Human Capital and the Managerial Revolution in the United States: Evidence from General Electric*

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Abstract

This paper estimates the returns to human capital accumulation during the first era of mega-firms in the United States by linking employees at General Electric—a canonical enterprise associated with the "visible hand" of managerial hierarchies—to the 1940 census. I find large returns to higher education through seniority in the hierarchy, span of control, earnings, and selection into management training, using the proximity of land-grant colleges and historical universities to birth states for identification. The findings highlight the human capital determinants of the managerial revolution at a prominent firm, driven by earlier public investments in the US education system.

Keywords: Returns to education, human capital, management practices, hierarchies

JEL Classifications: M10, M50, N62

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1 Introduction

The professionalization of management and expanding access to education were fundamental to the early development of the American economy. Managerial hierarchies enabled coordination and scale in complex business organizations (Chandler, 1977, 1994), while US leadership in the provision of education led to productivity advance through human capital accumulation (Goldin and Katz, 2008). Yet, these two changes have not been connected empirically, despite influential work on the importance of management practices (Bloom and Van Reenen, 2007; Bloom, Sadun and Van Reenen, 2010; Giorcelli, 2019) and human capital (e.g., Nelson and Phelps, 1966; Lucas, 1988; Barro, 2001; Gennaioli et al., 2013) to firm performance and economic growth.

This paper demonstrates that human capital accumulation through increased access to higher education played a key role in shaping the managerial revolution at a prominent firm—General Electric (GE)—during the early twentieth century. It links expanding access to education to the rise of professional managers as agents in the development of large-scale manufacturing. In doing so, it highlights an important channel through which public investments supporting affordable access to higher education determined the allocation of talent in a leading managerial hierarchy.

I use a new dataset linking personnel records at GE to the federal census in 1940 (Ruggles et al., 2021). Using corporate *Organization Directories* I observe unique data on the position of individuals in the hierarchy, their experience, their job responsibility, department and the frequency of attendance at GE management training camps. I use matching data from the 1940 census on an individual's age, wages, education and other socioeconomic measures, providing a window into the economics of management, firm organization, and the demand for skills.

GE was a leading entity in the first period of mega-firms (Lamoreaux, 2019). As one of the world's most profitable and influential enterprises, it is often studied because of its organizational structure (e.g., Rajan and Wulf, 2006; Brynjolfsson and Milgrom, 2013). Unlike the extensive conglomerate formed under the leadership of Jack Welch (1981-2001) or Jeff Immelt (2001-2017), in 1940 GE focused on manufacturing light bulbs, appliances like refrigerators, and equipment like X-ray machines. Similar to prominent high-tech firms such as Apple, Microsoft or Google today, in 1940 GE was the 4th largest firm in the US by market capitalization, employing 76,314 workers.

Using micro data for a canonical firm means I can go beyond the wage returns to human capital typically studied in the literature to gain a more complete sense of the private gains. I estimate the returns to education at four levels: within the hierarchy (C-suite and senior managerial positions relative to lower levels), through span of control; the wage return; and selection into management training. Managerial employees at GE were highly educated, completing a mean of 14.3 years of education. 62 percent had attained four or more years of a college education compared to 57 percent of engineers in the 1940 census (Edelstein, 2009), 11 percent for equivalently-aged managers officials and proprietors, and 5.0 percent for equivalently-aged male workers. Vocational training was also prevalent. Among those in senior managerial or executive positions, almost two-thirds had received GE management training. Although GE was an exceptional firm, and my estimates are conditional on entry into a managerial career, it is important to understand the returns to education among high performers, since skills in the upper tail of the distribution are vital for economic growth (Squicciarini and Voigtländer, 2015).

Any estimated effect of education on position in the hierarchy or earnings can be conflated with unobserved ability returns (Card, 2001). To estimate a causal effect, I exploit the institutional expansion of the US education system to generate quasi-random variation in college years. Specifically, I instrument for years of education and college attendance using two instruments: a continuous measure of the number of land-grant colleges in the census division around an individual's birth state (the range is 3 to 8) and a binary measure for the existence of historical universities founded before 1800 in that state. Whereas college education in the traditional states, like Massachusetts, had historically been shaped by the education of elite families, land grant colleges established under the Morrill Act in 1862 and its extension to southern states in 1890, created affordable higher education and the "democratization of learning," especially in scientific and technical areas (Klein, 1930). The intuition for the instruments relates to the use of proximity to colleges as a source of exogenous variation in educational attainment (e.g., Card, 1993; Kane and Rouse, 1995) and to research designs that utilize land grant colleges for identification (e.g., Moretti, 2004; Furman and

MacGarvie, 2007; Ehrlich, Cook and Yin, 2018; Andrews, 2020; Russell, Yu and Andrews, 2021).

The instruments move in opposite directions: an additional land grant college in the census division of an individual's birth state is associated with an additional 0.3 years of education and a 4 to 6 percent increase in the probability of a college education whereas being born in a state with historical universities is associated with 0.8 to 1.1 fewer years of education and a 14 to 20 percent lower probability of college attendance. In support of the assumption that individuals attended colleges in areas local to their birth states, census data show most unmarried white males lived at home between ages 15 and 29 (Gutmann, Pullum-Pinon and Pullum, 2002). Personnel records for a sample of GE employees show that most attended a college in a highly localized area around their birth state. I also find support for the monotonicity assumption that treatment must be a consistent function of the instruments based on estimates of the first-stage specification on sub-samples of employees (Mogstad, Torgovitsky and Walters, 2021; Słoczyński, 2022).

I begin by estimating the returns to education through rank in the managerial hierarchy. I use GE's 1940 *Organization Directory* to establish the level at which each individual was employed and estimate this as a function of educational attainment. An additional year of education increases the probability of being in the upper levels by 1.6 percent and a college education by 9 percent relative to the non-college educated. 2SLS estimates are 1.8 percent and 10 percent respectively. My estimates are robust to different modelling approaches, and in the spirit of Young (2022), to dropping major clusters of observations in the 2SLS specifications.

While job responsibility and position in the hierarchy can reflect administrative rules in promotion (Doeringer and Piore, 1985; Baker, Gibbs and Holmstrom, 1994*a*), abler managers should also be stratified in an organization according to theories of knowledge hierarchies (Garicano, 2000; Garicano and Rossi-Hansberg, 2006). I measure span of control as the average number of subordinates below a focal individual following the broad intuition for constructing these hierarchy-based measures in Fox (2009) and Ortín-Ángel and Salas-Fumás (2002). OLS results show an additional year of education is associated with an increase in span of control by 0.06 standard deviations whereas a college education is associated with a substantial 0.31 standard deviation increase. 2SLS estimates are about 1.2 to 1.3 times larger. These results connect the positional returns to education to additional job responsibility in the hierarchy.

Next I estimate wage regressions. The return to a year of education is 5.3 percent under OLS or 8.9 percent under 2SLS. For comparison, Feigenbaum and Tan (2020) use 1940 census data to estimate a population-based causal return to schooling of 4 percent in a sample of twins, Clay, Lingwall and Stephens (2021) use changes in compulsory schooling laws to identify a causal return of 7 to 8 percent in a sample of native-born white men from the 1940 census, and modern studies find returns to a year of education of about 10 percent (Deming, 2022). In my data, the largest returns to education are striking at the college-level with a college wage premium of 35 percent under OLS or 64 percent in 2SLS specifications. The college premium is even larger when adjusting for the top-coding of incomes in the 1940 census at $5,000 or about $100,000 today.

Finally, I estimate the causal relationship between education and selection into management training. Results again indicate a strong role for college attendance, suggesting an interaction between formal education and an upgrading of workplace capabilities. I then estimate specifications comparing the effects of education and training. Management training dominates over education in its relationship to position in the hierarchy but not in wage regressions where education premiums may be more reflective of the demand for skills. This finding highlights the significance of returns to formal education in this setting since the wage returns to corporate training tend to be much larger than the returns to additional years of schooling (e.g., Loewenstein and Spletzer, 1998).

Overall, I find large positional, job responsibility, and wage returns to education during the managerial revolution in the US using detailed micro data on a major firm that helped to define this era by changing the daily lives of consumers. These payoffs relied on exceptional prior public investments in education, especially as a consequence of the diffusion of science and technology instruction through the land grant colleges. Since education puts “capable workers at the helm” (Goldin and Katz, 2008), the findings link investments in human capital formation with talent stratification in the type of corporation that played a key role in long-run US economic growth.

Galambos (1975) refers to the emergence of large scale business organizations like GE as “the single most significant phenomenon in modern American history." While Pollard (1965) discusses hierarchy, coordination, span of control and the spread of management practices during the British industrial revolution, scale created additional demands on managerial tasks in the US. According to Chandler (1977), large firms like GE expressed efficiency through professional management whereas Lamoreaux (1995) cautions large firms could also pursue monopoly or control over scarce resources and restrict access to managerial expertise. My study contributes to this literature by focusing on the value of human capital at the micro-level and how managerial skill was organized hierarchically (see Appendix Section A, for further related literature).

Frydman (2019) shows that top executives in US firms in the 1930s and 1940s were highly educated, especially in science and technology, and connects this human capital advantage to managerial pay. I build on this work by observing human capital at multiple layers of the corporate hierarchy, through span of control and management training. The findings relate to new research showing the distinctiveness of US management over the long run. Notably, Bianchi and Giorcelli (2021) show how efforts to promote management training in firms during the Second World War led to persistent performance improvements in treatment firms. Managers who performed well in an education akin to an MBA as a result of wartime initiatives subsequently experienced faster career advancement than their lower performing counterparts (Giorcelli, 2023).

In the economics of organizations, hierarchies can be coordinating devices for the allocation of talent (Geanakoplos and Milgrom, 1991; Garicano, 2000; Garicano and Rossi-Hansberg, 2006). Despite the prominence of these theories, Gibbons (2020) argues that more research is still needed to understand "what visible hands do." Human capital and compensation data are rarely observed across multi-layered hierarchies, especially historically. The analysis contributes unique data and findings to the growing literature on micro-aspects of managerial communication and performance (e.g., Bandiera et al., 2020; Impink, Prat and Sadun, 2020) and the long-standing debate in personnel economics on how human capital impacts wage-setting and job seniority in firms (Altonji and Shakotko, 1987; Topel, 1991; Baker, Gibbs and Holmstrom, 1994*a*,*b*; Lazear and Shaw, 2007).

The findings also relate to the large literature on human capital, wage changes, and technological progress (e.g., Katz and Murphy, 1992; Juhn, Murphy and Pierce, 1993; Krueger, 1993; Autor, Levy and Murnane, 2003). To the extent that "management is a technology" (Bloom, Sadun and Van Reenen, 2016), the spread of mass production, the adoption of electricity in manufacturing and the emergence of R&D intensive forms of business organization during the early twentieth century would have affected the relative demand for managerial skill. The large returns to additional years of education that I find in a preeminent managerial hierarchy contributes to research highlighting the deep roots in the US of complementarities between technology and human capital accumulation (Goldin and Katz, 1998; Katz and Margo, 2014).

2 Data Sources

The analysis relies on two main data sources: personnel documents from GE and matching data from the 1940 federal census. I observe 1,893 white-collar employees at GE, 22 of whom are women. I match 1,347 (71 percent) of these individuals to the 1940 census.

2.1 Hierarchy, Span of Control and Departments

As one of the largest firms in the US, GE maintained comprehensive directories of its white-collar workers. These were internal publications for use by GE employees to facilitate communication between individuals in the organization. GE's 1940 annual report notes the firm was active in three main product areas: "Apparatus" "Appliance" and "Lamps". Each of these groupings had multiple divisions, with sales offices within those divisions being organized geographically. The 1940 *Organization Directory* lists a total of 6,815 employees many of whom worked in decentralized departments or affiliated companies. 1,893 worked in white-collar positions in Schenectady.

The 1,893 employees in my data are working in Schenectady as the headquarter location, but they will also have had responsibilities for coordinating divisional activities. Multidimensional (M-form) structures had started to diffuse at this time, and according to Chandler (1977) a distinctive feature was separation of high-level decision making from more routine management localized in the divisions. However, Freeland (1996) shows at General Motors—a prominent M-form firm—

that decision-making remained highly centralized through managers in corporate headquarters.

Hierarchical levels can be identified using the physical layout of the *Organization Directory*. C-suite executives are listed on the front-pages, then within each department the indent distance associated with each name defines the next level of the hierarchy. Employees are stratified by six levels with senior executives (above vice president) at the top of the hierarchy (Level 1), followed by vice presidents (Level 2) managers (Level 3) and lower-ranked employees (Levels 4 to 6).

