Educational Expansion and Occupational Change: U.S. Compulsory Schooling Laws and the Occupational Structure 1850-1930*

Emily Rauscher
University of Kansas
Fraser Hall Room 716
1415 Jayhawk Blvd
Lawrence, KS 66045
emily.rauscher@ku.edu

Abstract

During the U.S. industrial revolution, educational expansion may have created skilled jobs through innovation and skill upgrading or reduced skilled jobs by mechanizing production. Such arguments contradict classic sociological work that treats education as a sorting mechanism, allocating individuals to fixed occupations. I capitalize on state differences in the timing of compulsory school attendance laws to ask whether raising the minimum level of schooling: 1) increased school attendance rate; or 2) shifted state occupational distributions away from agricultural toward skilled and non-manual occupation categories. Using state level panel data constructed from 1850-1930 censuses and state-year fixed effects models, I find that compulsory laws significantly increased school attendance rates, particularly among lower class children, and shifted the categorical distribution toward skilled and non-manual occupations. Thus, rather than deskilling through mechanization, raising the minimum level of education seems to have created skilled jobs and raised the occupational distribution through skill-biased technological change. Results suggest education was not merely a sorting mechanism, supporting the importance of education as an institution even around the turn of the century.

Introduction

In January 2012, President Obama called for states to extend compulsory education in the U.S. to age 18. Common arguments – from politicians and others – in support of such educational expansion suggest that education spurs the economy and innovation, promotes job creation, and expands skilled and higher paying jobs that demand more educated workers. While debates remain about its contemporary effects (e.g., Keep and Mayhew 2004), educational expansion is frequently identified as central to economic growth and job creation in the context of what some call the "knowledge economy" (Powell and Snellman 2004), when production relies more on intellectual resources than on physical or natural resources (Coomans 2005; Lutz et al. 2008; Hooks et al. 2010).

In other contexts, however, education could enable mechanization of skilled labor and reduce skilled jobs. Technological change does not always favor skilled work (Acemoglu 1998). In the late 19th century U.S., technological advances allowed production of many goods to shift from workshops to factories, reducing the need for skilled workers and increasing jobs with low skill requirements (Goldin and Katz 2008). Thus, although the economy grew, the U.S. industrial revolution could be a context in which educational expansion is associated with the growth of non-skilled rather than skilled jobs. This paper examines the U.S. from 1850 to 1930 as a case study to better understand the relationship between educational expansion and occupational structure.

The argument that education promotes occupational upgrading contradicts the idea, implicit in much early sociology of education and status attainment work (Blau and Duncan 1967; Erikson and Goldthorpe 1992), that education allocates individuals into a fixed occupational structure. On one hand, raising the level of education in a society could generate

1

macro-level occupational changes. On the other hand, if education primarily sorts workers

among occupations, then individual gains could merely be relative to others as more educated

individuals displace the less educated, relegating them to the least attractive jobs (Spring 1976).

For example, if education is a relative good, the average education level could consistently

increase (e.g., through credential inflation; Collins 1979, 1971) without ever shifting average

occupational status or job structure.

Individual-level effects of education on earnings and occupational attainment are well

established (Blau and Duncan 1967; Mincer 1974; Stevens and Weale 2004), but the macro-level

question remains open. Research has illustrated the importance of occupational structure for a

variety of outcomes (Marmot et al. 1978, 1991; Kuper and Marmot 2003; Armstrong et al. 2003;

Thompson 1989; Mouw and Kalleberg 2010). For example, Hout (1988) finds that the

association between social origins and occupational destination decreased from 1972 to 1985,

but this rise in equality was offset by declining structural mobility. Thus, even with increasing

equality of opportunity (relative mobility), occupational structure is strongly related to the

overall opportunity structure in a society and can drive aggregate occupational standing of a

society up or down (absolute mobility) (Featherman and Hauser 1978).

With potentially important policy implications, particularly for the developing world, this

paper asks whether rising education levels changed the distribution of occupations in the U.S.

from 1850 to 1930. To address the potential endogenous relationship between educational

expansion and occupational change, I capitalize on state differences in the timing of the first

compulsory school attendance law, which raised the minimum level of schooling in a state. If

this educational expansion drove technological advances or innovation that altered production, it

could have shifted the occupational distribution either toward or away from non-skilled manual

occupations. I pose two questions to investigate the relationship between educational expansion

and occupational structure. Did compulsory school attendance laws: 1) increase school

attendance rate; or 2) shift state occupational distributions toward skilled and non-manual

occupation categories? Supplementary analyses provided in the appendix also investigate

whether compulsory laws increased the state mean or standard deviation of continuous

occupational measures.

Education and the Occupational Distribution: Competing Theories and Research

Theories do not always agree on whether education should have macro-level effects on

the occupational distribution. If education promotes skill-biased technological change, then it

should shift the occupational distribution toward skilled and non-manual work. If, on the other

hand, education promotes production changes that favor non-skilled work, it could shift the

distribution toward non-skilled occupations. A competing view, implicit in much early

sociology of education literature, treats the occupational structure as independent of education

levels. Finally, aggregate effects may be conditional on factors such as education level, gender,

and time period.

Skill-Biased Technological Change

Schooling increases an individual's skills relevant for job productivity, such as cognitive

and technical skills, which pay off on the job market (Becker 1964; Schultz 1961). But

according to human capital theory, the benefits do not stop at the individual. There are also

social returns to education. Educated populations encourage innovation, technological advances,

and economic growth, so education raises both individual and group returns. According to

human capital theory, education facilitates innovation and technological developments (e.g.,

Anselin et al. 1997; Varga 1998), which change the tasks that employers need completed

(Acemoglu and Autor 2012). If these technological developments are skill-biased, they will

favor skilled workers. As employers need more advanced tasks completed and new skilled

occupations emerge, demand for educated (and presumably skilled) workers will increase.

Depending on the extent of skill-biased technological change, it could change production across

multiple industries and shift the occupational distribution of a society toward skilled or non-

manual occupations and away from non-skilled or agricultural occupations.

Alternatively, rising education levels in a "schooled society" could encourage employers

to take advantage of those skills by creating more skilled jobs or altering existing jobs to attract

more educated workers (Baker 2014, 2011, 2009; Murnane and Levy 1996). In other words, if

rising education shows companies that employing educated workers increases production and

profit, educational expansion could encourage companies to replace non-skilled with skilled jobs

and thereby change the occupational distribution.

Technological Redundancy

In some contexts, such as the 20th Century U.S. economy (Goldin and Katz 2008),

technological changes tend to be skill-biased, increasing the complexity of job skills and tasks.

