone system.

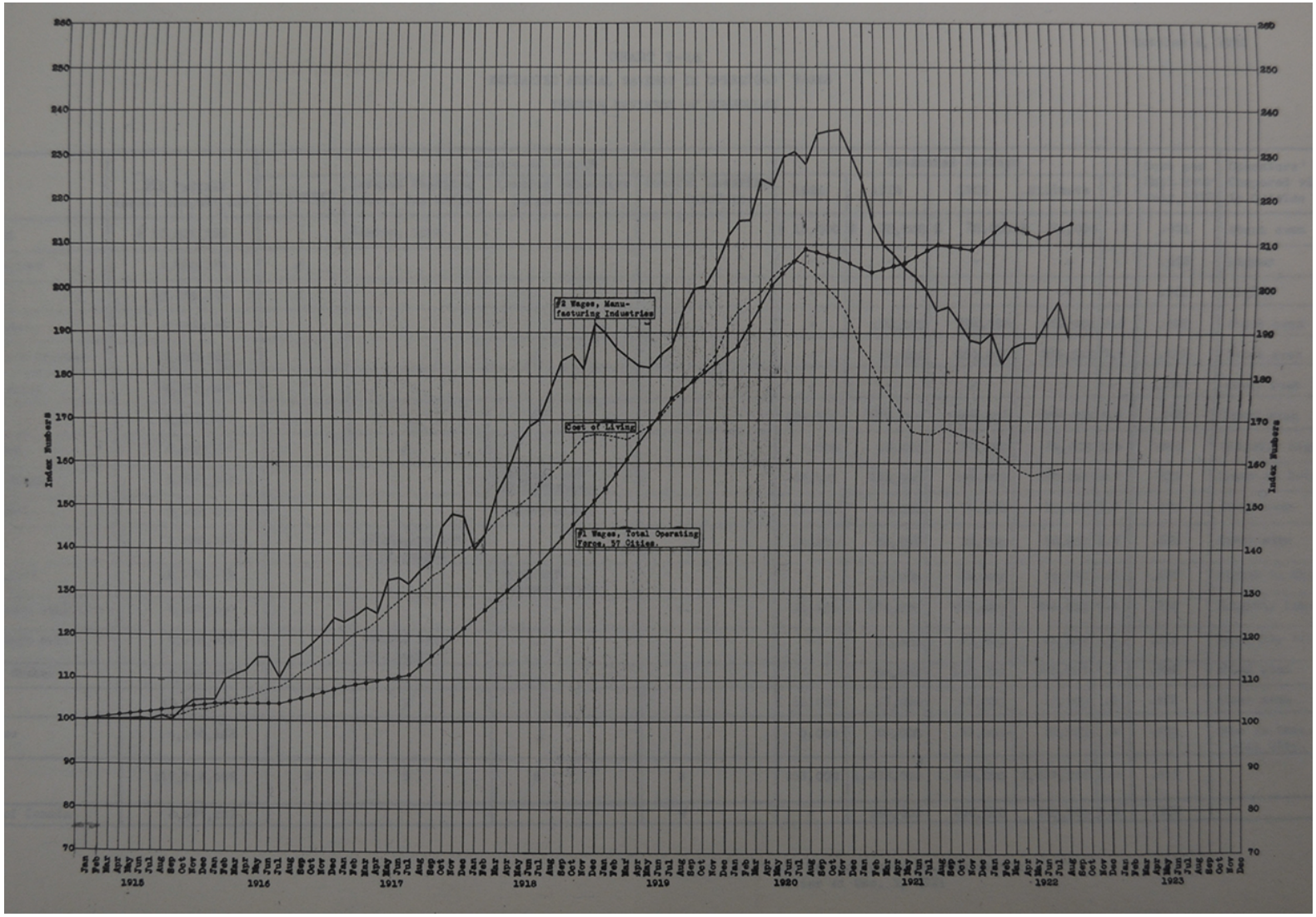
What drove AT&T to automate?

back

1. Diseconomies of scale in manual operation stretching the limits of operators and equipment, especially in large cities
   - Every Nth subscriber create $N-1$ new possible connections: MC increasing approx. geometrically
   - Empirically: automation spreads from large to small cities
2. Operator demand growing faster than population, and limited supply of qualified operators was being exhausted
   - Empirically: cutovers preceded by growth in share of target demographic working as operators
3. Rising operator wage pressures
   - Empirically: strong correlation of post-1920 cutovers with operator unionization and strikes in 1910s