Figure 1A compares the shape of the hierarchy at GE in 1930 and 1940, illustrating changes over time in who was included in the organization directories. In 1930 the hierarchy takes the typical pyramidal form, but the share of lower levels individuals reported in the directories falls by 1940. Interestingly, the number of senior and middle managers included in the directory in Level 3 and 4 increases that year. Although hierarchies tend to remain stable in shape as firms optimize by choosing a span of control of greater than one at each level (Baker, Gibbs and Holmstrom, 1994*b*; Ortín-Ángel and Salas-Fumás, 2002), this change lines up with Chandler's argument that managerial layers became more important in corporations. The structure of communications within organizations should reflect the channels needed for problem solving and effective decision-making (Simon, 1947; Arrow, 1974). In that sense, the changing levels across the 1930 and 1940 directories suggest shifting priorities around employee communication flows.

Levels in the hierarchy are defined independently of wages, but also closely correspond to thresholds in these data. Subject to the caveat that wages are top-coded, as discussed further below, Figure 1B shows significant level-jumps in annual compensation. A vice president, for example, earns 77.5 percent more than a Level 6 employee. For each change in level, an employee earns 12.8 percent more on average. Compensation increases are higher for upper level managers and executives (Levels 1, 2 and 3) relative to those lower in the hierarchy (Levels 4, 5 and 6), which is consistent with a skewed distribution of pay towards higher ranks (Rosen, 1986).

Span of control measures how relationships between managers and subordinates are defined and can be approximated using the structure of the hierarchy (Fox, 2009; Ortín-Ángel and Salas-Fumás, 2002). During the 1930s and 1940s, the relationship between span of control and administrative efficiency was debated by management and organizational theorists given the rising scale and complexity of business enterprise. Graicunas (1933) suggested that span of control should account for direct subordinate relationships, direct group relationships and cross-relationships. Urwick (1956), who built on Graicunas's ideas, advocated for a "restricted span of control" of no more than five or six subordinates to promote authority and responsibility in the organization, improve managerial effectiveness and reduce stress-loads faced by senior executives.

Using information in the *Organization Directory* to construct the corporate pyramid, I measure span of control in three ways: (a) using the number of subordinates in every layer in the firm below the focal layer (b) the number of subordinates in the next layer and (c) the number of subordinates in the next layer in the same department. The first measure captures direct and cross-department subordinate relationships. The second allows for cross-department communication but only at the level immediately below. An individual in the Executive Committee, for example, would communicate with the vice president of the R&D laboratory. The third assumes that the vice president of the R&D laboratory communicates with the manager below. That measure is closest to the modern definition of span of control as the number of *direct* subordinates being supervised.

I estimate span of control for individuals in Levels 1 to 6 of the hierarchy and test the robustness of the results to using only upper levels of the hierarchy given the censoring of directory observations below Level 4 shown in Figure 1A. Illustratively, let n_{L_d} be the number of individuals n in level L and department d of the hierarchy. An individual at Level 1 would then be assigned average spans of control using the following measures:

$$\overline{Span}^{a}_{\text{L1}} = \frac{n_{\text{L2}} + n_{\text{L3}} + \cdots + n_{\text{L6}}}{n_{\text{L1}}} \qquad \overline{Span}^{b}_{\text{L1}} = \frac{n_{\text{L2}}}{n_{\text{L1}}} \qquad \overline{Span}^{c}_{\text{L1}_d} = \frac{n_{\text{L2}_d}}{n_{\text{L1}_d}}$$

The first measure $Span^a$, includes in the calculation all subordinates across multiple levels of the hierarchy. For upper level managers and executives—the locus of decision making for the allocation of the firm's resources (Bandiera et al., 2012)—this produces a mean span of control of around 13. Measures $Span^b$ and $Span^c$, use the layer of the hierarchy immediately below, producing means of around four. A true measure of span of control, at least following the arguments in Graicunas (1933), would reflect an underlying composite of all three measures. I therefore use the standardized principal component of $Span^a$, $Span^b$ and $Span^c$ as an outcome variable in the empirical analysis. The first principal component explains 71.1 percent of the sample variance.

Finally, employees were organized into eight departments, shown in Figure A2 (e.g., Accounting, Engineering, Sales) so I can use department fixed effects to exploit variation within groups of employees. I also observe experience at GE by tracing individuals back to the 1930 *Organization Directory*. Thus, I can control for the returns to tenure at the firm.

2.2 Matching to the 1940 Census

Approaches linking individuals across censuses rely on name, age and location (place of birth) variables. Abramitzky et al. (2021) provide frontier methods for the implementation of matching while Bailey et al. (2020) argue that matching errors can be substantial when matching by hand or algorithmically. I link individuals in the 1940 *Organization Directory* to the 1940 federal census making particular use of the occupation string in the census data to generate accurate matches.

Census-to-census match rates are typically around 25 to 60 percent as the methods pioneered by Abramitzky et al. (2021) have evolved. I match 71.2 percent of individuals from the 1940 *Organization Directory* to the 1940 census, a high rate for three main reasons. First, Bailey et al. (2020) note that administrative records, like mine, tend to be of a higher quality so match rates should exceed census-to-census match rates where errors can occur in the matching variables of both census and reference years.[1] Second, I focus on a specific geographic area in the census— the Albany-Schenectady-Troy metro area—the location of GE's Schenectady-based activities. Most employees at this time lived in a highly localized area around their place of employment, so this restriction helps to narrow the pool of possible matches. Third, as the most pivotal step, I verify the match by matching the occupation in the directory to the occupation string in the census.

[1] Indeed, my match rate is a lower bound as the GE directory includes individuals in affiliated companies or decentralized departments, who may not have resided locally. Travelling sales managers may not have been at their homes at the time of enumeration. Census enumerators were asked to complete information about such individuals, but it is estimated that the 1940 census still under-enumerates by about 5 percent (King and Magnuson, 1995).

My matching process proceeded as follows. Due to spelling errors in the census I first used iterations of surname string similarity metrics, such as the Jaro-Winkler distance, to establish a set of possible matches. Within that set I then hand-matched to link the two datasets together. Distinct names could be easily matched such as *W. D. Coolidge*, director of the R&D laboratory at Schenectady in the GE directory who matches with *William D. Coolidge* from Schenectady in the census with an occupation string *"Engineer Rescharch Las" [sic]*. Naturally, more common names led to multiple matches. Using a Jaro-Winkler similarity threshold of 0.9 produced a mean of 13 matches per GE employee, with many more matches for common surnames: *D. A. Smith*, an auditor at GE in the accounting department, for example, had 65 potential matches.

To manually match, I used the individual's first name and, if available, their middle initial, in conjunction with their occupation description to compare against the job title in the 1940 directory, as illustrated in the previous Coolidge example. In another example, *R. C. Muir* a vice president at GE matches to Roy C. Muir from Schenectady with an occupation string in the census of *"Vice President" [sic]*, while J. D. Lockton an Assistant Treasurer at GE matches to *John D. Lockton*, also of Schenectady, with an occupation string of *"Asst Treasurer"*. As a final example, *W. L. Carson* at the general engineering laboratory at GE matches to *William L. Carson* from Colonie, Albany in the census with an occupation string *"Electrical Engineer-gen El Co" [sic]*.

Following Bailey et al. (2020), an important issue for inference is whether the unmatched have characteristics that differ systematically from the matched. One test is the match rate by hierarchical level. Figure A2A shows relatively uniform match rates by level from 65 to 74 percent. Figure A2B plots coefficients and confidence intervals for the probability of being matched, controlling for any mechanical matching by the length of an individual's surname, its commonness (defined by a count of equivalent surnames in the directory), or the number of initials in a name. An F-test fails to reject the joint null hypothesis of no difference in match rates by level in the regressions without controls (F=0.47, p=0.754) or with name diagnostic controls (F=0.48, p=0.747).

2.3 Education, Income and other Variables from the 1940 Census

During the 1940 census, individuals were asked the maximum full grade of school or college they had completed. If they had been educated outside the US the enumerator was instructed to enter the American school system equivalent, or otherwise the number of years of schooling they had received. Since the data are self-reported there is scope for measurement error. Goldin and Katz (2000) find a tendency among older individuals to conflate the number of years of school and the highest grade completed, biasing education levels upwards.

The maximum number of college years reported in the census is top-coded at "5+" so the range of years of schooling I observe spans from zero to 17 (4 individuals in the data reported no schooling at all in the census). Figure 2 shows the distribution of education years in the data with bunching around the completion of elementary school (1 to 8 years), high school (9 to 12 years) and college (13 years or more). Figure A3 shows a monotonically declining number of years of education by age, as would be expected given the expansion of the US education system over time.

Earnings are recorded in the 1940 census as the amount of money, wages or salary earned over the prior year. This variable is also top-coded with enumerators instructed to write "5,000+" for any individual reporting earnings in excess of $5,000. Earnings captures wage-work and excludes "business profits" or "fees from income." Goldfield (1958) concludes that the data should be reasonably accurate for wage-workers. Response rates were high with only some degree of salary-underreporting. Figure 3 shows plots of the wage series by age using an OLS regression and a Tobit specification to adjust for top-coding. Both series reflect the life-cycle profile in earnings.

Separately, the census records if an individual received above $50 from sources other than wage-work, including interest or dividends. In that regard, GE employees could participate in stock ownership, savings and investment plans (Moriguchi, 2005). About 34 percent reported receiving $\geq$ \$50 in such income, rising to 64 percent for those in upper levels (Levels 1 to 3).

The census also records the number of weeks an individual worked in 1939, and it provides a snapshot of their hours worked during the week of March 24-30, 1940. Most individuals in the data (88.4 percent) worked 52 weeks of the year. When estimating the wage returns to education, I use weekly wages defined as annual earnings divided by the number of weeks worked.

Two issues are of note when using the 1940 wage data. First, reluctance to reveal income may induce selection bias for higher-level workers given privacy norms around salary (Cullen and Perez-Truglia, 2018). Of the 1,347 individuals traced to the census, I observe wage information on 73.7 percent. Figure A4 shows 95 percent confidence intervals from a regression estimating the probability of wage data being observed by level and formal tests reject any statistically significant differences between the coefficients (F=1.04, p=0.387). While the point estimate is lower than the baseline (Level 6) for top executives in Level 1, consistent with heightened disclosure reservations for those who earned more, it is higher than the baseline for those in Level 2 occupations.

Second, while top-coding is a generic problem in administrative data, it is more pronounced in my setting with 15 percent of individuals reporting a top-coded salary. Using data from Piketty and Saez (2001), the actual top 5 and 1 percent income thresholds for earners in 1939 dollars are $3,033 and $5,389 respectively, so the top-coding threshold in my data is about the top 1 percent of earners. I adopt multiple approaches to address income censoring: I estimate the returns including and excluding top-coded values; I use Tobit regression specifications with an upper-censoring limit; and I impute values for top-coded observations in the hierarchy based on detailed executive compensation data from Frydman and Saks (2010).

Specifically, the Frydman and Saks data document compensation for top executives active in US corporations from 1936 to 1991. I calculate median compensation (remuneration plus bonus) for the 1939 cross section of 214 executives active in 67 firms to line up with the salary data in the 1940 census reflecting earnings in the year prior. I then assign top-coded values in my dataset the median value of $65,922. By comparison, the actual top 0.01 percent income threshold in 1939 in the Piketty and Saez data is $45,211. Furthermore, three top GE executives are included in the Frydman and Saks data starting in 1942: Clark H. Minor who earned $67,000 in annual salary plus bonuses, and Gerard Swope and Owen D. Young both of whom earned $66,000. GE's CEO, Philip D. Reed, earned $128,000 in 1945, the first year he is included in the data.[2] This imputation

[2]The actual top 0.01 percent income thresholds in 1942 and 1945 in the Piketty and Saez data are $61,759 and $43,666 respectively.

approach will provide an upper bound on the returns to education given that imputed values will reflect compensation for the highest paid executives in US corporations at this time.

I use further variables collected from the 1940 census as socioeconomic status and family background controls. I observe marital status and number of children (which may have constrained additional years of education), home ownership (as a proxy for intergenerational social status) and being an immigrant (as a control for potential wage differentials or other forms of discrimination). 7 percent of individuals were foreign-born; most were from the United Kingdom or Germany.

Finally, the data sources identify gender: 22 women were employed in Levels 4, 5 and 6 of the hierarchy, consistent with barriers to advancement in the workplace (Goldin, 2021). Star scientist Katharine B. Blodgett, for example, was awarded a Ph.D. in physics from Cambridge University in 1926, was 42 years of age in 1940, worked in GE's R&D laboratory as an expert in surface chemistry, and earned $3,502 in annual salary. Because women were not employed in upper levels of the hierarchy and the return to schooling tends to be greater for women than for men, I exclude these observations from the empirical analysis. Controlling for age, women had completed 1.6 fewer years of education than men; they earned 38 percent less at the same levels.