In other contexts, however, technological change could *reduce* average occupational skill

requirements through capital investments, routinization, and specialization, as occurred during

19th century industrialization (Kaestle and Vinovskis 1980; Braverman 1974). During the U.S.

technological revolution, for example, technology allowed the production of many goods to

move from workshops to factories (Goldin and Katz 2008). With that transition, unskilled

workers or machines could replace skilled craftsmen. Acemoglu (1998) provides a few

examples of 18th or early 19th century technological advances that made skills redundant rather

than complementing them, including the spinning jenny, weaving machines, and assembly lines. Thus, in contexts where technology replaces skilled workers, education could promote innovation and generate new technologies that favor non-skilled occupations and shift the occupational distribution away from skilled occupations toward non-skilled occupations.

Education Allocates Individuals into a Fixed Occupational Structure

The idea that education can change the occupational structure contradicts a traditional perspective – implicit in such classics as Blau and Duncan (1967) and Erikson and Goldthorpe (1992) – of education as a sorting mechanism that assigns individuals to existing occupations. Meyer (1977) nicely distinguishes this allocation theory of education from legitimation theory or the idea that the institution of education increases societal complexity and creates occupational positions. From the allocation perspective, occupations are not responsive to education, but are pre-existing spots waiting for individuals with the most appropriate or highest training (e.g., queuing theory; Reskin 1991). Individuals who gain more or better education can enter better occupations, but occupations do not change based on the qualifications of the labor market. Schools may sort individuals based on ability, interest, or social background, recreating inequality in the parents' generation. Whether schools explicitly sort individuals or individuals sort themselves within schools (Lucas 2001; Willis 1981), the education system assigns people to existing occupations. Research on the school-to-work transition, for example, tends to focus on how schools might better meet the skill requirements of existing occupations or connect individuals to employees (Arum and Hout 1998; Rosenbaum et al. 1990). The onus is on schools, not employers. Given evidence of employer influence on the curriculum (Field 1976; Bowles and Gintis 1976), schools work to produce graduates with the skills that fit existing jobs, not promote occupational change.

While this sorting or allocation perspective may no longer be credible in our contemporary "schooled society" (Baker 2014), in earlier decades when the U.S. educational system was gaining importance (e.g., through compulsory schooling laws), education may have held limited potential to shape the occupational distribution. In that case, education could have increased individual attainment without changing the overall occupational structure. The same types of work would need to be completed, regardless of the amount of schooling in the labor force. Individuals who achieved greater levels of schooling could achieve better occupations by displacing others, while the overall occupational standing remained unchanged. For example, according to queuing theory (Reskin 1991), schools may sort individuals into a place in the queue rather than immediately into an occupational slot. Consistent with credentialing arguments (Collins 1971), therefore, the average education level could consistently increase without ever boosting aggregate occupational income or status. If the institution of education was relatively weak around the turn of the century, compulsory education should not change the occupational distribution. In contrast, if even in this early period the institution of education increased societal complexity (Meyer 1977), compulsory schooling should expand the occupational distribution.

Conditional on Level, Gender, and Time Period

An alternative possibility is that occupational effects of education are not simply universal, but are conditional on factors such as level, gender, and time period. First, effects may depend on the *level* of education that expands (Aghion et al. 2009) or the initial level of education. Societies with low initial levels of education could benefit more from expansion than those with higher levels (Krueger and Lindahl 2001). Similarly, it is unclear whether basic primary education, post-secondary, or some combination is most beneficial for the economy

(Sapir et al. 2004; Acemoglu and Autor 2012; Lutz et al. 2008). Alternatively, expansion at the lowest non-universal level of education could yield the greatest impact (Walters and Rubinson 1983). In countries with low education levels, mass primary schooling or simply requiring school attendance may be the best investment. In areas where nearly everyone attends high school, post-secondary education may be the key to growth.

Second, expansion effects could differ by gender. Educating girls could yield greater economic benefits than educating boys (Benavot 1989). Alternatively, the relationship between schooling and occupation may have differed for men and women around the turn of the century, with women accruing weaker (or stronger) occupational returns to their education than men. Furthermore, women's occupations are measured with more error than men's, because more women worked in the home (Olivetti 2013; Goldin 1990). For all of these reasons, analyses are conducted separately by gender.

Finally, results could differ over time, depending on economic or political context, among others. For example, Walters and Rubinson (1983) find that educational expansion did not (convincingly) increase economic productivity from 1890 to 1928, but did boost productivity from 1933 to 1969. They suggest that effects only emerged after the Great Depression, when New Deal protections pressured industry to adopt new labor-saving technologies. While Walters and Rubinson improve on earlier research with longitudinal data, a limitation (shared by most research on macro-level educational effects) is the lack of an exogenous change in education. Thus, an external influence on education could yield more precise estimates and overturn their null findings before the Great Depression.

There is a great deal of research investigating the relationship between education and economic growth or technological advances, some supporting the positive macro-level potential

of education (Sapir et al. 2004; Mankiw et al. 1992; Krueger and Lindahl 2001; Barro 2001, 1997; Aghion et al. 2009; Goldin and Katz 2008; Acemoglu and Autor 2012; Hanushek and Woessmann 2009; Li and Huang 2009; Battese and Broca 1997) and others raising doubts about its apparent economic benefits (Kendrick and Grossman 1980; Lundgreen 1976; Wolf 2002; Keep and Mayhew 2004; see Stevens and Weale 2004 or Chabbott and Ramirez 2000 for reviews). With few exceptions (e.g., Cheung and Chan 2008), however, the bulk of this research focuses on economic growth, leaving a limited understanding of the relationship between education and the occupational distribution. Furthermore, most of the empirical research only establishes an association between education and growth, rather than a causal relationship (Bils and Klenow 2000). Two exceptions use compulsory schooling laws as an exogenous influence on education (Aghion et al. 2009; Acemoglu and Angrist 2000).

After constructing state panel data based on U.S. censuses from 1850 to 1930, I use time series analyses and exploit state differences in the timing of compulsory school attendance laws to investigate the effect of education on occupational distributions. Along with state-year fixed effects and controls for state characteristics related to the timing of the law, state variation in timing of the law reduces concern about endogeneity between educational expansion and occupational structure, allowing a more precise estimate than existing research.