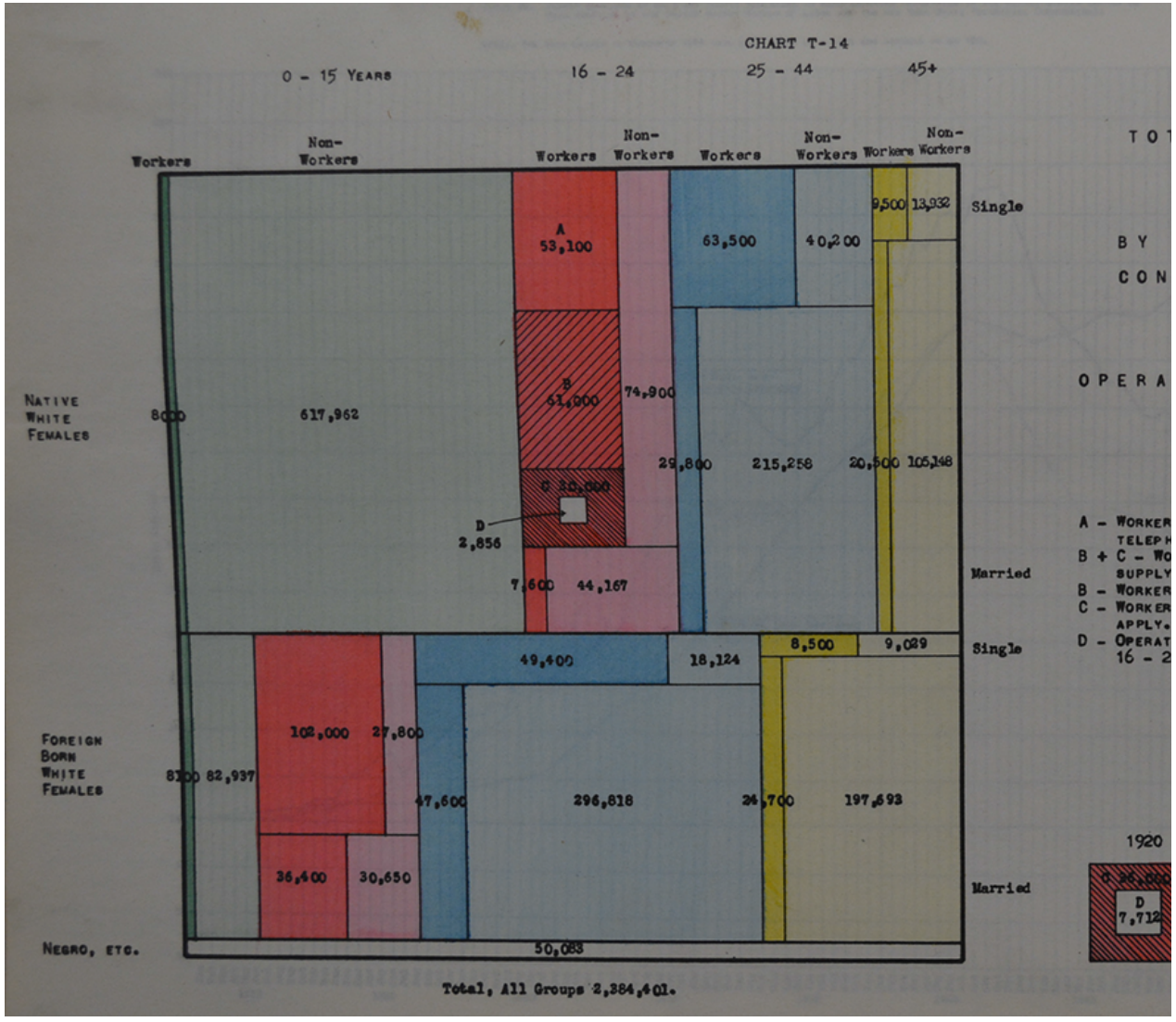
AT&T operator wage index, 1915-1922

back



AT&T operator target labor pool, 1922

back



City characteristics by cutover timing

back

	Unconditional city means by timing of first cutover					
Characteristic	pre-1920	1921-1925	1926-1930	1931-1935	1936-1940	post-1940
Population 16+ (1000s)	38.92	116.82	43.87	18.41	9.14	4.06
	(10.14)	(31.40)	(7.49)	(3.31)	(1.71)	(0.13)
Average age	27.93	27.97	28.15	28.32	27.70	27.75
	(0.38)	(0.26)	(0.22)	(0.29)	(0.36)	(0.06)
Percent female	48.46	50.08	48.94	50.08	50.03	50.34
	(0.78)	(0.38)	(0.53)	(0.65)	(0.58)	(0.11)
Percent f/n/w/y	12.25	11.62	11.46	11.74	11.96	12.32
	(0.44)	(0.29)	(0.24)	(0.27)	(0.33)	(0.06)
Percent working	60.54	60.35	60.81	59.60	58.96	57.55
	(0.96)	(0.64)	(0.53)	(0.69)	(0.75)	(0.14)
Percent operators	0.19	0.21	0.19	0.17	0.19	0.21
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.00)
F/n/w/y percent working	41.17	40.68	40.23	44.01	36.71	35.09
	(1.42)	(1.52)	(0.96)	(1.44)	(1.58)	(0.24)
F/n/w/y percent operators	1.16	1.36	1.19	1.02	1.12	1.21
	(0.12)	(0.14)	(0.08)	(0.08)	(0.10)	(0.02)
Unionized by 1920	0.17	0.26	0.19	0.09	0.08	0.03
	(0.07)	(0.06)	(0.04)	(0.04)	(0.04)	(0.00)
Had strike by 1920	0.07	0.10	0.09	0.03	0.03	0.01
	(0.05)	(0.04)	(0.03)	(0.02)	(0.02)	(0.00)