2.4 Management Training

Knowledge acquired through management training provides another channel through which human capital accumulation can affect position in the managerial hierarchy, job responsibility or earnings. Yet, it is rare to observe systematic data on training at the firm-level (e.g., Bartel, 1995; Hoffman and Burks, 2017). I exploit unique data through GE's operation of a training center on Lake Ontario—called Association Island—about 160 miles north west of Schenectady where managers and other employees from across all its US plants would be sent for vocational training, team-building and networking over 2 to 3 day events. Tents/cabins were used for housing; a fleet of boats transported participants to the island; and a plane delivered mail daily from Schenectady.

Employees at GE received both general and specific training. In the context of Acemoglu and Pischke (1998) general training made sense because turnover was low, and GE could capture the surplus on the human capital of its employees. Training can also amplify efficiency through vertical spillovers if lower level employees acquire skills that allow higher-level managers to focus on strategic decision making (Espinosa and Stanton, 2022). Each GE department had its own training camp, with "Camp General" bringing together employees from across the organization. At these events, typically held in the summer, presentations were given by company leaders on research, engineering, manufacturing, marketing and administration. Employees learned how to "more adequately understand and discharge their responsibilities to customers, to stockholders, and to each other" and they developed skills "for the development of principles, products and methods." Training by camps started around 1910 and lasted until 1956 when the center was closed.

I collected data on the incidence of management training using attendance lists at Camp General matched to individuals in the 1940 *Organization Directory*. Between 1927 and 1939 GE held 9 camps. Around 13 percent had been to one of these prestigious camps with 7 percent attending more than once. Because attendance was not randomly-assigned—more capable employees were more likely to receive vocational training as their careers advanced—these data cannot be used to identify the causal effects of training. Rather, I estimate both selection into training through years of education, and I approximate the average return to training relative to the return to education while controlling for tenure at GE, general labor market experience, personal background characteristics and position in the hierarchy.

2.5 Descriptive Statistics

Table 1 provides descriptive evidence on the main variables. By age, I observe careers at a snapshot in time with individuals being in their early 40s on average. Those who had reached upper levels of the hierarchy (12 percent of the data) were closer to 50 years of age. There are no substantive differences across the hierarchy in the share of immigrants or the rate of marriage, though senior managers and executives had slightly more children and were more likely to own a home. Though data on home values from the census is sparse, this was generally an affluent group with the average value of a home for someone in the upper levels being $21,595, almost five-times higher than the average of $4,473 for the Albany-Schenectady-Troy metro area.

Education levels were high compared to national averages with a mean of around 14 years of schooling. Moreover, formal education was deeply embedded into both upper and lower levels of the hierarchy. Few had no schooling at all. 70 percent had received some form of a college education with 11 percent having five or more years of college, compared to 1.5 percent of equivalently aged males in the Albany-Schenectady-Troy metro area. At GE's R&D lab the share with five or more years of a college education was 18 percent, signifying the growing reliance on scientists and engineers in an era where in-house R&D had diffused widely (Mowery and Rosenberg, 1991).

Individuals worked 51 weeks of the year on average and completed a 40 hour work-week. Wage compensation was naturally higher in upper levels relative to lower levels and non-wage income was also relatively more prevalent (64 versus 30 percent). Tenure at the firm was often long. 45 percent of the individuals in the data can be traced to the 1930 *Organization Directory* while 72 percent of upper level executives and managers had at least a decade of experience at GE. The span of control measures reflect the breadth of job responsibility in upper levels of the hierarchy. Management training was widespread in upper levels of the hierarchy with 62 percent of individuals attending a GE training camp at least once.

3 Empirics and Identification

I follow the general Mincer (1974) approach to estimating the returns to human capital with an extended set of outcome measures. Mincer modelled investments in education by agents seeking to maximize the present value of lifetime earnings, and I use this framework to capture the economic return to an additional year of education in the managerial hierarchy more broadly. Specifically, I run regressions at the individual-level,

$$\mathbf{y}_i = \beta_1 \mathbf{E}_i + \beta_2 \mathbf{E}_i^2 + \beta_3 \mathbf{E}_i^{GE} + \gamma \mathbf{Education}_i + \delta \mathbf{X}_i + \eta_d + \epsilon, \tag{1}$$

where $\mathbf{y}_i$ is one of the outcomes for individual i: an indicator for upper levels of the hierarchy, span of control, the log of weekly wages, and an indicator for management training.

Potential labor market experience $\mathbf{E}_i$ is included along with its squared value, being defined as (age – years of education – 7) to approximate labor market activity since leaving full-time education. I also measure *actual* experience at GE, $\mathbf{E}_i^{GE}$, using an indicator for individuals who could be traced to the 1930 *Organization Directory*. The background variables $\mathbf{X}_i$ are from the census (marital status, number of children, immigrant, home ownership) while η_d denotes department fixed effects (see Figure A1). The key parameter, γ, measures the private return to education.

There are at least three main issues associated with estimating this type of specification: measuring education, changing cohort effects, and causal identification of the private return.

3.1 Measuring Education

I use the number of years of education reported in the census and I also run specifications using an indicator variable coded 1 for college attendance and 0 otherwise. Additionally, I estimate the following version of equation 1 with a full set of dummy variables for 9 to 17 years of education relative to a non-school/elementary school baseline. This provides a check on functional form and tests for differential returns by level of education.

$$\mathbf{y}_i = \beta_1 \mathbf{E}_i + \beta_2 \mathbf{E}_i^2 + \beta_3 \mathbf{E}_i^{GE} + \theta_I \mathbf{Education}_i^{(9-17)} + \delta \mathbf{X}_i + \eta_d + \epsilon. \tag{2}$$

Because years of education is self-reported in the 1940 census, measurement error may be non-classical. Goldin (1998) notes how older adults tended to overstate their years of schooling at a time when the rest of the population was experiencing substantial gains in schooling years. Feigenbaum and Tan (2020) adopt a "milestone approach" to address this issue in their study of the returns to schooling based on the 1940 census, assuming that respondents recall reaching education milestones rather than the precise number of years. In my study, the results using an indicator for college attendance as a milestone should be most robust to measurement error biases.

3.2 Cohort Effects

Cohort effects will be important if expectations of the returns to education change substantially over time thereby affecting the decision to invest in additional schooling (Heckman, Lochner and

Todd, 2006). While Goldin and Katz (2008) find a pronounced general drop in the college education premium between 1915 and 1950 as the supply of college graduates outstripped demand, we do not know how the premium may have varied over time in a corporate setting. I construct four cohorts by birth quartile: those born 1857-1889, 1890-1899, 1900-1907 and 1908-1921. I then estimate both equation 1 and 2 to recover returns by cohort and report the results in the Appendix.

3.3 Land Grant Colleges and Historical Universities

My estimates of the returns to education are all conditional on securing employment at GE. If individuals with greater wage-earning potential and innate ability choose to acquire more schooling, the OLS returns to education will be biased upwards. Alternatively, if GE screened for workers based on education and ability, the less well-educated might be positively selected with higher ability than otherwise similar individuals randomly chosen from the population. Assuming wages equal productivity, the true effect of education is likely to be even larger than the one I estimate.

For identification, I estimate equation 1 using 2SLS with two instruments: the number of land grant colleges in the census division of an individual's birth state—allowing for localized movement across states to access education—and an indicator for historical universities in an individual's birth state.[3] The exclusion restriction requires that these instruments capture exogenous sources of variation in educational attainment and do not shift the outcome measures directly. These assumptions are motivated by the historical background and institutional context, described in the Appendix, Section A. Here, I sketch out the main arguments for identification.

Land grant colleges were first established under the 1862 Morrill Act which sought to "promote the liberal and practical education of the industrial classes." States were granted public land in proportion to their size, which could be sold to raise financing for the new colleges. The 1890 Morrill Act extended provisions to the southern states. Nevins (1962) notes the significance of the 1862 Act as the state of Illinois, for example, would have "waited many years" for the University of Illinois to be established, whereas "without the act the state of California might have been long

[3]Given the demographics of individuals in the dataset, I exclude historically black colleges and tribal colleges established under the land grant system.

delayed in developing its university to the point where, with eight different campuses, it is one of the wonders of the educational world." Prior to the Act, 21 state universities and colleges existed. More than 70 land-grant colleges and universities were founded as a consequence of the 1862 and 1890 legislation. Every state had at least one land grant college; some had as many as three.[4]

Moretti (2004) asserts that "the geographical location of land-grant colleges seems close to random" which he uses to identify city-level changes in the number of college graduates active in the labor market during the late twentieth century. In a study of the returns to education Ehrlich, Cook and Yin (2018) argue that "the [1862] Morrill Act was a largely exogenous policy change that exerted a pronounced effect on the growth of higher education in the United States." Although Andrews (2020) and Russell, Yu and Andrews (2021) find a link between the location of some of the land grant colleges and correlated determinants of education, in about 40 percent of cases Andrews notes, the placement of the institution was as good-as-random. Furman and MacGarvie (2007) use historical universities and the sale of land and scrip to finance land-grant colleges under the Morrill Act of 1862 as instruments in their work on the relationship between universities and the spread of industrial research during the early twentieth century.

In my setting, historical universities act as an exogenous determinant of high-cost elite education, while the land-grant instrument exploits lower access costs. Accordingly, the political advocacy group, the *Farmers' Alliance* noted: "The son of a rich man can go to Harvard, Yale, Columbia, or Princeton, and pay the $150 to $200 per year demanded by these institutions for tuition... but the boy from the poor man's home cannot do this... the free state university is his only hope" (Gelber, 2011). Because states could have land-grant colleges *and* traditional universities, individuals born in non-traditional states where land grant colleges were opened should be most responsive to the treatment. That subgroup accounts for 38 percent of the sample.

A threat to identification arises if unobservables are correlated with the instruments, which would violate the exclusion restriction. Carneiro and Heckman (2002) question the general va-

[4]Initial enrollments were high though financial inducements through room-and-board subsidies and scholarships were also offered at some of the colleges to maintain student numbers. For a later period—1931—Goldin and Katz (1999) find a one standard deviation reduction in tuition costs and fees at public universities is associated with about a 9 percent increase in enrollments.

lidity of schooling-distance-instruments on this basis. Parents who opt to have children in close proximity to a college may differ from those who choose to have children at a greater distance. Highly educated parents may move to states with high returns to education while parental networks may impact careers directly, not just through education as the exclusion restriction requires.

Each of these mechanisms tend to be less relevant in my setting. The land grant colleges were often located in more sparsely populated places (see Figure 4) which lessens the concern that these locations reflected auspicious nurturing environments where children would benefit from network formation later in life. Although these connections were beneficial for advancing careers in finance that heavily relied on networking, as demonstrated by Michelman, Price and Zimmerman (2021), formal technical knowledge would have held significance in a high-tech R&D-oriented firm like GE. Indeed, the land grant colleges were celebrated because of the direct link between the quality of science and technology instruction and career outcomes. As *The United States Office of Education* noted in its 1930 survey of the land grant colleges:

> The directors of the research laboratories of the General Electric Co., the Westinghouse Electric & Manufacturing Co., the General Motors organization and the American Telephone and Telegraph Co. hold degrees from land-grant engineering colleges [as do]... the presidents of the General Electric Co.... and many others of the leading manufacturing and public utility industries.

Figure 4 illustrates identifying variation in the data by mapping individuals by their birth state as well as the instruments: the land grant colleges by census division and states with historical universities. The largest share of individuals (38.7 percent) were born in GE's headquarter state of New York, which has one land grant college—Cornell University—inside the state and three in its census division. 12.6 percent were born in states where land grant colleges were established under the 1890 Morrill Act. Both instruments are set to zero for immigrants.

Finally, the instruments rely on the localization of higher-education relative to a birth state. Two pieces of evidence support this assumption. First, the median home-leaving age for white males between 1880 and 1940 was 22 to 24 years of age with 65 percent of unmarried white males living at home between ages 15 and 29, rising to about 85 percent by 1940 (Gutmann, Pullum-Pinon and Pullum, 2002). Second, although the 1940 census does not detail specific colleges attended, these data are available from personnel files at GE for a subset of employees. Herman C. Verwoert from the Central Engineering Department at GE, for example, was born in the state of California and attended UC Berkeley. Figure 5 plots the birth state against the home state for each individual showing a close correspondence between the two variables. 57 percent had attended a college in their birth state; 60 percent had attended a college in the census division of their birth state.

4 Results

In this section I present the main results for the outcome measures—position in the hierarchy, span of control, and earnings. I then estimate selection into management training as a function of education, before estimating the returns to management training relative to the returns to eduction.