Compulsory Education Laws: A Brief Overview

The U.S. was a world leader in education in the 19th Century (Garfinkel et al. 2010). Compulsory school attendance laws began with Massachusetts in 1852. Other states in New England and the North followed more quickly than the South, but by 1918 (when Mississippi passed the law) all states had made attendance compulsory.[1] Compulsory laws aimed to achieve

universal school attendance and were primarily directed at lower class and immigrant families who did not already send their children to school. For example, the Commissioner of Education (1891:493) reported, "It must be borne in mind that the law applies to children of tender years, whose right it is to have schooling. If the misfortune or shiftlessness of parents has resulted in poverty, shall the burden of this fall upon young children?" Opposition to compulsory schooling reportedly came "from the lawless and criminal classes; from the idle and shiftless; from those who take no interest in the education of their children, or care nothing for them but to get work out of them; and, of course, from those who have felt the penalties of the law" (1891:520). In a late 19th century dissertation, John Perrin (1896:71) consistently suggested compulsory laws were necessary to prevent poor children of the "dangerous and perishing classes" from remaining or becoming immoral, criminal, idle, and irresponsible citizens. Ernest Carroll Moore (1902; who later became superintendent of Los Angeles schools and held various positions at UCLA) expressed similar ideas. Compulsory schooling laws aimed to override "irresponsible" parents and increase attendance among lower class and immigrant youth.

Compulsory laws were not perfectly enforced. By introducing potential punishments for non-attendance, they did encourage attendance but compliance was not complete. Because the laws primarily targeted lower class youth, I examine effects of the law on school attendance by social background. Effects may be stronger for lower class youth. Below I outline hypotheses, provide more details about methods and data, present results, and then discuss potential contemporary implications of the findings.

Hypotheses

What happened to occupations when states raised the minimum level of schooling through compulsory school attendance laws? If this educational expansion generated *skill-biased technological change*, the state occupational distribution should shift away from non-skilled and agricultural occupations toward more skilled or non-manual occupations.[2]

If this educational expansion encouraged *technological redundancy*, replacing skilled workers, the state occupational distribution should shift toward non-skilled manual occupations, away from skilled occupations.[3]

If education *allocated individuals into a fixed occupational structure* then compulsory schooling should not change the occupational distribution. If effects of education are *conditional* on the level at which education expands, then effects on the occupational distribution should differ depending on whether a state had low or high initial school attendance rates.

Methods

Data and Measures

IPUMS Census data (Ruggles et al. 2010) allow construction of state-level panel data from 1850 to 1930 with measures every ten years, providing information before the first compulsory attendance law (Massachusetts in 1852) and ten years after the last (Mississippi in 1918).[4] Table 1 provides the number of state observations with complete data in each year. States join the data set as they are included in the census and the union.[5] Table 2 provides summary statistics for state-level measures based on state-year observations from 1850 to 1930. The proportion in school represents the proportion of school-age youth (ages 6 to 13) who attended school in the last 12 months, measured separately by gender.[6] Compulsory school is an indicator for whether a state has a compulsory attendance law in a given census year. The

proportion total in school measures the proportion of all state residents in school regardless of age.

[Tables 1 and 2 about here]

In the main analysis, occupations are measured using occupational categories, which clearly distinguish between skilled and unskilled occupations. Specifically, I assign occupations to categories based on the Erikson, Goldthorpe, and Portacarero (EGP 1979) classification system, which is widely used in sociological research (Erikson and Goldthorpe 1992; Hout 1989; Torche 2011). The EGP system classifies occupations according to how difficult it is for employers to monitor performance and how specific the required skills are (Goldthorpe 2000). Census occupation codes are translated to EGP categories using Morgan and Tang's (2007) coding scheme, which is based on a variety of sources and has been used in previous occupational research (Torche 2011).[7] Like Morgan and Tang, the census data I use are unable to distinguish self-employed individuals or managers by how many workers they supervise. This analysis therefore excludes EGP category IV (self-employed and small proprietors) and may include more low-level managers than appropriate in EGP category I (higher-grade professionals). This classification scheme results in eight categories, listed in Table 3. Analyses are limited to the aggregated version of five categories to simplify interpretation, but changes in the distribution of all eight categories suggest a similar pattern.

[Table 3 about here]

Supplementary analyses investigate the relationship between compulsory laws and continuous occupational measures, including the state mean and standard deviation of occupational income score and occupational socioeconomic index score. Additional information about measures and results are provided in the appendix. All occupation measures are calculated

11

separately by gender and represent aggregate state data at each census year for all men or women with valid occupational information. Although dependent variables (occupational distribution and school attendance) are measured separately by gender, other state-level measures are the same for men and women.[8]

Additional time-varying state measures provide controls. These measures are gathered from ICPSR (1970) Historical Census Data 1790-1970. However, these data do not always include appropriate or consistent measures across censuses and are therefore supplemented with information from original census tables and a compilation of statistical abstracts (U.S. Bureau of the Census 1975). Proportion manufacturing employment measures the proportion of the population working in a manufacturing job. Proportion illiterate measures the proportion of the state population who cannot read. Incarceration rate is the number of people incarcerated (per 100,000 state residents). The proportion of non-white prisoners measures the proportion of state prisoners who are not white.[9] Finally, the total state population attending school measures the proportion of all state residents who attended school in the last year, regardless of age.

Analytical Approach

The analysis involves three steps, all using state-level data and regressions. First, I conduct preliminary time-series analyses to investigate state-level characteristics related to the timing of compulsory laws among U.S. states.[10] These analyses (available upon request) identify the factors that best explain the timing of compulsory laws: manufacturing employment rate; illiteracy rate; proportion of non-white prisoners; and incarceration rate (raw and multiplied by years since 1850 to allow the relationship to vary over time). I show regression results with and without controlling for these measures.

Second, I examine the relationship between passing a compulsory schooling law and school attendance rate among the targeted age group to assess whether the laws changed attendance patterns. I examine these effects separately by social background because the laws primarily targeted lower class children. Third, I examine the relationship between compulsory schooling and state occupational distribution measures.

Despite claims by politicians, an apparent relationship between education and occupational change could be spurious. For example, a strong economy could fuel expansion of both skilled jobs and education if a society has more cash to fund schooling. To help address endogeneity, I exploit U.S. state differences in the timing of compulsory school attendance laws. Tracing within-state changes (using state fixed effects) eliminates time-constant differences between states. The preliminary analyses reveal that some states were likely to require attendance before others. However, when examining within-state changes and controlling for the factors that best explain state variation in when attendance was required, the precise timing of each state's first compulsory law depended on relatively arbitrary factors (e.g., the proportion of current state legislators who supported compulsory attendance and when or by whom the law was proposed). Along with state-year fixed effects, these arbitrary factors reduce concerns about endogeneity, allowing a more precise estimate of the relationship between education and occupational structure.

Finally, supplementary analyses use the proportion of adjacent states with a compulsory schooling law as an instrument for whether a state requires school attendance in a given year. These IV analyses – discussed in greater detail in the online appendix – provide an alternative approach to supplement the main analyses.

Another potential concern is that state occupational changes may reflect national trends. For example, a national economic recession (such as the panic of 1873) could contract occupational variation in all states. All regressions include indicators for each census year to address year-specific differences in occupational distributions.