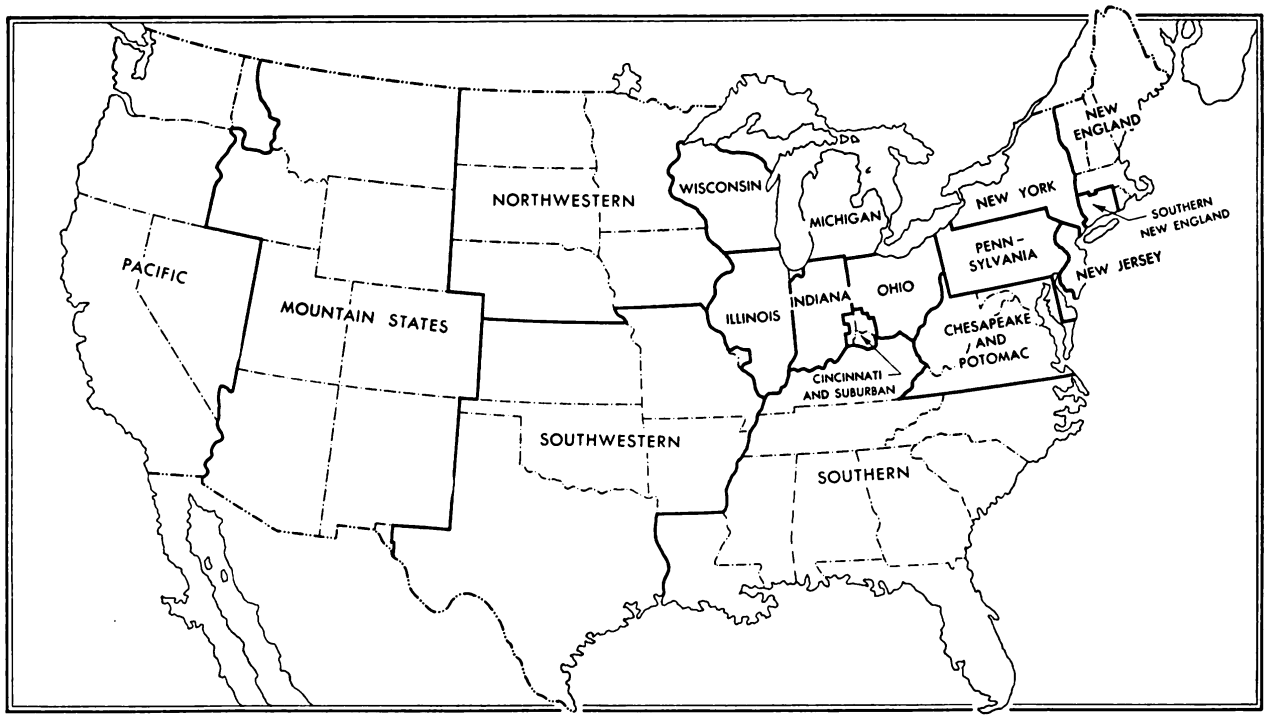
City characteristics by cutover timing

back

	Conditional city means by timing of first cutover					
Characteristic	pre-1920	1921-1925	1926-1930	1931-1935	1936-1940	post-1940
Average age	26.78	26.64	27.07	27.49	27.09	27.37
	(0.42)	(0.32)	(0.27)	(0.32)	(0.36)	(0.08)
Percent female	48.76	50.43	49.22	50.30	50.19	50.44
	(0.86)	(0.51)	(0.65)	(0.69)	(0.61)	(0.16)
Percent f/n/w/y	13.76	13.38	12.88	12.83	12.77	12.82
	(0.49)	(0.38)	(0.32)	(0.30)	(0.33)	(0.09)