4.1 Positional Returns in the Managerial Hierarchy

Table 2 Panel A reports linear probability estimates of equation 1 where the dependent variable is an indicator for individuals in upper levels of the hierarchy relative to those lower down. I provide estimates of the positional return to an additional year of education (columns 1 to 4) and to a college education relative to a non-college education (columns 5 to 8). I use specifications with experience controls, department fixed effects (see Figure A1) and background controls from the census. Panel B of Table 2 reports 2SLS estimates with the same covariates and fixed effects.

Column 1 Panel A shows that an additional year of education is associated with a 1.9 percent increase in the probability of being in the upper level of the hierarchy whereas column 2 implies a 1.7 percent increase in the probability when controlling for experience at GE. Column 3 adds department fixed effects and column 4 further adds background controls. The estimates are highly stable across these specifications. Columns 5 to 8 show the college-level estimates of the positional return are also stable with large magnitudes. Being college-educated increases the probability of being in the upper levels by 9 to 11 percent relative to the non-college educated.

Panel B shows 2SLS results. In the first-stage, each land grant college in the census division of an individual's birth state is associated with an additional 0.26 to 0.32 years of education (columns 1 to 4) and a 4 to 6 percent increase in the probability of a college education (columns 5 to 8), whereas being born in a traditional state with historical universities is associated with 0.8 to 1.1 fewer years of education and a 14 to 20 percent lower probability of college attendance. The Montiel-Pflueger F-statistics suggest relevance of the instruments for identification. Assuming at least one of the instruments is convincingly exogenous, the Hansen J test for overidentification fails to reject the null hypothesis that the models are correctly specified with both instruments.

For these estimates to represent local average treatment effects (LATEs) requires the effect of the instruments on years of education or college attendance to be constant across individuals. As an informal test of the monotonicity assumption, Table A1 reports first-stage coefficients for sub-samples of the data based on the specifications in columns 4 (for years of education) and column 8 (for college attendance) of Panel B Table 2. Under monotonicity, the sign of the first-stage coefficients on the instruments cannot become positive (negative) in any sub-sample if it was negative (positive) in the full sample.[5] For each sub-sample split by median age, labor market experience, or measures of socioeconomic characteristics, the coefficients retain the same sign as the coefficients in the full sample. Also, the sub-sample coefficients are almost always statistically significant from zero and of a similar size to the first-stage coefficients in the full sample.

Turning to the 2SLS estimates, in columns 1 to 4 an extra year of education increases the probability of being in the upper levels of the hierarchy by 1.8 to 2.4 percent whereas in columns 5 to 8 a college education increases the probability by 10 to 14 percent relative to the non-college educated, with confidence intervals that include zero in the most demanding specifications in columns 4 and 8. The 2SLS point estimates for years of education are between 13 and 31 percent larger than the corresponding OLS estimates, or between 12 and 34 percent larger for the college attendance indicator. Under a LATE interpretation these results are consistent with higher returns to schooling for a complier group experiencing more years of education due to the land grant system.

[5] This approach has been implemented in a number of empirical papers including, for example, Maestas, Mullen and Strand (2013), Dobbie, Goldin and Yang (2018), Autor et al. (2019) and Bhuller et al. (2020).

Table A2 reports robustness checks on the OLS and 2SLS results for years of education (Panel A) and college attendance (Panel B). All specifications use experience controls, department fixed effects and background controls. Using a probit specification (column 1) produces a positional return in the hierarchy to an additional year of education of 1.2 percent, compared to 1.6 percent in the linear probability model. The corresponding return to a college education is 7.4 percent compared to 10 percent in the linear probability case. Following Murphy and Welch (1990) column 2 uses a quartic term in years of labor market experience for estimation and the results are similar. Column 3 uses years of age instead of years of labor market experience, confirming the general tendency noted by Card (1999) that the age-returns will be lower than the experience-returns. Column 4 shows that the results are robust to dropping immigrants (7 percent of observations). Dropping outliers leads to lower returns in column 5, but this specification identifies off only 31 individuals in upper levels of the hierarchy compared to 148 in the regressions in Table 2.

Turning to the 2SLS robustness checks in columns 6 to 9, Young (2022) finds that instrumental variable estimates can be highly sensitive to dropping a few clusters of observations. I cannot drop the largest cluster of individuals born in the state of New York as this would reduce sample size in upper levels of the hierarchy, but when excluding individuals born in Pennsylvania and Massachusetts—the two largest birth state clusters outside of New York—columns 6 and 7 reveal larger positional returns in the managerial hierarchy compared to the estimates in Table 2. In these regressions the Montiel-Pflueger F-statistics indicate even stronger first stages. An additional year of education leads to a 2.2 percent increase in the probability of being in the upper level of the hierarchy whereas a college education increases the probability by around 13 percent.

While the results from Table A1 are consistent with the assumption of monotonicity, as an additional check I follow the suggestion in Słoczyński (2022) and use interactions between the instruments and covariates to estimate specifications closer to the original LATE estimation framework in Angrist and Imbens (1995). In column 8 of Table A2 I replicate the specifications in Table 2 column 4 (for years of education) and column 8 (for college attendance) but add interactions between both instruments and labor market experience as well as the socioeconomic characteristics from the census (being married, a homeowner and number of children). The point estimates on years of education and college attendance are slightly larger and more precisely estimated than the 2SLS estimates in Table 2 (2.4 percent versus 1.6 percent and 13 percent versus 10 percent respectively) with a cost that the instruments are somewhat weaker with a more saturated specification.[6]

Under weak instruments the 2SLS estimates will be biased towards OLS. Column 9 therefore re-estimates the same models using LIML and column 10 implements the UJIVE estimator of Kolesár (2013), which is the most consistent estimator in this context. Whereas LIML is robust only to the threat of weak instruments, the UJIVE estimator is robust to both weak instruments and treatment effect heterogeneity.[7] In column 9 the coefficients on years of education and college attendance are identical—or close—to the 2SLS estimates in column 8.[8] The UJIVE estimates are also similarly-sized, implying a 2.4 percent increase in the probability of being in the upper level of the hierarchy per additional year of education or a 14 percent increase for college attendance.

Finally, Figure 6 tests the assumption of linear returns to education while the Appendix (see Figure A5) reports results from estimating the rate of return to education by birth cohort. The return to education in the hierarchy increases reasonably uniformly by year with large effects in the college-year ranges. Figure A5A-B shows most of the positional return to education is being driven by educational differences among older individuals who were at the most advanced stage in the life cycle of their careers. Overall, the results are consistent with strong positional returns to human capital accumulation in the structure of the managerial hierarchy.

4.1.1 Span of Control

If education influences the capacity for decision making in organizations, positional returns to education should be reflected in span of control. While span of control is related to position in the hierarchy given the pyramidal structure of the organization, it provides additional information about the breadth of job responsibility across functional areas and within departments. I therefore

[6]The Montiel-Pflueger F-statistic in both specifications is around 17 but the 10 percent worst case bias threshold under 2SLS is 18 to 19.

[7]For the UJIVE estimator I use the Stata code written by Raymond Han in Abdulkadiroğlu et al. (2020).

[8]The Montiel-Pflueger F-statistics now clear the LIML 10 percent worst case bias thresholds, because the threshold values decline faster (compared to 2SLS) as the number of instruments increases (Olea and Pflueger, 2013).

repeat the analysis using span of control as an outcome (defined in Section 2.1).

Table 3 Panel A shows an additional year of education is associated with an increase in span of control of 0.06 to 0.07 standard deviations, which is a large effect across the range of years of education in the data. The coefficients are precisely estimated and stable across specifications with experience controls (columns 1 and 2) department fixed effects (column 3) and background controls (column 4). Similarly, the relationship is consistently estimated in columns 5 to 8 where a college education is associated with a higher span of control by 0.31 to 0.36 standard deviations.

Table A3 shows the OLS results are robust to using a quartic term in years of labor market experience (columns 1 and 5) and to dropping immigrants (columns 3 and 7). In accordance with the positional returns discussed above, the size of the coefficients is sensitive to using years of age instead of years of labor market experience as a control (columns 2 and 6) and to outliers (columns 4 and 8) given those in the upper levels are disproportionately dropped. Indeed, Table A4 shows the returns to education are larger for top managers and executives in the hierarchy (Levels 1 to 3), particularly at the college level, although including background controls in this smaller sample does weaken precision. Since span of control is a principal component measure, Table A5 shows consistent results when estimating the returns on each of the individual components: subordinates below the focal layer; in the next layer only; and in the next layer in the same department.

2SLS estimates in Table 3 Panel B have identical first stages to those shown in Table 2. The 2SLS estimates for years of education are larger than the OLS estimates in Panel A by between 17 and 38 percent for years of education or by 27 to 51 percent for college attendance, although four of the eight estimates are not statistically significant from zero. In the robustness checks in Table A3 the point estimates for both years of education and college attendance are all statistically significant at the 10 percent level or better with similar to slightly larger quantitative magnitudes.

Figure 7 shows OLS estimates by year of education with particularly strong effects in the upper tail of the distribution. Span of control increases by 0.5 standard deviations for those with five or more years of a college education (17 years of education in the data) relative to the baseline of 0-8 years of education. This effect is even larger for individuals in the oldest cohort where the relationship between education and span of control is strongest (see Figure A6). In sum, these results suggest an organizational link between human capital accumulation through educational attainment and greater breadth in job responsibility. This mechanism helps to explain large positional returns to human capital in upper levels of the managerial hierarchy.

4.2 Wage Returns to Education

I now turn to estimates using earnings as an outcome measure, which should reflect the labor market returns to education. OLS estimates in Panel A of Table 4 imply a return to a year of education of about 5 to 6 percent in the basic Mincer earnings model (column 1), when controlling for experience at GE (column 2), when adding department fixed effects (column 3) and when using background controls from the census (column 4). When adding fixed effects for hierarchical level in column 5 the estimate of the returns remains robust. Across columns 6 to 9 the wage-return to college years is substantial at between 30 and 34 log points or between 35 and 41 percent based on the exact percentage change ($\Delta\text{wages} = \exp(\hat{\gamma}) - 1$). The within-hierarchy-level estimate of the return to a college education relative to the non-college educated is 35 percent in column 10.

In the 2SLS regressions in Panel B of Table 4 the return to a year of education is 9 to 10 percent, whereas the return to a college education relative to a non-college education is 62 to 72 percent. The instrumented returns are therefore 50 to 68 percent larger than the corresponding OLS returns for years of education and 55 to 67 percent larger in the case of the college indicator. The assumption underlying the 2SLS estimates is that investment in land-grant colleges, especially outside of the traditional states, would have induced exogenous reductions in the cost of accessing higher education. These results imply the widening of college attendance yielded important earnings gains in the labor market. Both instruments perform well under the diagnostic test for weak instruments. The Montiel-Pflueger F-statistics exceed the 10 percent critical values in all specifications, exceeding the 5 percent critical value in the most demanding specifications with granular fixed effects (columns 4, 5, 9 and 10). Taken together, the 2SLS results imply human capital accumulation through educational attainment led to sizeable wage-differentials.

Robustness checks in Table A6 show that OLS returns to both a year of education (Panel A) and to a college education (Panel B) are quite stable in columns 1 to 4. The 2SLS estimates imply causal effects of education on wages of around 8 to 9 percent for a year of education or 65 to 69 percent for college attendance when dropping large clusters of observations of individuals born in Massachusetts and Pennsylvania in columns 5 and 6. Columns 7 and 8 produce similar 2SLS return estimates when using interactions between experience and socioeconomic characteristics as excluded instruments in the first stage. While the instruments are comparatively weaker in these specifications, the Montiel-Pflueger F-statistic exceeds the 10 percent critical value using the LIML estimator in column 8. In column 9 the UJIVE estimator leads to quite close point estimates, suggesting that an additional year of education caused labor market earnings to be 9.4 percent higher, or earnings to be 72 percent higher for the college educated.

Figure 8 plots OLS point estimates and 95 percent confidence intervals of the returns to education from equation 2. The impact of a college education on wage differentials is striking with a wage-return of around 49 percent over the baseline of 0-8 years of education for an individual with 16 years of education or 60 percent over the baseline for an individual with 17 years or more of education. That latter return is 2.8 times the return to education for an individual with 13 or 14 years of education. These results are consistent with substantial economic returns to human capital investment, especially in a context where the workforce was highly educated (see Table 1).