Analyses are conducted separately by gender for two reasons. First, a line of research (e.g., Benavot 1989) suggests that expansion of girls' schooling may contribute more to economic development than boys' schooling. Second, the relationship between schooling and occupation was probably different for men and women around the turn of the century. Many women worked in the home, which adds more error to women's occupational measures (Olivetti 2013; Costa 2000; Goldin 1990). In fact, occupational information is not even available for women until the 1860 census. The average state labor force participation rate of working age adults (age 16-65) from 1860 to 1930 ranged from 87% to 89% for men and from 14% to 25% for women. Women's labor force participation may be a better measure than occupational status. Therefore, analyses also predict state labor force participation rate of working age adults by gender. Women's labor force participation, however, is also measured with error, particularly in censuses prior to 1940, which undercount women in particular occupations such as agriculture, domestic service, or boarding house keepers (Olivetti 2013; Costa 2000; Goldin 1990). Despite this limitation, women's labor force participation in this study provides a measure of work beyond the home or outside of home production (Costa 2000). Furthermore, although the census definition changed in 1940, this study is limited to years before 1940, so the measure is consistent. Finally, to address the final hypothesis, separate analyses are conducted for states above and below the median state attendance rate at each census year.[11]

Regressions use the following model (Equation 1), with state and year fixed effects and time-varying state controls, weighted by population size.[12] This approach identifies an effect of the compulsory schooling law between censuses on each side of the law, net of time-constant state differences and nation-wide changes over time. Thus, β_1 measures the change in occupational distribution or school attendance rate associated with passing a compulsory school attendance law.

$$\text{Outcome}_{ij} = \alpha + \beta_1 \text{CompSchool}_{ij} + \beta_2 \text{Controls}_{ij} + \text{State}_i + \text{Year}_j + \varepsilon_{ij} \tag{1}$$

Controls include the time-varying measures that best predict the timing of compulsory schooling laws. To help rule out arguments that attendance would have increased anyway, without the legal change, one additional control is included in analyses of compulsory effects on school attendance: the total proportion of the state population attending school. Compulsory attendance laws only targeted school-age youth, so effects on school-age attendance should be net of changes in the overall state school enrollment rate.

The β_1 estimate in equation 1 is conservative, because it only identifies the change in the outcome within a ten year period. For example, New Jersey made attendance compulsory in 1875. With state and year fixed effects, β_1 captures the change in New Jersey's occupational distribution between the 1870 and 1880 censuses. This estimate is conservative because it only allows a maximum of ten years (five years in the case of NJ) for the law to influence the occupational distribution. A short-term effect is more likely at the turn of the century than today, given earlier entry into the labor market and fewer years of schooling at the time (Zelizer 1985; Hine 1999; Goldin and Katz 2008). However, supplementary analyses investigate a longer-term effect of the compulsory law using a delayed indicator for the presence of a compulsory law that is identical to the original but lagged by ten years. Using the example of New Jersey again,

which passed a compulsory law in 1875, this lagged indicator would remain 0 until 1885, ten years after the law. When added to equation 1, the coefficient for this delayed measure will estimate the longer-term relationship between passing a compulsory law and the outcome ten years later. Because the delayed measure expands the time window of the estimate, other changes are more likely to have occurred in the intervening years. This longer-term estimate therefore achieves less internal validity and should be interpreted with caution.[13]

An additional potential concern is spatial autocorrelation of error terms. For example, rising demand for skilled labor in one state could encourage residents in a neighboring state to either move or commute to improve their employment opportunities. States in close proximity to each other could have higher or lower than expected measures of occupational distribution, resulting in spatially correlated error terms. Following Goetz and Swaminathan (2006), I create a spatial-weights matrix calculating the distance between every state (based on average state latitude and longitude).[14] That weights matrix is used to calculate Moran's I on the residuals of the occupational distribution models including all states and controls. The results suggest there is spatial correlation in the error terms for only three outcomes: men's labor force participation; women's mean occupational income score; and women's mean SEI score. That is, Moran's I reaches significance ($p<0.05$) in only three models. In most cases, therefore, spatial correlation of the error terms is not significantly different from zero and spatial correlation is not a concern. For those models which show evidence of spatial autocorrelation, however, I conduct supplementary analyses, adding additional controls to address this concern.[15] These additional controls do not change results.

Results

Figure 1 shows the average state attendance rate of school-age boys by father's occupational SEI score and census from the compulsory law. Before the compulsory law, lower class boys were less likely to attend school than others. After the law, however, attendance was nearly equal by father's occupational status.

[Figure 1 and Table 4 here]

Regression analyses, shown in Table 4, echo the equalizing role of compulsory laws on school attendance. In states below the median attendance rate, compulsory laws significantly increased attendance among boys and girls from all social backgrounds, although slightly more for sons of farmers. States above the median attendance rate experienced no increase in attendance from compulsory laws. Among all states, compulsory laws significantly increased attendance among low SEI boys and girls (ranging from 3% to 7% depending on gender and whether controls are included). In all of the models that include all states, this increase in attendance for low SEI children is greater than the increase for high SEI children, suggesting the laws increased class equality in school attendance rates for both boys and girls. Children of farmers show no change in attendance, except in states below median attendance. This could be because youth in rural areas generally had relatively high rates of school attendance even before compulsory laws. Children of fathers with high SEI occupations show some evidence of an increase in attendance (ranging from 2% to 11%). However, when including all states, the laws increased equality of attendance by raising attendance most among low SEI children.

[Figure 2 about here]

Figure 2 illustrates these different effects on attendance by social background. Based on the model including all states with controls, the figure shows a significant 4% increase in attendance rates for low SEI boys, an insignificant increase for sons of farmers, and a 2%

17

increase for high SEI boys. Overall, results from Table 4 suggest that compulsory laws

increased attendance rates among boys and girls from low socioeconomic backgrounds, unless

the state attendance rate was already above the median. There is evidence that the laws also

increased attendance among higher status children, albeit less than for lower status children.

Beyond attendance, descriptive information suggests that compulsory laws may also have

shifted the occupational distribution. Figure 3 shows the proportion of men and women in each

occupational category among states with and without a compulsory law. States with a

compulsory law had significantly lower proportions of men and women in agricultural

occupations and significantly higher proportions in upper non-manual occupations. Men in

states with a compulsory law also had significantly higher proportions in lower non-manual and

skilled manual occupations. These are descriptive data, however, and could simply reflect state

differences or changes over time.

[Table 5 and Figure 3 about here]

Regression results, presented in Table 5, adjust for these differences but still suggest

compulsory attendance laws shifted the occupational distribution. For men, the compulsory

coefficient is positive in all models predicting the proportion in non-agricultural occupations and

negative for all models predicting the proportion in agriculture. When including all states

(providing a larger sample size), these coefficients are significant. Thus, the change in

compulsory law shifted the occupational distribution away from agriculture. At the same time,

the proportion in non-manual, skilled manual, and non-skilled manual occupations increased.