Percent working	56.67	55.83	57.18	56.80	56.90	56.27
	(1.05)	(0.79)	(0.69)	(0.73)	(0.73)	(0.22)
Percent operators	0.23	0.25	0.23	0.19	0.21	0.22
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
F/n/w/y percent working	29.26	26.78	29.05	35.40	30.36	31.15
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F/n/w/y percent operators	1.17	1.37	1.21	1.03	1.13	1.22
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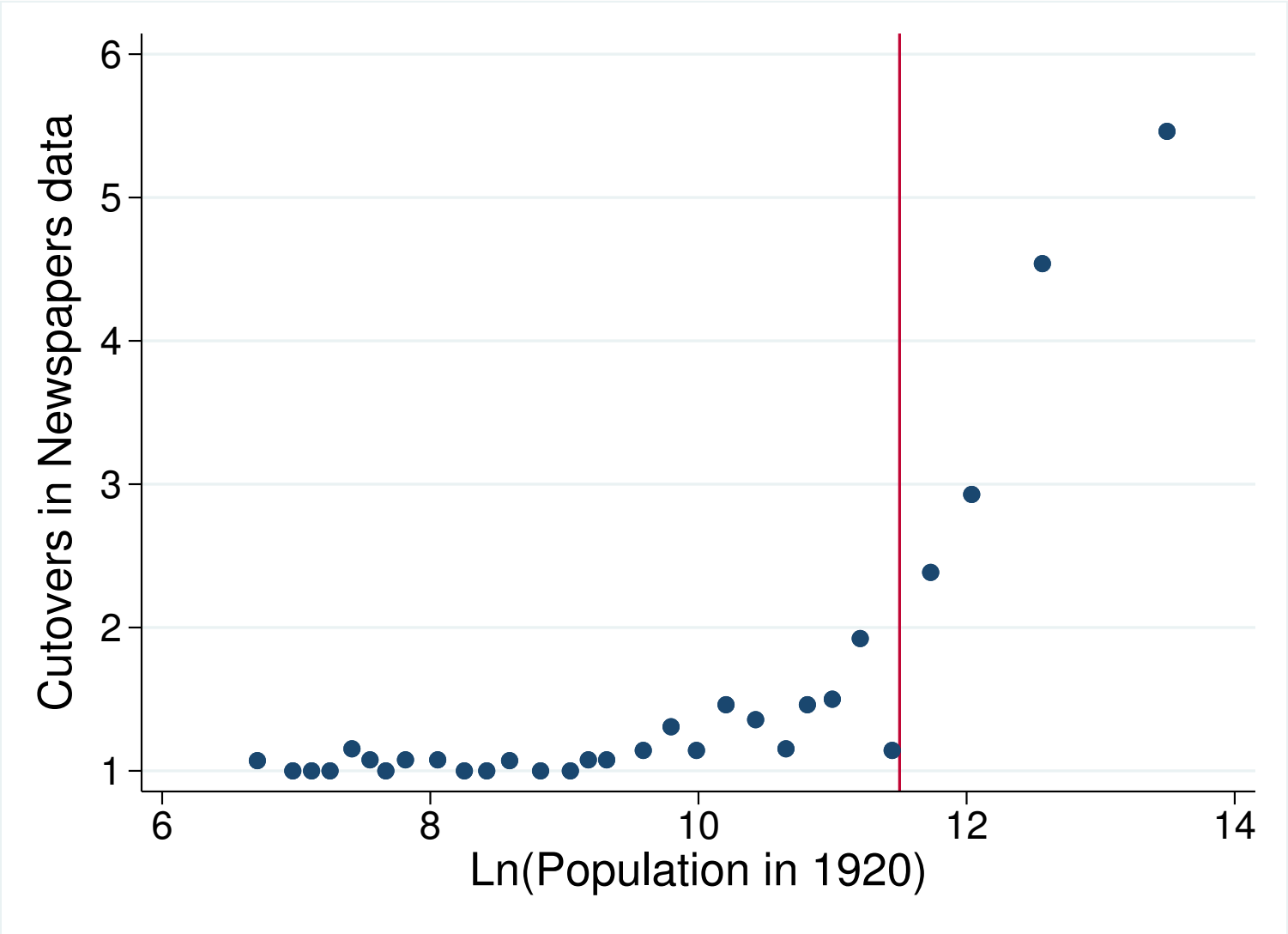
Dial adoption by operating company, 1937