Finally, Figure A7A-B indicates that the returns to education are concentrated in the *younger* cohorts, contrary to the older-cohort effects estimated for the returns to education as a function of seniority in the hierarchy (see Figure A5) or span of control (see Figure A6). For the population as a whole, we know education premiums declined over time during the early twentieth century, driven by the large increase in the supply of educated workers (Goldin and Katz, 2008). These results show relatively higher wage-returns to younger, better-educated, workers in a managerial hierarchy, perhaps because of the economic value of specialized capabilities in science and technology areas tied to their educational knowledge.

4.2.1 Testing for Robustness to Top-Coding

Top-coding of wages in the 1940 census at annual incomes exceeding $5,000 could bias these results under the type of convex pay structure predicted in tournament models of top executive compensation (Rosen, 1986). Table 5 presents results from three approaches: dropping top-coded observations; using Tobit (censored) regressions; and replacing top-coded values with median executive compensation data from Frydman and Saks (2010), as described in Section 2.3.

In Panel A dropping the top-coded observations means estimating the returns to education for individuals in the data below senior executive positions, which is the main component of the dataset. The returns to a year of education range from 4.9 to 5.5 percent compared to 5.3 to 6.2 percent when the top-coded observations are included in Table 4. Hence, the results are similar in terms of magnitudes. Likewise, the returns to a college education relative to a non-college education are in the range of 33 to 36 percent, compared to 35 to 41 percent in Table 4. Results from the Tobit regressions in Panel B show a return to a year of education in the range of 6.2 to 7.3 percent, and to a college education of 41 to 49 percent, again close to the main OLS results.

In Panel C imputing top-coded compensation values using the median value for top executive pay in the US at this time ($65,922 annual, expressed as weekly wages in the regressions) shows larger estimated returns to a year of education of 15.1 to 16.7 percent, and to a college education of 116 to 138 percent. These estimates represent an upper limit on the returns due to the assumption that each individual in the GE hierarchy with top-coded earnings in the 1940 census would have earned at the median level for all US executives. Re-estimating these specifications by replacing top-coded values with the 25th percentile ($42,000 annual, expressed as weekly wages in the regressions) instead of the median leads to estimated returns to a year of education of 13.4 to 14.8 percent and to a college education of 99 to 117 percent. Based on the results in Panels A and B the baseline return estimates in Table 4 Panel A are not overly sensitive to top-coding, perhaps because within-firm inequality in executive pay was quite low during this era (Frydman, 2019). The results in Panel C imply the baseline estimates will reflect lower bounded returns.

4.3 Linking Education to Management Training

I now examine the relationship between selection into management training and education with a binary variable for attendance at management training camps as the outcome (see Section 2.4).

Table 6 Panel A reports results from linear probability models showing that human capital accumulation could be amplified by education through its impact on selection into management training. A year of education is associated with a 2.8 to 3.5 percent increase in the probability of management training (columns 1 to 4) or a 2.0 percent increase with fixed effects for hierarchical level (column 5). A college education is associated with a 14 to 18 percent increase (columns 5 to 9), falling to 9.5 percent in the within-level specification in column 10.

Table 6 Panel B estimates causal effects using the same 2SLS approach as in Table 2. The 2SLS coefficients on years of education and college attendance are consistently larger than the OLS coefficients in Panel A, which accords with all the results presented so far showing large effects of treatment for individuals exposed to more education through the land grant colleges. A causal interpretation of these estimates would rule out the confounding effect that higher ability workers choose to acquire more education and therefore were selected-in to management training.

Both the estimates in Panel A and Panel B of Table 6 are robust in Table A7 based on specifications with a full set of fixed effects. Using a Poisson regression to model counts of attendance at management training camps, instead of a binary indicator, shows that a year of education is associated with a 16.6 percent increase in the intensity of attendance (column 1) while a college education is associated with almost a doubling of the intensity relative to those who did not attend college. The OLS linear probability results are robust to different implementations of the experience controls (columns 2 and 3) and to dropping immigrants (column 4). Dropping outliers leads to smaller estimated effects because, as before, the extreme values are associated with individuals in upper levels of the hierarchy where the treatment effects of education were largest.

Robustness checks on the 2SLS results in columns 6 to 10 reveal slightly larger returns to education when dropping clusters of individuals born in Pennsylvania and Massachusetts (columns 6 and 7). Using interactions between covariates and the instruments leads to weaker first stages in columns 8 and 9, but overall in these specifications—as well as in column 10 which implements the UJIVE estimator—the impact of education on selection into management training is large. A year of education is associated with a 3.5 to 3.7 percent increase in the probability of receiving management training, whereas a college education is associated with a 19 to 23 percent increase.

Figure 9 illustrates an approximately linear relationship between years of education and the likelihood of management training over most of the range of values, with higher returns at extended years of college attendance. 17 or more years of education, for example, is associated with a 30 percent increase in the probability of management training relative to a baseline of no years of education or just elementary school. As shown in Figure A8, most of the estimated effect is being driven by the oldest cohort where position in the hierarchy as a function of age would have increased potential exposure to management training. These results imply strong career dynamics in management training over the life cycle.

4.3.1 The Joint Effect of Education and Training

As a final exercise, I assess the relative importance of education and management training as determinants of seniority in the managerial hierarchy and pay. Training might boost human capital by fostering skill acquisition in ways that can have a more immediate impact on productivity compared to education. Or, given seniority systems and administrative rules governing access to training, education may be a more powerful determinant of an individual's earnings. In theory at least, variation in wages should provide the most informative insight into employee productivity.

Table 7 shows results that are broadly consistent with the relative importance of education. Management training is associated with a 53 percent increase in the probability of being in the upper levels of the hierarchy, and controlling for years of education or college attendance the relationship between management training and position in the hierarchy remains robust (columns 2 and 3), while the coefficients on the education variables are small in size and statistically insignificant from zero. In the wage regressions, however, it is the coefficients on training that become smaller in size when controlling for the return to education. In column 6, for example, management training is associated with a 12.9 percent increase in wages whereas a college education is associated with a 33 percent increase. Although the gap in returns closes when accounting for censoring in the wage distribution (see column 9), firm-level training tends to be associated with much larger wage-returns in general (Loewenstein and Spletzer, 1998). The contrast in my setting suggests formal education imparted the type of productivity-enhancing skills that could lead to an increase in wages, especially in a context where highly educated R&D scientists commanded compensation premiums and firms had begun to introduce performance-based pay (Holden, 2005).

In sum, the results illustrate both the large magnitude of the wage-returns to education at GE and, importantly also, that the wage returns to education estimated in Table 4 are not being confounded by the returns to management training. Controlling for management training, the return to a year of education in Table 7 is 5.1 percent (column 5) to 5.9 percent (column 8) and the return to a college education is 33 percent (column 6) to 38 percent (column 9), close to the baseline estimates of the returns to education in Table 4, which do not condition on training.

5 Conclusion

Despite the importance of skilled managers to long-run economic growth (Bloom and Van Reenen, 2007; Bloom, Sadun and Van Reenen, 2010; Giorcelli, 2019), little is known about the acquisition of these skills at the individual-level during the managerial revolution in the US. While there is an active debate over the virtues of markets versus hierarchies (Chandler, 1977, 1994; Lamoreaux, Raff and Temin, 2003; Gibbons, 2020) we lack a micro-level understanding of how "visible hands" were actually organized, or the link between human capital and management practices at this time. Using new data on GE, a canonical mega-firm of the era, this paper has illustrated how returns to education shaped organizational structure. If firms faced learning costs and communication challenges as production expanded, it would have made sense to stratify management to exploit increasing returns through specialization by vertical layer (Garicano, 2000).

While detailed data on GE allows for insights in depth for a single firm, the main limitation is external validity. GE was like other large firms of the era in its focus on science and R&D, but it was also distinctive in the way it conducted personnel management (Moriguchi, 2005), which may have affected the returns to education. One way to test for generalizability, following the argument in List (2020), would be to proceed step-by-step using the available organization directories for other large firms like AT&T, DuPont and Ford. This would also improve our understanding of how managerial hierarchies became such a widespread phenomenon in the US during the early twentieth century. As I have shown, linking individuals with the aid of the occupation string from federal census data has the potential to yield high quality matches and to widen the field of historical personnel economics. Future work could also explore corporate directories in other countries to examine how distinctive US managerial hierarchies were in international comparative perspective and the extent to which there is any further link to supporting education institutions.

In the US, managerial hierarchies were a fundamental product of the educational environment. My instrumentation strategy using the presence of land grant colleges and historical universities local to an individual's birth area highlights how the formation of a preeminent managerial hierarchy was highly contingent on a national system of secondary and higher education created by the prior public investments during the nineteenth century documented by Goldin and Katz (2008). As Deming (2022) notes "We know that investment in education works and that skills matter for earnings, but we do not always know why." My results reveal large returns to higher education through position in the hierarchy, span of control, compensation and selection into management training. Access to educational opportunities may have created a pathway to long-run economic growth through the human capital accumulation and careers of professional managers who coordinated the allocation of resources in large firms. On the basis of evidence from GE, US leadership in education was foundational to the managerial revolution in manufacturing.

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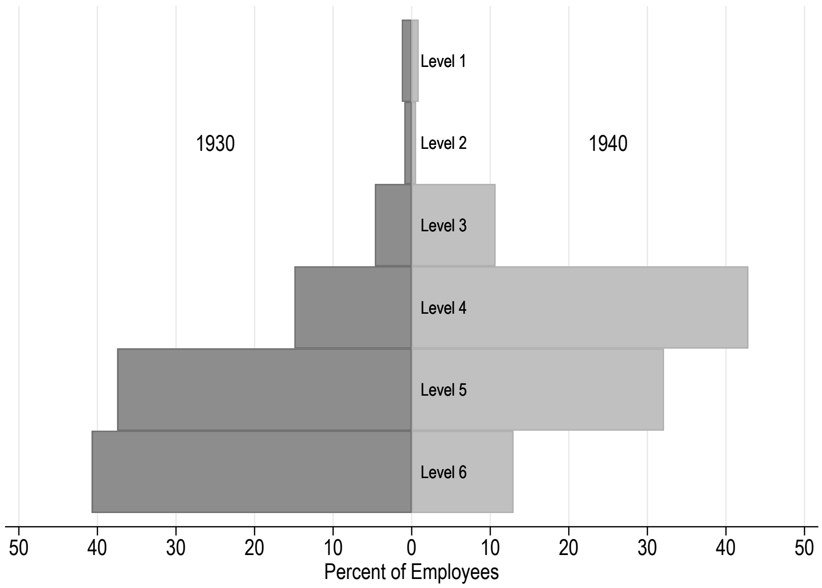
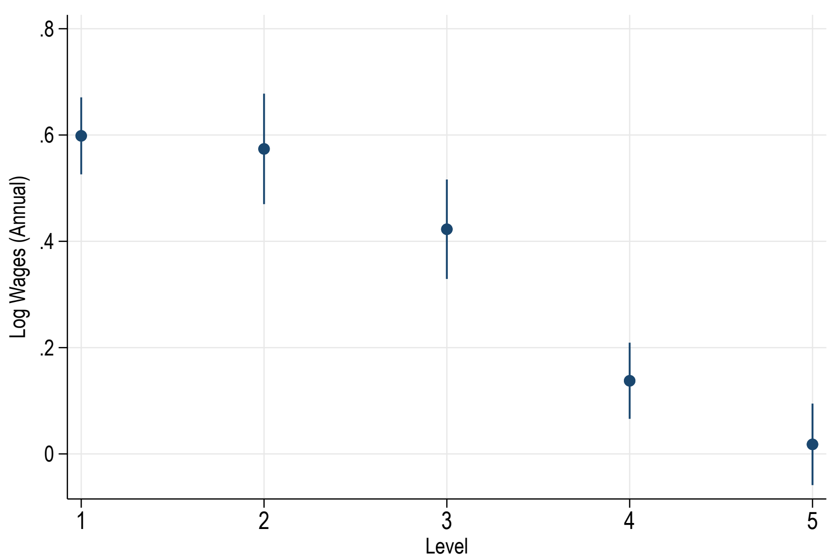
FIGURE 1: THE MANAGERIAL HIERARCHY AND COMPENSATION