When controls are included, the increase in the proportion of upper non-manual occupations did

not increase significantly, but the proportion of lower non-manual and skilled manual

18

occupations saw a statistically significant increase of 1% (p<0.05). The proportion in non-skilled manual occupations also increased by 1% (p<0.05).

These changes in the occupational distribution of men seem to support both skill-biased technological change and technological redundancy arguments. Compulsory laws, which contributed to educational expansion, increased the proportion in non-manual and skilled occupations, consistent with the belief that education promotes skill-biased technological change. However, the laws also increased the proportion in non-skilled manual occupations, suggesting that this instance of educational expansion made some skilled work redundant through mechanized production.

Results among states above the median attendance rate are most consistent with the technological redundancy hypothesis. Requiring attendance reduced agricultural occupations and increased the proportion in non-skilled manual jobs. The proportion in the rest of the occupational categories remained unchanged by the law. Among states below the median attendance rate, there are no significant effects of the law but the coefficients are consistent with skill-biased technological change. This pattern suggests that, while educational expansion changed men's occupational distribution, the way it did so depended on initial schooling levels.

Among women, results are most consistent with skill-biased technological change, regardless of initial school attendance rate. Compulsory attendance reduced the proportion in agricultural occupations in in only two models without controls. With only one exception, however, the compulsory coefficient is significant and positive in all models predicting the proportion of women in skilled manual occupations. Thus, among women, compulsory schooling laws seem to have shifted the occupational distribution toward skilled manual occupations. The other occupational categories generally show insignificant changes.

Figure 4 illustrates the effects of a compulsory law on the categorical occupational distribution for men and women in all states, with controls included. Compulsory laws significantly reduced the proportion of men in agriculture by 3% and increased the proportion of men in lower non-manual, skilled manual, and non-skilled manual occupations by 1% each. Among women, compulsory laws significantly increased the proportion in skilled manual occupations by 2%. Other changes to women's occupations do not reach significance.

[Figure 4 about here]

Supplementary analyses of continuous occupational measure are presented in the appendix. Consistent with the main analyses, these results suggest that compulsory schooling raised average occupational standing and expanded the distribution – at least for men.

To summarize results, I find that compulsory laws increased attendance rates, particularly among lower class boys, thus contributing to educational expansion. Consistent with the skill-biased technological change hypothesis, in most cases this educational expansion also expanded and shifted the occupational distribution up, away from agriculture toward skilled and non-manual work. The pattern of these effects, however, differs by gender and initial schooling levels. In one case (men in states above the median attendance rate), results support the hypothesis that educational expansion promoted technological redundancy during the industrial revolution. However, results are most consistent with skill-biased technological change. While Walters and Rubinson (1983) improved on earlier research and found null effects of educational expansion from 1890 to 1928, they did not exploit an exogenous change in education. Exploiting compulsory schooling laws, which expanded schooling and should yield more precise estimates, I find consistent evidence that educational expansion impacted various measures of the occupational distribution.

An important limitation of the current study is that education could change job characteristics that remain hidden using the current occupation measures. For example, if workers have more skills, employers could give them more freedom and self-control at work or assign additional responsibilities to the same jobs (Halaby 1994). Alternatively, treatment could remain the same and employers could merely change the job title to make employees feel their education is useful or avoid a sense of over-education. Thus, several aspects of occupational change remain hidden using occupational data from the census. In these scenarios, however, schools are not simply training individuals for a fixed set of occupations. Rather, as the results presented here suggest, occupational distributions seem to change with rising education in the population. There have been tremendous changes in the occupational distribution over time and all of those changes certainly do not reflect educational expansion. Nevertheless, the results of this study suggest education contributed to part of this occupational change.

Conclusion

Because late 19th century technological advances allowed production of many goods to shift from workshops to factories, the U.S. industrial revolution could be a context in which educational expansion is associated with the growth of non-skilled rather than skilled jobs (Goldin and Katz 2008). To better understand the relationship between educational expansion and occupational structure, this paper posed two questions. From 1850 to 1930, did U.S. compulsory school attendance laws: 1) increase attendance rates; or 2) shift state occupational distributions away from agricultural toward skilled or non-manual occupation categories?

Exploiting state differences in the timing of compulsory attendance laws, I find that the laws increased attendance rates, particularly among lower class boys, thus contributing to

educational expansion. There is very little evidence to support the technological redundancy hypothesis that this educational expansion facilitated mechanization of production and large-scale deskilling. Rather, consistent with the hypothesis that educational expansion created skill-biased technological change, in most cases compulsory laws shifted the distribution toward skilled, non-manual occupations. Furthermore, supplementary analyses of continuous occupational measures suggest the laws also increased average occupational standing and expanded the distribution. Thus, education is not merely a sorting mechanism allocating individuals to fixed jobs; consistent with institutional arguments (e.g., Meyer 1977), it can change the occupational structure. Contrary to much classic social stratification work that treats the occupational structure as fixed (e.g., Blau and Duncan 1967; Erikson and Goldthorpe 1992), evidence based on the U.S. from 1850 to 1930 suggests that a rising educational tide lifted all occupational boats. While education may hold more potential to shape the occupational distribution in contemporary society, results support the importance of education as an institution even around the turn of the century, when education was gaining importance.

There is not consistent evidence that societies with high or low education levels benefit more from expansion. Rather, results suggest different patterns of benefits depending on initial schooling level, including occupational expansion if initial attendance is low and rising average occupation if initial attendance is high.

Women experienced an expansion of income opportunities and increased employment in skilled manual occupations. These effects are relatively limited compared to those for men and suggest that educational expansion may have had less ability to impact the occupational opportunities of women. For example, if educational expansion increased demand for workers

22

without changing labor force participation rates, women's wages may have increased to try to attract workers but only in jobs to which women already had access.

This study cannot identify which is the best level of educational investment. Increasing education levels at the top end of the education distribution could have generated even greater structural mobility or occupational expansion. Alternatively, the lowest non-universal level of education could be the greatest potential growth generator – primary school in this historical case or possibly in developing countries, but secondary or post-secondary education in the contemporary U.S. Nevertheless, I find that raising the minimum level of schooling (to attendance) did offer some benefits, improving the occupational distribution for both men and women. This turn-of-the-century-U.S. case study may hold limited relevance for the contemporary world, because of globalization or the current knowledge economy (Powell and Snellman 2004), for example. However, universal primary education could yield similar benefits in developing countries. Similarly, raising the U.S. compulsory schooling age to 18, as proposed by President Obama, could raise overall occupational standing. More broadly, results support what economists call spillover effects or externalities of education (Acemoglu and Angrist 2000), suggesting the benefits of education extend beyond individuals to the society in which they live.