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- Ranges from 23% to 75%, with substantial variance
- Michigan Bell, 75%... vs. Wisconsin, 23%
- Bell of Pennsylvania, 66%... vs. New Jersey, 35%

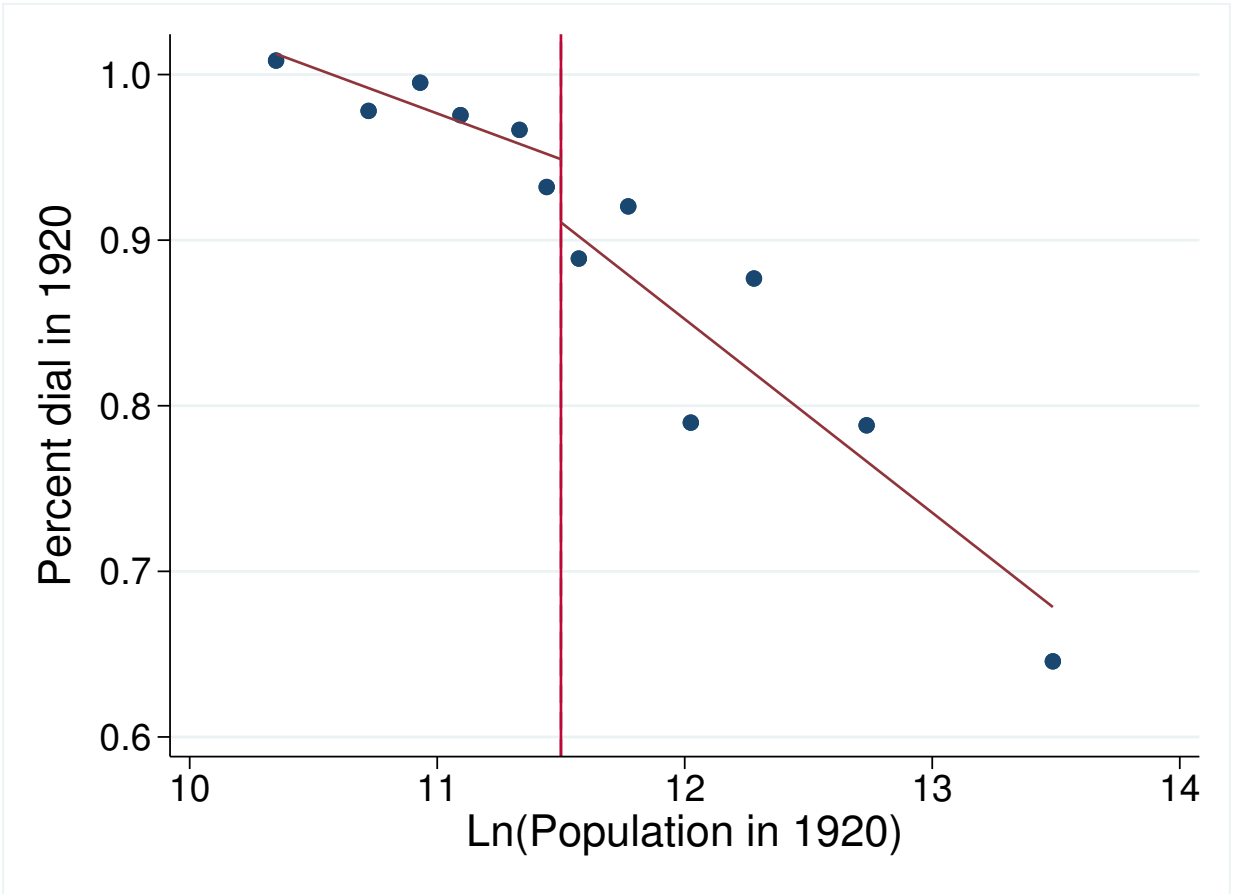
- Smaller cities typically have only 1 cutover in Newspapers data



- Smaller cities in AT&T data typically 100% dial in 1940...
  1. Regardless of time since first cutover