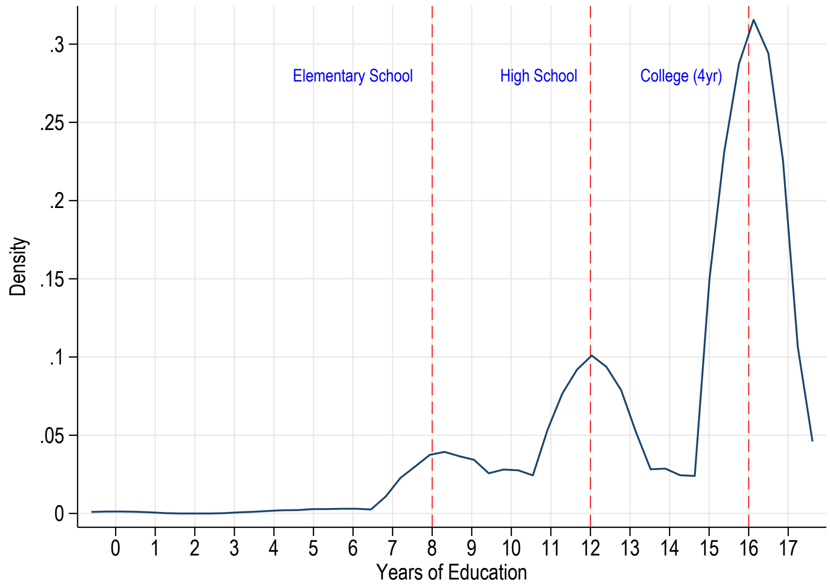
A: THE HIERARCHY 1930 AND 1940



B: WAGES IN THE HIERARCHY 1940

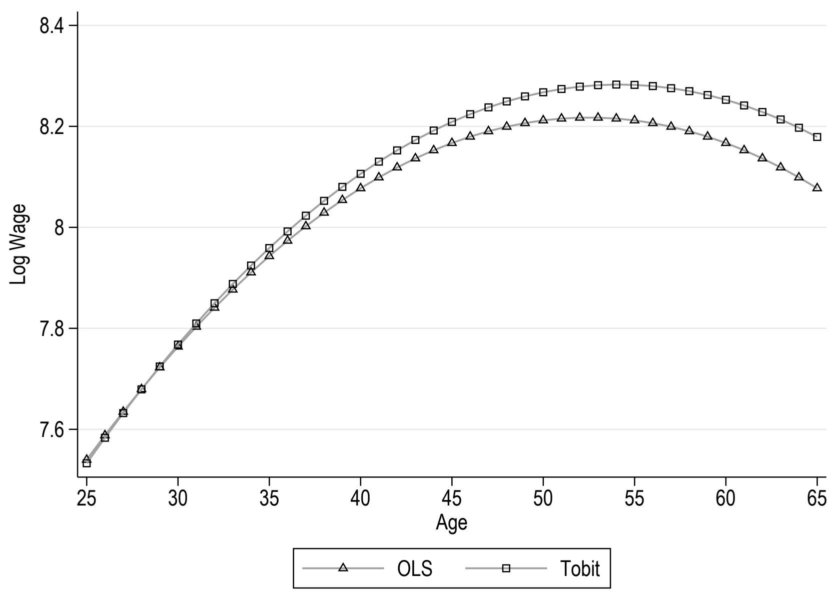
Notes: Figure 1A shows hierarchical levels with Levels 1, 2 and 3 being upper level positions and Levels 4, 5 and 6 being lower level positions. Figure 1B plots point estimates and 95 percent confidence intervals from an OLS regression of annual wages on indicators for levels in the hierarchy controlling for weeks and hours worked. The baseline is Level 6.

FIGURE 2: THE DISTRIBUTION OF EDUCATION



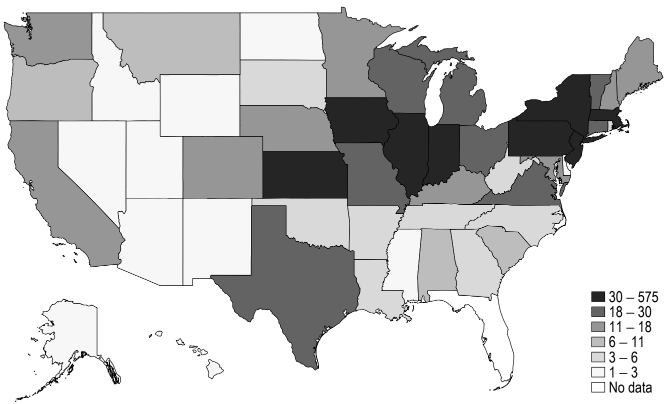
Notes: This figure shows the distribution of education by years for individuals in the dataset.

FIGURE 3: ANNUAL COMPENSATION OVER THE LIFE CYCLE

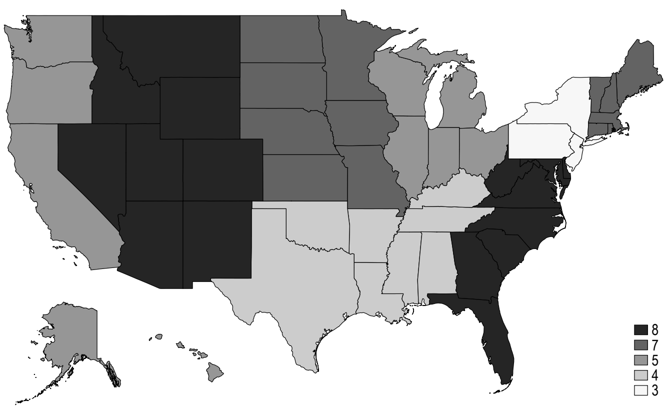


Notes: This figure shows point estimates from regressions of annual wages from the 1940 census using age and a quadratic in age as main covariates, controlling for women, immigrants and hours and weeks worked. Tobit estimates adjust for top-coding of census wages at $5,000.

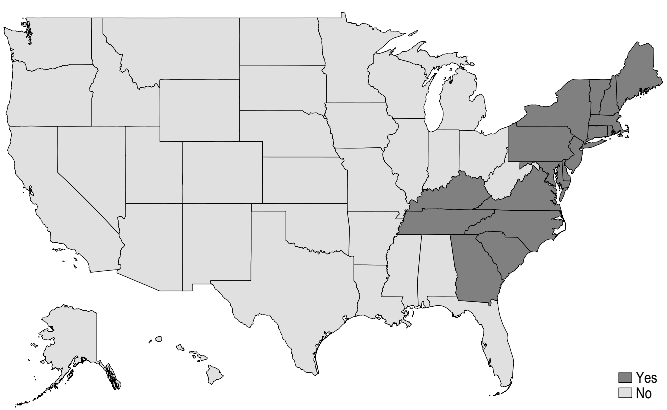
FIGURE 4: BIRTH STATES, LAND GRANT COLLEGES AND HISTORICAL UNIVERSITIES



A: INDIVIDUALS BY BIRTH STATES



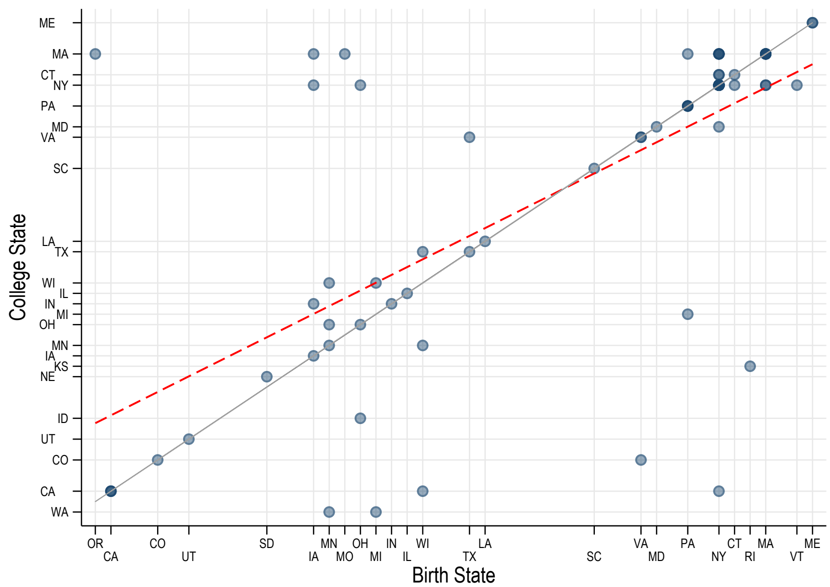
B: LAND GRANT COLLEGES



C: HISTORICAL UNIVERSITIES

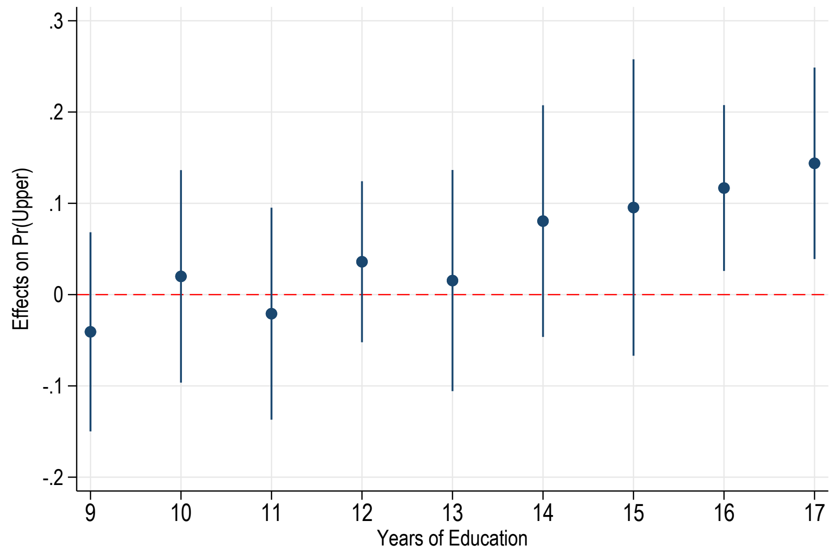
Notes: Figure A shows the geography of birth places for individuals in the dataset, Figure B the number of land grant colleges in each census division (excluding historically black colleges and tribal colleges) and Figure C whether a state has historical universities defined as those founded before 1800.

FIGURE 5: THE RELATIONSHIP BETWEEN BIRTH STATES AND COLLEGE STATES



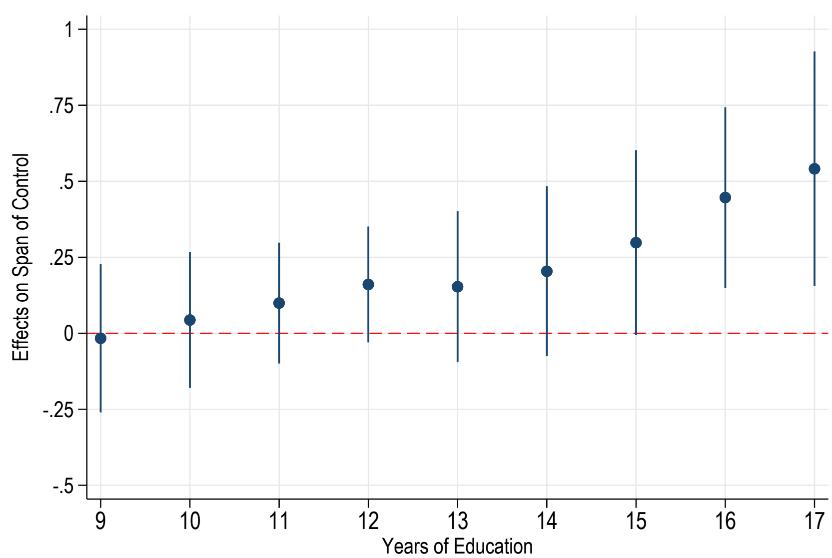
Notes: This figure shows the relationship between birth states and college states. The solid line is a 45 degree line and the dashed line is the line of best fit. The states are organized on each axis to reflect their geographic proximity to each other. Shading reflects the concentration of observations.

FIGURE 6: POSITION IN THE HIERARCHY BY YEARS OF EDUCATION



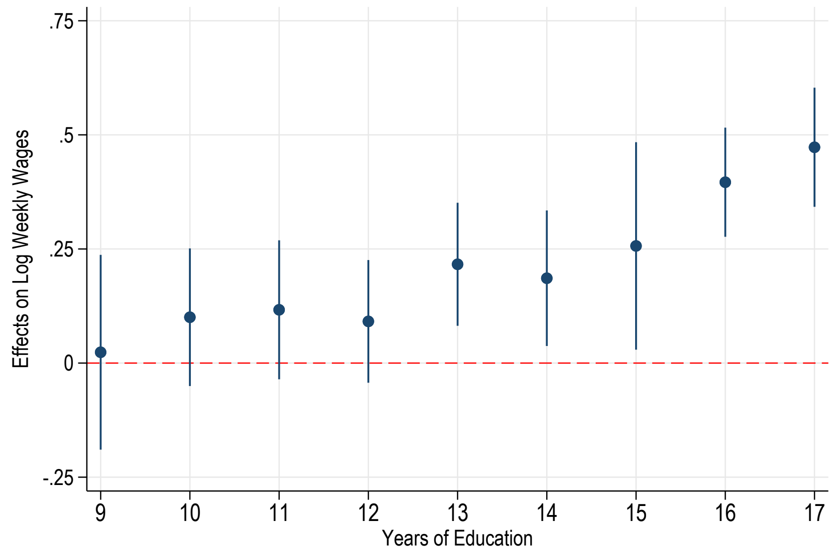
Notes: This figure shows point estimates and 95 percent confidence intervals from estimates of equation 2 where the dependent variable is coded 1 for upper levels and 0 for lower levels. The baseline is 0-8 years of education. Specification includes experience controls, a GE experience control, department fixed effects and background controls (number of children, marital status, being an immigrant, home ownership).