About the Authors

Emily Rauscher is Assistant Professor of Sociology at the University of Kansas. Her research seeks to understand how inequality is transmitted between generations and what policy levers or mechanisms moderate that process. Among other journals, her research has recently appeared in *Educational Evaluation and Policy Analysis* and the *Journal of Health and Social Behavior*.

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Tables

Table 1: State Observations by Year

Year	Below Median Attendance	Above Median Attendance	All Years
1850*	15	16	31
1860	17	16	33
1870	19	19	38
1880	19	19	38
1900	20	22	42
1910	21	24	45
1920	23	22	45
1930	23	22	45
Total	157	160	317

* Women's occupational information is unavailable for 1850.

Table 2: Summaries – State Census-Year Observations 1850-1930

	Below Median Attendance		Above Median Attendance		All States	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Compulsory School	0.66	0.47	0.57	0.50	0.61	0.49
% In School - Men	0.70	0.30	0.74	0.15	0.72	0.23
% In School - Women	0.71	0.29	0.75	0.15	0.73	0.22
Men Occupation Measures						
% Upper Non-Manual	0.10	0.04	0.09	0.02	0.10	0.03
% Lower Non-Manual	0.09	0.05	0.06	0.03	0.08	0.04
% Skilled Manual	0.19	0.09	0.14	0.06	0.17	0.08
% Non-Skilled Manual	0.29	0.09	0.23	0.08	0.25	0.09
% Agriculture	0.32	0.24	0.48	0.15	0.41	0.21
Mean Occ Income Score	22.21	3.85	19.85	2.22	20.93	3.28
Mean SEI Score	24.03	5.65	21.17	2.72	22.47	4.54
Occup Income Std. Dev.	10.02	0.92	10.39	0.73	10.22	0.84
SEI Std. Dev.	19.77	2.71	18.72	1.88	19.20	2.35
Women Occupation Measures						
% Upper Non-Manual*	0.12	0.05	0.14	0.06	0.13	0.06
% Lower Non-Manual*	0.38	0.12	0.40	0.13	0.39	0.13
% Skilled Manual*	0.09	0.05	0.11	0.06	0.10	0.06
% Non-Skilled Manual*	0.28	0.09	0.18	0.08	0.23	0.10
% Agriculture*	0.14	0.20	0.16	0.19	0.15	0.20
Mean Occ Income Score*	16.25	3.55	13.99	2.95	15.06	3.43
Mean SEI Score*	25.68	8.94	24.87	6.76	25.25	7.86
Occup Income Std. Dev.*	8.14	1.36	8.81	1.00	8.49	1.23
SEI Std. Dev.*	18.77	4.19	20.35	3.44	19.60	3.88
Control Variables						
% Manuf Employment	0.09	0.05	0.05	0.03	0.07	0.05
% Illiterate	0.13	0.14	0.08	0.07	0.11	0.11
% Non-White Prisoners	0.30	0.24	0.20	0.18	0.25	0.22
Incarceration Rate (per 100k)	79.61	44.69	73.86	37.85	76.48	41.14
% Total in School	0.16	0.04	0.22	0.03	0.19	0.04
Year	1902.05	21.78	1892.99	23.81	1897.12	23.31
N (state-year observations)	157		160		317	
N* (state-year observations)	142		144		286	

State measures based on 1850-1930 US census data, ICPSR 1970, and Behrens et al. 2003, weighted by population.
* Women's occupational information is unavailable for 1850.

Table 3: Occupational Categories

Collapsed	EGP Category	Description and Examples
Upper Non-Manual	I. Higher Grade Professionals	Esteemed professional occupations, managers (e.g., doctor, accountant)
	II. Lower Grade Professionals	Less esteemed professions (e.g., nurse), service managers (e.g., postmaster), supervisors of non-manual workers
Lower Non-Manual	IIIa. High Routine Non-Manual	Higher grade: administration and commerce (e.g., clerk, messenger)
	IIIb. Low Routine Non-Manual	Lower grade: sales and service (e.g., salesperson, cashier)
Skilled Manual	V. Low Technicians/Supervisors	Lower grade technicians, supervisors of manual workers (e.g., conductor, foreman)
	VI. Skilled Manual Workers	Skilled production and repair (e.g., craftsman, carpenter, plumber)
Non-Skilled Manual	VIIa. Non-Skilled Manual Workers	Semi- and non-skilled manual workers not in agriculture (e.g., laborer, weaver, deliveryman)
Agriculture	VIIb. Agriculture	All agricultural workers

Occupational categories are based on the Erikson, Goldthorpe, and Portacarero (EGP 1979) classification system, assigned using Morgan and Tang (2007). Census data are unable to distinguish self-employed individuals or managers by how many workers they supervise. These categories therefore exclude EGP category IV (self-employed and small proprietors) and may include more low-level managers than appropriate in EGP category I (higher-grade professionals).

Table 4: Estimated Effect of Compulsory Law on School-Age Attendance Rate by Father's SEI

	Men		Women	
	No Controls	Controls	No Controls	Controls
Below Median Attendance				
Low SEI	0.09 **	0.04 *	0.11 **	0.07 **
	(0.03)	(0.02)	(0.03)	(0.02)
Farm	0.12 **	0.07 *	0.11 **	0.05 *
	(0.03)	(0.02)	(0.03)	(0.02)
High SEI	0.08 **	0.05 **	0.11 **	0.05 *
	(0.02)	(0.02)	(0.02)	(0.02)
N = 157				
Above Median Attendance				
Low SEI	0.00	-0.01	-0.01	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Farm	0.00	0.00	-0.01	-0.01
	(0.02)	(0.01)	(0.02)	(0.01)
High SEI	-0.01	-0.02 +	-0.02 +	-0.02 +
	(0.01)	(0.01)	(0.01)	(0.01)
N = 160				
All States				
Low SEI	0.07 **	0.04 **	0.06 **	0.03 *
	(0.02)	(0.01)	(0.02)	(0.01)
Farm	0.02	0.01	0.01	0.01
	(0.02)	(0.01)	(0.02)	(0.01)
High SEI	0.04 **	0.02 *	0.03 **	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
N = 317				

Standard errors in parentheses. ** $p<.01$; * $p<.05$; + $p<.10$

All models include state and year fixed effects, weighted by state school-age population in each SEI group.

Controls include: % manufacturing employment; % illiterate; % non-white prisoners; % incarcerated (raw and multiplied by years since 1850); % total in school.