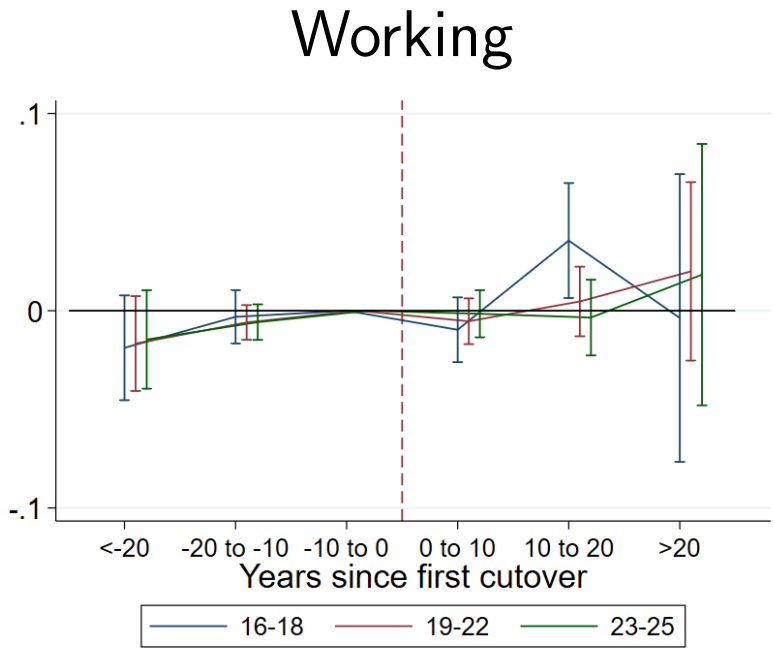


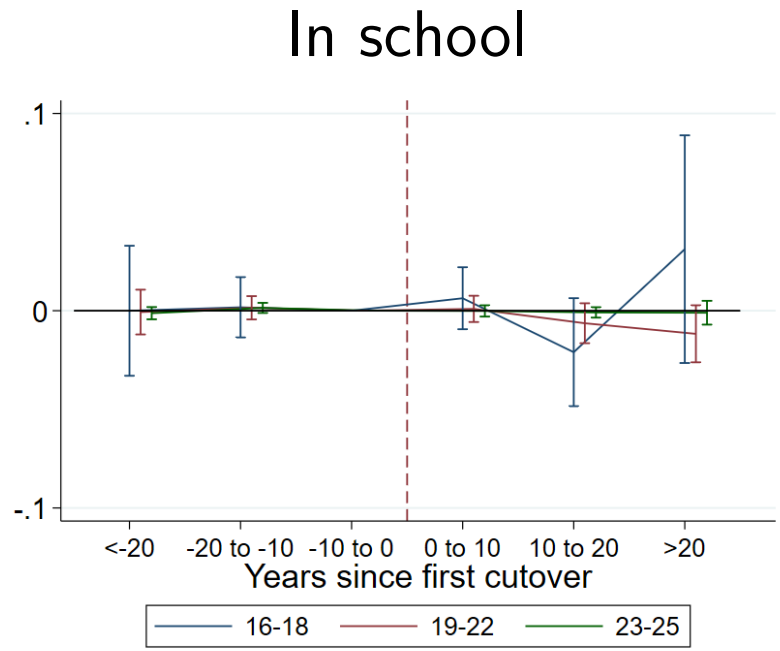
- Smaller cities in AT&T data typically 100% dial in 1940...
  2. Regardless of population



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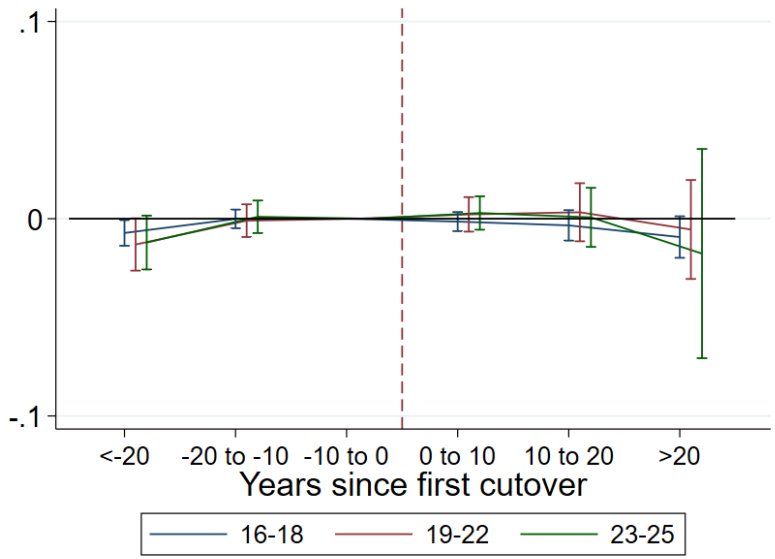
Fraction of young women by age bin who are working / in school / married / with children