FIGURE 7: SPAN OF CONTROL BY YEARS OF EDUCATION



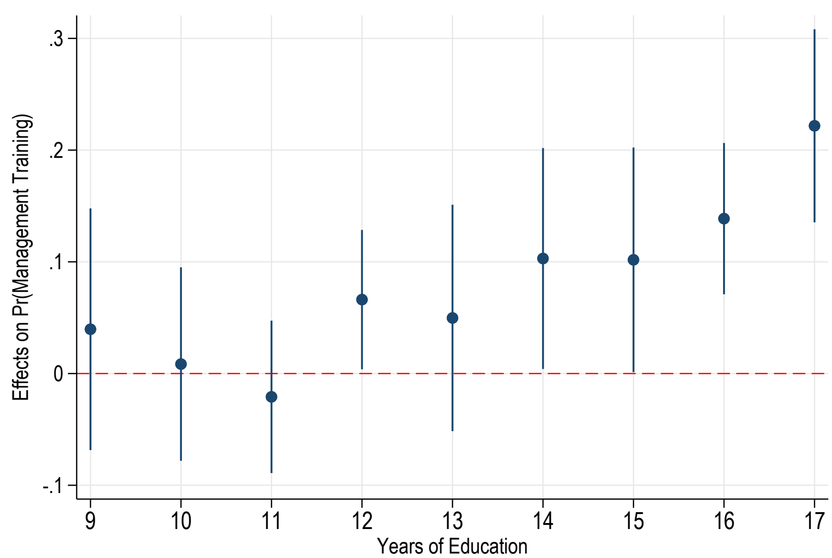
Notes: This figure shows points estimates and 95 percent confidence intervals from estimates of equation 2 where the dependent variable is the standardized value of the first principal component of the span of control measures described in Section 2.1. The baseline is 0-8 years. Specification includes experience controls, a GE experience control, department fixed effects and background controls (number of children, marital status, being an immigrant, home ownership).

FIGURE 8: COMPENSATION BY YEARS OF EDUCATION



Notes: This figure shows points estimates and 95 percent confidence intervals from estimates of equation 2 where the dependent variable is the log of weekly wages. The baseline is 0-8 years. Specification includes experience controls, a GE experience control, department fixed effects, background controls (number of children, marital status, being an immigrant, home ownership) and hierarchical level fixed effects.

FIGURE 9: MANAGEMENT TRAINING BY YEARS OF EDUCATION



Notes: This figure shows points estimates and 95 percent confidence intervals from estimates of equation 2 where the dependent variable is coded 1 for attendance at management training camps and 0 otherwise. The baseline is 0-8 years. Specification includes experience controls, a GE experience control, department fixed effects, background controls (number of children, marital status, being an immigrant, home ownership) and hierarchical level fixed effects.

TABLE 1: DESCRIPTIVE STATISTICS

	All	Upper	Lower
Personal Characteristics:			
Age	42.22	49.74	41.23
Married = 1	0.64	0.65	0.63
Number of Children	1.06	1.22	1.04
Immigrant = 1	0.07	0.07	0.07
Homeowner = 1	0.63	0.71	0.62
Education:			
No Schooling = 1	0.00	0.01	0.00
Elementary School = 1	0.01	0.01	0.01
Middle School = 1	0.11	0.12	0.11
High School = 1	0.18	0.14	0.18
College = 1	0.70	0.73	0.69
College (4+ years) = 1	0.62	0.66	0.62
Years of Education	14.26	14.34	14.25
Years of Education if College = 1	15.92	15.97	15.91
Managerial Hierarchy:			
Upper = 1	0.12	1.00	0.00
Span of Control (overall)	2.07	13.43	0.49
Span of Control (next level)	1.00	4.47	0.51
Span of Control (next level same department)	0.97	4.21	0.51
Compensation:			
Weeks Worked	51.43	51.57	51.41
Hours Worked	40.34	40.23	40.35
Annual Wage	3250.51	4374.15	3112.47
Weekly Wage	62.75	84.38	60.09
Non-wage Income = 1	0.34	0.64	0.30
Experience:			
Management Training = 1	0.13	0.62	0.06
Management Training (frequency)	0.33	2.04	0.09
Employed GE in 1930 = 1	0.45	0.72	0.41

Notes: This table reports descriptive statistics on the main variables. Upper levels of the hierarchy are Level 1, 2 and 3 in the organizational structure whereas lower levels are Level 4, 5 and 6. Span of control is described in Section 2.1 as the average number of subordinates in all levels below in the hierarchy, in the next level below, and in the next level below in the same department.

TABLE 2: RETURNS TO EDUCATION: POSITION IN THE HIERARCHY

	1	2	3	4	5	6	7	8
	Panel A: OLS							
Years of Education	0.019***	0.017***	0.016***	0.016***				
	(0.004)	(0.004)	(0.004)	(0.004)				
College					0.107***	0.092***	0.090***	0.089***
					(0.023)	(0.023)	(0.023)	(0.023)
R^2	0.069	0.077	0.087	0.089	0.067	0.075	0.086	0.087
	Panel B: 2SLS							
Years of Education	0.024**	0.021**	0.021**	0.018				
	(0.010)	(0.011)	(0.010)	(0.011)				
College					0.141**	0.123**	0.121**	0.100
					(0.060)	(0.061)	(0.060)	(0.061)
First Stage Coefficients:								
Land Grant College	0.296***	0.265***	0.260***	0.320***	0.049***	0.044***	0.044***	0.057***
	(0.054)	(0.053)	(0.052)	(0.063)	(0.010)	(0.010)	(0.010)	(0.013)
University <1800	-1.065***	-1.079***	-1.090***	-0.791***	-0.194***	-0.197***	-0.198***	-0.135***
	(0.284)	(0.290)	(0.283)	(0.187)	(0.056)	(0.057)	(0.057)	(0.035)
Montiel-Pflueger F	22.0	19.5	20.0	29.6	17.3	15.2	15.3	23.0
p-value (Hansen J)	0.906	0.696	0.495	0.346	0.982	0.755	0.543	0.336
Observations	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293
Mean of Dep. Var.	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	Y	Y	Y	Y
Department FE	N	N	Y	Y	N	N	Y	Y
Background Controls	N	N	N	Y	N	N	N	Y

Notes: This table reports results from linear probability models where the dependent variable is an indicator coded 1 for upper levels of the hierarchy (Levels 1, 2 and 3) and 0 for lower levels (Levels 4, 5 and 6). "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in the 2SLS specifications are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. Robust standard errors in parentheses. In the 2SLS specifications the standard errors are clustered by birth state. *p<0.1, **p<0.05, ***p<0.01.

TABLE 3: RETURNS TO EDUCATION: SPAN OF CONTROL

	1	2	3	4	5	6	7	8
	Panel A: OLS							
Years of Education	0.067***	0.062***	0.058***	0.060***				
	(0.016)	(0.016)	(0.016)	(0.017)				
College					0.355***	0.326***	0.307***	0.308***
					(0.082)	(0.083)	(0.083)	(0.088)
R^2	0.070	0.072	0.091	0.094	0.065	0.067	0.088	0.090
	Panel B: 2SLS							
Years of Education	0.084*	0.079	0.080*	0.070				
	(0.046)	(0.048)	(0.048)	(0.045)				
College					0.488*	0.457	0.465*	0.392
					(0.275)	(0.286)	(0.280)	(0.253)
First Stage Coefficients:								
Land Grant College	0.296***	0.265***	0.260***	0.320***	0.049***	0.044***	0.044***	0.057***
	(0.054)	(0.053)	(0.052)	(0.063)	(0.010)	(0.010)	(0.010)	(0.013)
University <1800	-1.065***	-1.079***	-1.090***	-0.791***	-0.194***	-0.197***	-0.198***	-0.135***
	(0.284)	(0.290)	(0.283)	(0.187)	(0.056)	(0.057)	(0.057)	(0.035)
Montiel-Pflueger F	22.0	19.5	20.0	29.6	17.3	15.2	15.3	23.0
p-value (Hansen J)	0.944	0.953	0.621	0.338	0.863	0.975	0.682	0.336
Observations	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293
Mean of Dep. Var.	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	Y	Y	Y	Y
Department FE	N	N	Y	Y	N	N	Y	Y
Background Controls	N	N	N	Y	N	N	N	Y

Notes: This table reports results from models where the dependent variable is the standardized principal component of span of control described in Section 2.1. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in the 2SLS specifications are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. Robust standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Table 4: Returns to Education: Compensation

	1	2	3	4	5	6	7	8	9	10
					Panel A: OLS					
Years of Education	0.062***	0.061***	0.060***	0.056***	0.053***					
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)					
College						0.344***	0.340***	0.335***	0.309***	0.298***
						(0.027)	(0.028)	(0.028)	(0.027)	(0.028)
R^2	0.367	0.367	0.386	0.406	0.430	0.353	0.353	0.376	0.395	0.423
					Panel B: 2SLS					
Years of Education	0.093***	0.095***	0.096***	0.086***	0.089***					
	(0.011)	(0.013)	(0.012)	(0.011)	(0.011)					
College						0.532***	0.535***	0.540***	0.480***	0.497***
						(0.050)	(0.059)	(0.051)	(0.057)	(0.054)
First Stage Coefficients:										
Land Grant College	0.306***	0.268***	0.264***	0.332***	0.316***	0.051***	0.045***	0.044***	0.061***	0.058***
	(0.059)	(0.058)	(0.057)	(0.057)	(0.055)	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)
University <1800	-1.163***	-1.186***	-1.186***	-0.818***	-0.769***	-0.217***	-0.221***	-0.220***	-0.138***	-0.132***
	(0.285)	(0.292)	(0.285)	(0.174)	(0.169)	(0.056)	(0.059)	(0.059)	(0.034)	(0.032)
Montiel-Pflueger F	23.3	20.4	20.8	40.0	38.9	18.5	16.5	16.1	29.4	30.3
p-value (Hansen J)	0.999	0.849	0.944	0.323	0.389	0.666	0.601	0.781	0.315	0.415
Observations	956	956	956	956	956	956	956	956	956	956
Mean of Dep. Var.	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	N	N	Y	Y	Y	N	N	Y	Y	Y
Background Controls	N	N	N	Y	Y	N	N	N	Y	Y
Hierarchical Level FE	N	N	N	N	Y	N	N	N	N	Y

Notes: This table reports results from models where the dependent variable is the log of weekly wages. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in the 2SLS specifications are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. Robust standard errors in parentheses. In the 2SLS specifications the standard errors are clustered by birth state. *p<0.1, **p<0.05, ***p<0.01.

TABLE 5: RETURNS TO EDUCATION: COMPENSATION (TOP-CODING)

	1	2	3	4	5	6	7	8	9	10
	Panel A: Dropping Top-Coded Observations									
Years of Education	0.054***	0.055***	0.054***	0.049***	0.050***					
	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)					
College						0.302***	0.303***	0.305***	0.276***	0.284***
						(0.028)	(0.029)	(0.029)	(0.028)	(0.029)
R^2	0.296	0.297	0.309	0.330	0.335	0.291	0.291	0.305	0.327	0.332
Mean of Dep. Var.	3.977	3.977	3.977	3.977	3.977	3.977	3.977	3.977	3.977	3.977
Observations	814	814	814	814	814	814	814	814	814	814
	Panel B: Tobit									
Years of Education	0.073***	0.072***	0.071***	0.066***	0.062***					
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)					
College						0.401***	0.393***	0.387***	0.360***	0.341***
						(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
Mean of Dep. Var.	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065	4.065
Right-Censored Obs.	142	142	142	142	142	142	142	142	142	142
Observations	956	956	956	956	956	956	956	956	956	956
	Panel C: Imputing Top-Coded Observations									
Years of Education	0.167**	0.161***	0.152***	0.151***						
	(0.034)	(0.033)	(0.028)	(0.029)						
College						0.867***	0.824***	0.789***	0.770***	
						(0.164)	(0.157)	(0.120)	(0.124)	
R^2	0.265	0.268	0.315	0.319		0.238	0.243	0.295	0.298	
Mean of Dep. Var.	4.448	4.448	4.448	4.448		4.448	4.448	4.448	4.448	
Observations	956	956	956	956		956	956	956	956	
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	N	N	Y	Y	Y	N	N	Y	Y	Y
Background Controls	N	N	N	Y	Y	N	N	N	Y	Y
Hierarchical Level FE	N	N	N	N	Y	N	N	N	N	Y

Notes: This table reports results from models where the dependent variable is the log of weekly wages. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. In Panel C top coded observations are replaced with the median value of (weekly) executive pay for all US executives active at the same time as described in Section 2.3. In Panel C standard errors are bootstrapped with 1000 replications and clustered by hierarchical level. *p<0.1, **p<0.05, ***p<0.01.