Table 5: Estimated Effect of Compulsory Law on Occupational Distribution
Panel A: Men

	Upper Non-Manual	Lower Non-Manual	Skilled Manual	Non-Skilled Manual	Agriculture
Below Median Attendance					
Compulsory Law	0.01	0.01	0.01	0.00	-0.03
Compulsory Law + Controls	0.00	0.01	0.01	0.00	-0.02
N = 157					
Above Median Attendance					
Compulsory Law	0.00	0.00	0.01	0.02 **	-0.03 **
Compulsory Law + Controls	0.00	0.00	0.00	0.01 *	-0.02 *
N = 160					
All States					
Compulsory Law	0.01 *	0.01 *	0.02 **	0.02 **	-0.05 **
Compulsory Law + Controls	0.00	0.01 *	0.01 *	0.01 *	-0.03 **
N = 317					

Panel B: Women

|	Upper Non-Manual	Lower Non-Manual	Skilled Manual	Non-Skilled Manual	Agriculture
Below Median Attendance					
Compulsory Law	0.02	0.06 *	0.04 *	-0.01	-0.10 **
Compulsory Law + Controls	0.01	0.03	0.03	-0.02	-0.04 +
N = 142					
Above Median Attendance					
Compulsory Law	-0.01	0.01	0.02 *	0.01	-0.03
Compulsory Law + Controls	-0.01	0.00	0.02 *	0.01	-0.02
N = 144					
All States					
Compulsory Law	0.00	0.01	0.04 **	0.00	-0.05 **
Compulsory Law + Controls	0.00	-0.01	0.02 **	0.01	-0.02
N = 286					

** p<.01; * p<.05; + p<.10
All models include state and year fixed effects, weighted by total state population.
Controls include: % manufacturing employment; % illiterate; % non-white prisoners; % incarcerated (raw and multiplied by years since 1850).
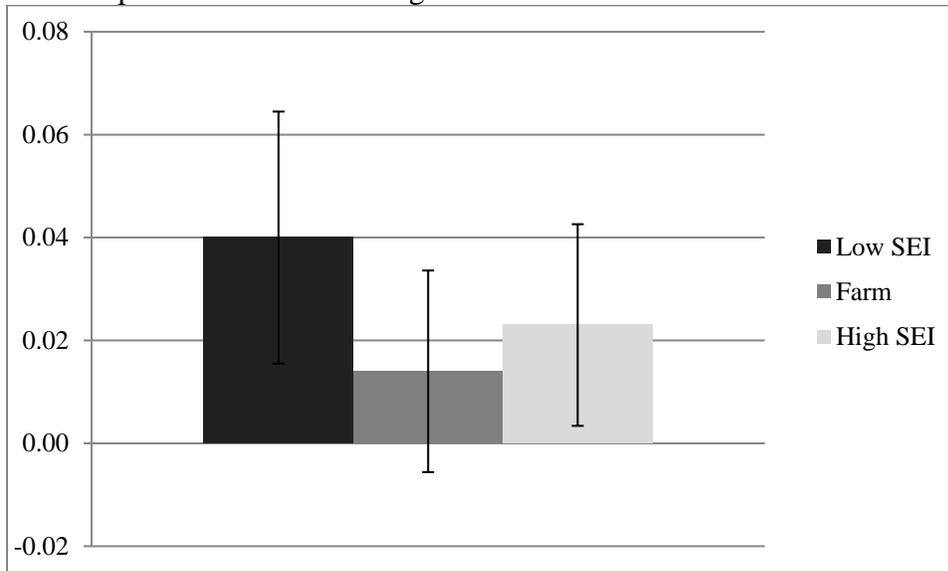
Figures

Figure 1: Mean State Attendance Rate of School Age White Men by Census from Compulsory Law
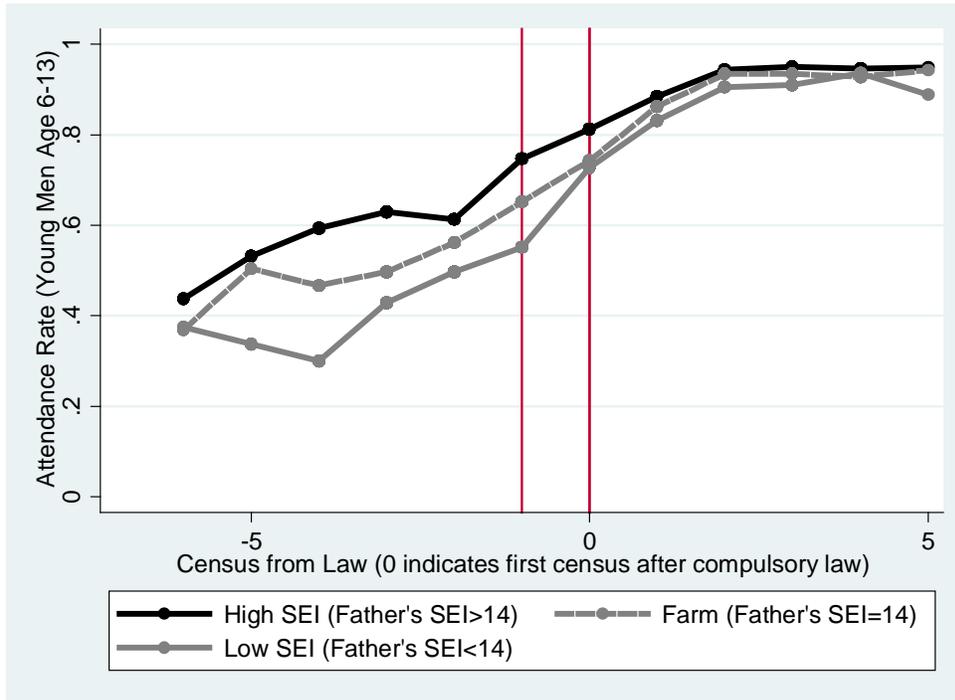
Source: IPUMS Individual Census Data 1850-1930.

Compulsory laws are related to educational expansion; the first census after the law shows greater equality in attendance by father's occupational status and a greater increase in attendance for youth from lower status backgrounds (father's SEI < 14).