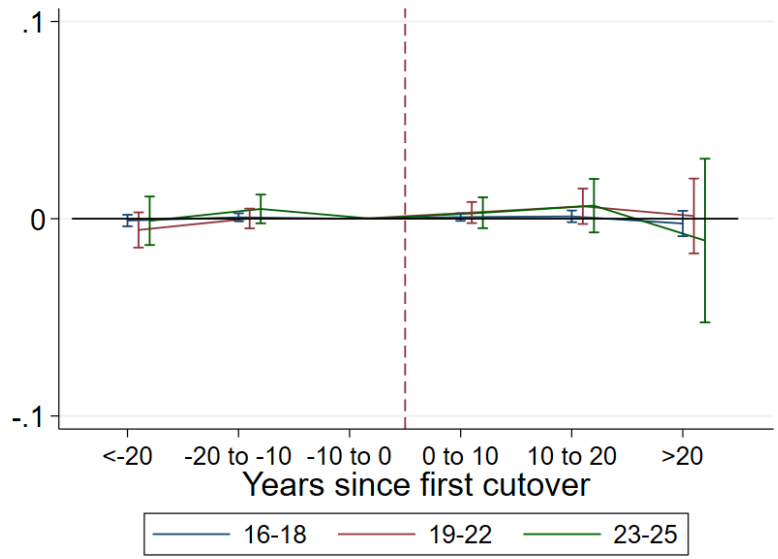


Fraction of young women by age bin who are working / in school / married / with children

Married



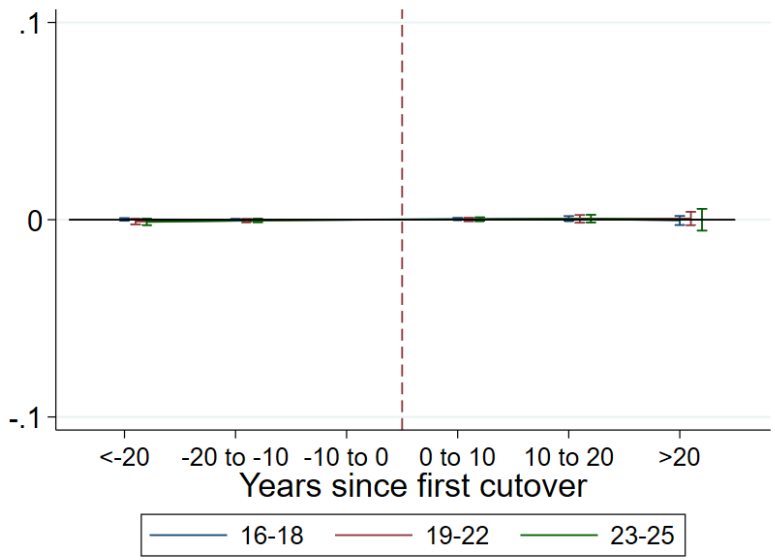
Has children



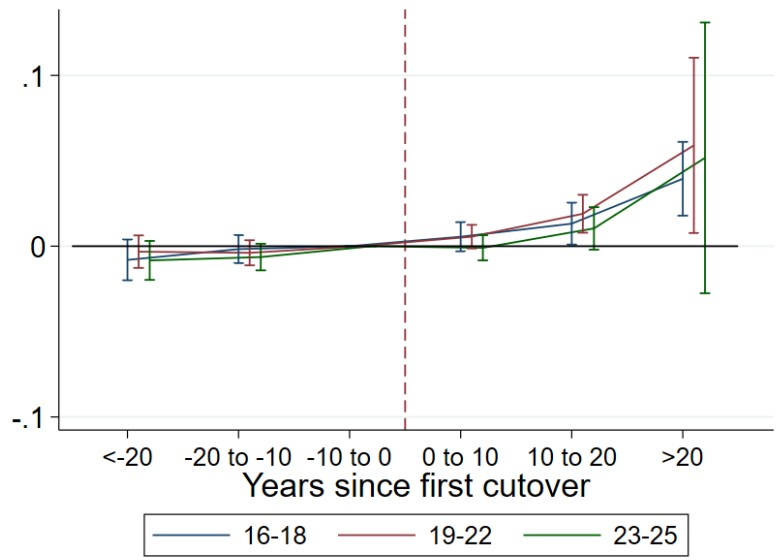
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Fraction of young women in assorted occupations