Figure 2: Estimated Effect of Compulsory Schooling Law on State Attendance Rate by Occupational Status – Young Men in All States
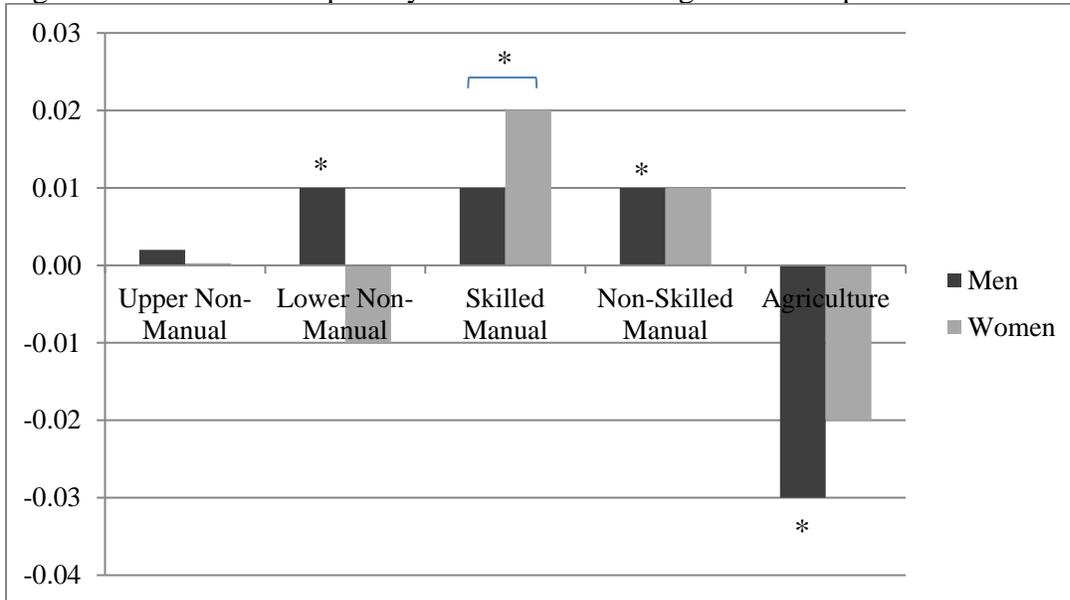

Based on models for all states in Table 5, including controls.

Figure 3: State Occupational Distribution by Gender and Compulsory Law Presence
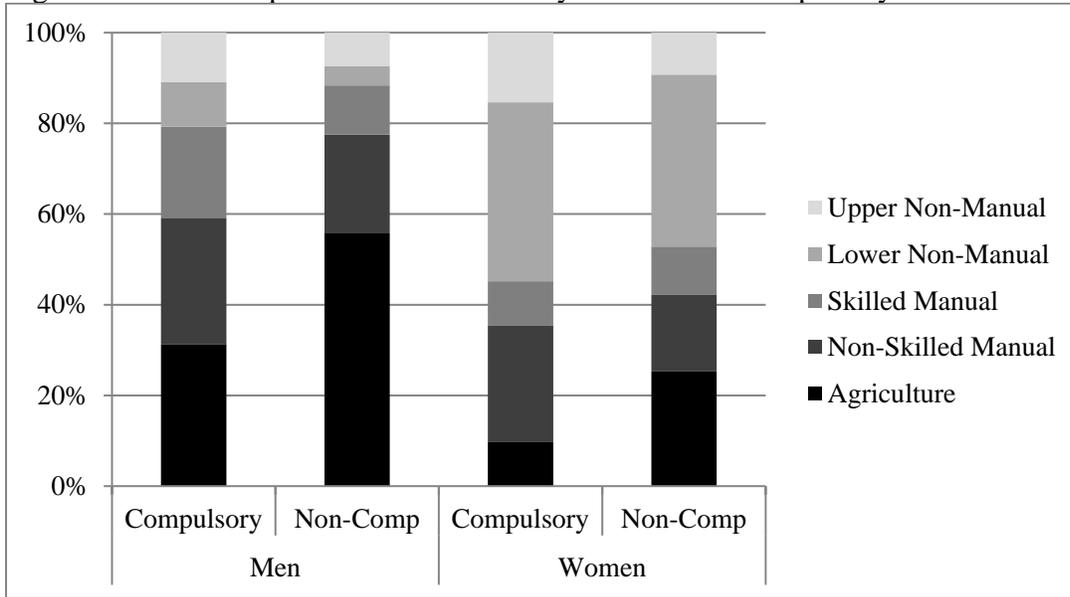
Mean proportion of state residents in each occupational category by gender. Compulsory includes states that have already passed a compulsory law. Non-compulsory includes states that have not.

Differences between compulsory and non-compulsory states are all statistically significant (p<0.05) with two exceptions: Women Lower Non-Manual and Women Skilled Manual.

Figure 4: Estimated Compulsory Law Effect on Categorical Occupational Distribution

Based on models including all states with controls in Table 5. * p<0.05

Endnotes

1. The year school attendance became compulsory in each state is shown in supplementary Table S1.

2. Supplementary analyses using continuous measures of the occupational distribution should also reveal that the laws increase state average occupational scores and their dispersion.

3. Supplementary analyses using continuous measures should also reveal that the laws reduce state average occupational scores.

4. The 1890 census was destroyed by fire, so state occupation measures and separate school attendance by father's occupation are unavailable that year. The analysis is conducted without 1890 measures, treating the 1880 to 1900 gap as other census gaps.

5. Alaska and Hawaii are not included because they did not become states until 1959. A few states do not have complete information in all years so there are fewer than 48 state observations in all years.

6. Although many states required attendance at age 14, I exclude youth age 14 from the school age category because they may have been close to turning 15 or grandfathered in and unaffected by compulsory laws.

7. Specifically, Morgan and Tang (2007:S10-S21) provide EGP categories for the 1980 and 1990 census occupation codes. The IPUMS Census data include 1950 census occupation codes. I convert 1950 to 1990 census codes using the 1950 census, which includes standardized occupation codes for both 1950 and 1990, and then categorize the 1990 census codes appropriately based on Morgan and Tang (2007).

8. Occupational information is unavailable for women in 1850, so the number of state-year observations is slightly smaller when predicting occupational distributions among women.

9. Many thanks to Behrens et al. (2003) for generously providing these incarceration measures.

10. Note in Table S1 that the timing of compulsory attendance laws did not follow regional boundaries, except for states in the South, which were slower to pass compulsory laws than the rest of the country.

11. Supplementary analyses (not shown) are also conducted separately among Northern and Southern states. In general, these results suggest compulsory schooling had more positive effects on state occupational distributions in the South than the North.

12. Results are similar when omitting weights.

13. Results of this supplementary analysis are consistent with both a short-term and a longer-term effect. These results further support the evidence that the compulsory laws shifted the

occupational distribution toward more skilled and higher status jobs. However, I only present estimates from the more conservative, short-term approach below.

14. State average latitude and longitude were downloaded from http://dev.maxmind.com/geoip/legacy/codes/state_latlon/.

15. Specifically, for models predicting men's labor force participation (both OLS and IV models), adding controls for state proportion adult men and proportion foreign born makes the Moran's I statistic for the residuals insignificant. For OLS and IV models predicting women's mean occupational income score and mean SEI score, controlling for state proportion adult men (and proportion foreign born for the OLS model predicting women's mean SEI score) makes the Moran's I statistic for the residuals insignificant.