Office mach. operators

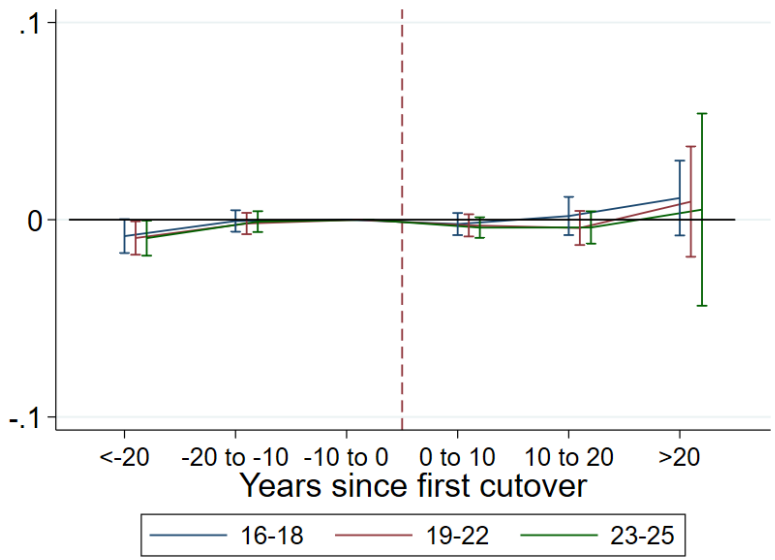


Typists/stenographers

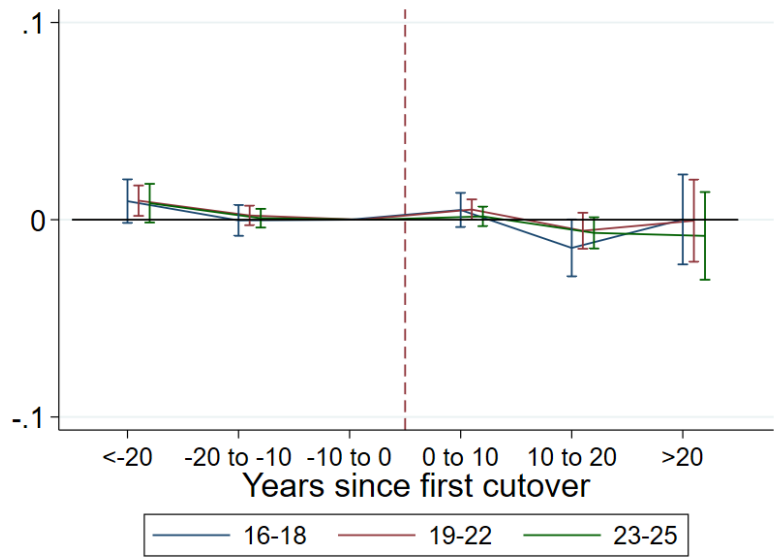


Fraction of young women in assorted occupations

Office clerks

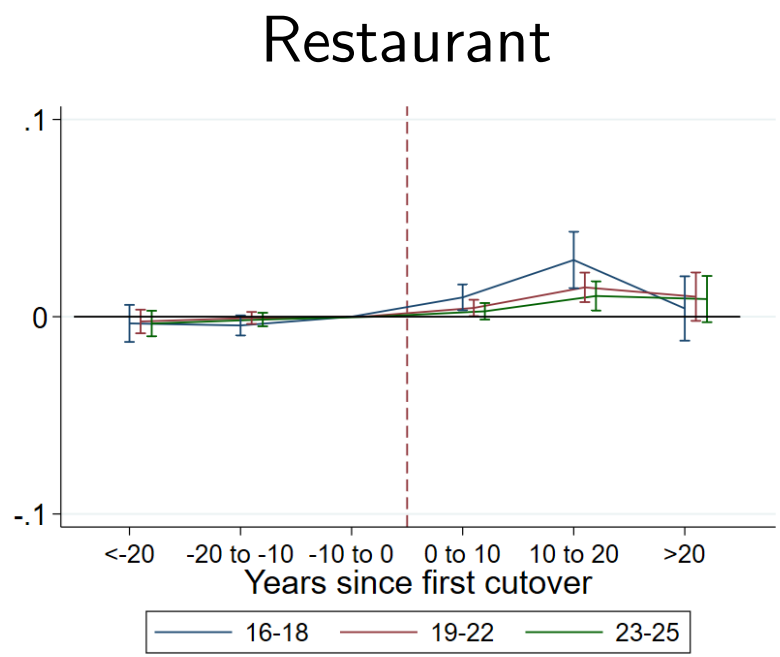


Sales clerks



Fraction of young women in assorted occupations





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