TABLE 6: SELECTION INTO MANAGEMENT TRAINING

	1	2	3	4	5	6	7	8	9	10
					Panel A: OLS					
Years of Education	0.035***	0.030***	0.028***	0.029***	0.020***					
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)					
College						0.181***	0.153***	0.144***	0.146***	0.095***
						(0.022)	(0.022)	(0.022)	(0.023)	(0.019)
R^2	0.122	0.144	0.177	0.182	0.421	0.108	0.132	0.168	0.172	0.415
					Panel B: 2SLS					
Years of Education	0.051***	0.046***	0.045***	0.043***	0.036***					
	(0.010)	(0.010)	(0.010)	(0.008)	(0.009)					
College						0.296***	0.266***	0.261***	0.243***	0.205***
						(0.070)	(0.066)	(0.064)	(0.052)	(0.055)
First Stage Coefficients:										
Land Grant College	0.296***	0.265***	0.260***	0.320***	0.309***	0.049***	0.044***	0.044***	0.057***	0.055***
	(0.054)	(0.053)	(0.052)	(0.063)	(0.060)	(0.010)	(0.010)	(0.010)	(0.013)	(0.012)
University <1800	-1.065***	-1.079***	-1.090***	-0.791***	-0.760***	-0.194***	-0.197***	-0.198***	-0.135***	-0.130***
	(0.284)	(0.290)	(0.283)	(0.187)	(0.177)	(0.056)	(0.057)	(0.057)	(0.035)	(0.032)
Montiel-Pflueger F	22.0	19.5	20.0	29.6	30.7	17.3	15.2	15.3	23.0	24.5
p-value (Hansen J)	0.829	0.843	0.537	0.159	0.214	0.706	0.973	0.654	0.155	0.219
Observations	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293
Mean of Dep. Var.	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	N	N	Y	Y	Y	N	N	Y	Y	Y
Background Controls	N	N	N	Y	Y	N	N	N	Y	Y
Hierarchical Level FE	N	N	N	N	Y	N	N	N	N	Y

Notes: This table reports results from models where the dependent variable is a binary indicator for attendance at management training camps. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in the 2SLS specifications are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. Robust standard errors in parentheses. In the 2SLS specifications the standard errors are clustered by birth state. *p<0.1, **p<0.05, ***p<0.01.

TABLE 7: RETURNS TO EDUCATION AND MANAGEMENT TRAINING

	1	2	3	4	5	6	7	8	9
		Upper			Wages			Wages (Tobit)	
Training	0.533***	0.532***	0.531***	0.184***	0.108***	0.121***	0.374***	0.288***	0.300***
	(0.040)	(0.041)	(0.040)	(0.040)	(0.036)	(0.037)	(0.068)	(0.062)	(0.064)
Years of Education		0.001			0.051***			0.059***	
		(0.004)			(0.005)			(0.006)	
College			0.011			0.287***			0.321***
			(0.019)			(0.028)			(0.032)
R^2	0.339	0.339	0.339	0.353	0.435	0.428			
Observations	1,293	1,293	1,293	956	956	956	956	956	956
Mean of Dep. Var.	0.114	0.114	0.114	4.065	4.065	4.065	4.065	4.065	4.065
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hierarchical Level FE	N	N	N	Y	Y	Y	Y	Y	Y

Notes: This table reports results from models where the dependent variables are an indicator for being in the upper levels of the hierarchy or the log of weekly wages in OLS (columns 4 to 6) or Tobit (columns 7 to 9) specifications. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. "Training" is a binary indicator for attendance at management training camps. *p<0.1, **p<0.05, ***p<0.01.

Online Appendix

Human Capital and the Managerial Revolution in the United States: Evidence from General Electric

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A Historical Background and Institutional Setting

This section provides additional historical context for understanding the integral role of the developing US education system as a forerunner to the managerial revolution in the United States.

A.1 Investments in Education

The early development of the US education system created an institutional foundation for the human capital century. All states and territories had compulsory attendance legislation by 1918. During the "high school movement" between 1910 and 1940, enrollment and graduation rates increased drastically, with more than half of youths graduating by the end of this time period (Goldin and Katz, 2011). The returns to education were large. Using data on wages from the 1915 Iowa State Census Goldin and Katz (2008) estimate an additional year of high school or college to be worth 11 to 12 percent in labor market earnings. They also find large within white-collar occupational returns, especially for college years at a time of increasing demand for skilled workers and growing firm scale. Between 1900 and 1909 the ratio of while-collar employees to production workers more than doubled. At AT&T in the early twentieth century Batt (1996) writes that "external recruits were usually college-educated, and tended to be placed in positions dispersed throughout the organization."

At the higher education level the rise of colleges and universities in the United States can be connected to the establishment of the land-grant system. Under the Morrill Acts of 1862 and 1890 the sale of government land in each state provided for the establishment of educational institutions to advance the study of "agriculture and the mechanical arts." More institutions of higher education were founded in the late nineteenth century than any other era in US history, with 432 colleges and universities being opened for instruction from 1860 to 1899. The number of private institutions—e.g., Caltech (1891), Stanford (1885), Chicago (1890)—even outnumbered those established under the land-grant system. Enrollment among 18 to 21 year-olds increased significantly—by more than five times between 1890 and 1940 (Goldin and Katz, 1999). The nature of the curriculum also shifted as the economy transitioned away from agriculture and towards large scale manufacturing enterprise. Colleges and universities reacted to this structural change by providing specialized offerings in subject areas associated with practical learning and science.

Education levels mattered because of the connection between human capital development and firm growth. Research at institutions of higher education influenced the types of projects undertaken in corporations in R&D intensive areas. Mowery and Rosenberg (1991) count 2,775 in-house corporate R&D facilities in the US in 1921 rising to 27,777 in 1940. In the pharmaceutical industry, Furman and MacGarvie (2007) detect a channel running from university research—captured by the number of Ph.D.'s granted—to the number of corporate R&D labs and employees in a county. Local agglomerations were frequently tied to university research. The Firestone Tire and Rubber Co was located close to the University of Akron, for example, which had expertise in the study of rubber and polymers. The major chemicals company DuPont was located 15 miles away from the University of Delaware, a center of excellence in chemical engineering (Mowery et al., 2015).

Indeed, the association between corporations and science strengthened during the early twentieth century, compounding the link between science, education and management. In 1926 Charles Stine, a Ph.D. educated chemist who ran DuPont's Central Research department emphasized the importance of the distinction between basic and applied science, citing GE's central R&D lab at Schenectady (established in 1900) as a forerunner in managing innovation. Stine argued that research of a fundamental nature was necessary to the development of innovative product lines, concluding in 1929 that the new science of innovation had been "marked by excellent progress." Neoprene (1931) and Nylon (1938) followed (Hounshell et al., 1988). In-house R&D laboratories exemplified the application of frontier science to the commercialization of new technologies (Arora et al., 2021).

The decision to organize R&D as centralized or decentralized entities and the management of salaried R&D workers became subjects of business administration, but business schools were nascent in this context. Wharton, founded in 1881, had some courses in business but it was not until the late 1890s that business education became more widespread. Chicago and the University of California both established schools of commerce which we know as Booth School of Business and Haas School of Business today. NYU and Dartmouth founded separate schools in 1900, and in 1908 Harvard established its business school, graduating a thousand students annually by 1929 (Groeger, 2021). Below this layer, local vocational schools existed. In Schenectady, for example, where GE was headquartered, such schools were jointly governed by GE and the City Board of Education and offered courses in business adminstration, law and accounting. However, very few managers at the time had any formal education in business, which only became a signal of credentials from around the 1960s (Frydman, 2019). Accordingly, the returns to a technical higher education would have mattered most. Philip D. Reed, CEO of GE in 1940, had graduated from the University of Wisconsin in 1921 with an electrical engineering degree. Of the six members of the

Executive Committee at GE in 1940, three had degrees in electrical engineering.

A.2 Evolving Management Practices

Complex organizational structures existed long before they first emerged in the US. In *The Genesis of Modern Management* Pollard argues that market discipline forced entrepreneurs to develop efficient management techniques in Britain during industrialization in contrast to more bureaucratic methods predominating in Continental Europe. As firms grew in size because new technologies were implemented, hierarchies emerged with managers occupying positions between proprietors and subordinate salaried staff. Although a distinct theory of management was absent during this era, entrepreneurs thought through the basic implications of principal-agent relationships, the structure of reporting and managerial capacity constraints with varying degrees of success.

While the emergence of scale in the US played a key role in the professionalisation of management, many of the consolidations described by Lamoreaux (1995) during the great merger wave in American business between 1895 and 1904—when over 1,800 firms were consolidated into 157 enterprises—were often motivated by market control not efficiency. Firms surviving this era of rising concentration and subsequent shakeout did so by navigating antitrust rules, and investing in organization, marketing and R&D (Lamoreaux, 2019). By 1940, Galambos (1975) finds, society had become increasingly accepting of these firms as they underwent organizational transformation, reflecting a reversal of public antagonism towards them in the late nineteenth century. Though it was not universal, there was a sense in which a firm could be "managerially efficient."

Given the R&D focus of big business, a technical education had advantages as managerial tasks became increasingly scientific. In 1911 Frederick W. Taylor, a mechanical engineer, published *The Principles of Scientific Management*, which created a framework for incentivizing workers through standardization and the differential piece rate system. Several firms abandoned Taylorism during the interwar years as a union avoidance strategy, but 43.7 percent of manufacturing workers were still covered by such agreements in 1935 (Jacoby, 1991). Techniques of management, including Taylorism, diffused widely through publications like *Industrial Management*, which focused on shop floor practices, and *The Harvard Business Review*, which began circulation in 1922 as a general management journal. In line with a fundamental change in managerial tasks, *The American Management Association* (founded in 1923) published an influential handbook in 1931 that covered leadership, team incentives, and employee-to-management communication (Guillén, 1994).

In almost every area of business administration, science began to replace intuition as a form of managerial decision-making. As Goldin and Katz (2000) note, expertise generally shifted from shop-floor craftsmen to skilled managers. Human resource management became a well-defined field by the 1920s. Elton Mayo and Fritz Roethlisberger from Harvard focused on human problems in the management of workers, conducting the famous Hawthorne studies at Western Electric in 1924 (Levitt and List, 2011). HR departments set compensation, administered aptitude tests and training programs and made provisions for health and well-being as an antidote to the blunt techniques of scientific management (Kaufman, 2008). With the rise of durable good purchases by households, companies like GE targeted consumers using sales techniques that would later contribute to the field of marketing science. In accounting and financial management, planning and budgeting improved due to advances in measurement such as the return-on-investment formula developed by Donaldson Brown at DuPont in 1914. Brown had graduated in 1902 with a degree in electrical engineering from Virginia Polytechnic Institute, a land-grant research university, beginning his career at the Sprague Electric Company, a subsidiary of GE (Flesher and Previts, 2013).

Starting in the 1920s, top executives began to be compensated through rigorous incentive schemes (Holden, 2005). The Hay System of job evaluation, introduced in the 1940s, assigned points to position in the hierarchy to administer compensation, building on point-based plans from a few decades earlier. Integrating employees with different job responsibilities and functional expertise into an organization became the defining characteristic of the managerial revolution. When in-house R&D produced new product lines that could be developed inside the boundaries of the firm using the multi-divisional (M-form) structure, switching from functional to divisional expertise placed even more of an emphasis on managerial abilities. M-form organizational structures were first used at General Motors and DuPont during the early 1920s. About one-fifth of the largest US corporations adopted this form by the early 1950s, including GE (Hannah, 1999).

In this context, administrative coordination superseded coordination by market mechanisms because organizations had the cognitive capacity to process information, adapt and learn (Simon, 1947; Arrow, 1974). According to Chandler (1977) "top managers, in addition to evaluating and coordinating the work of middle managers, took the place of the market in allocating resources for future production and distribution." Models of hierarchies (e.g., Lucas, 1978; Garicano, 2000; Garicano and Rossi-Hansberg, 2006) link managerial talent to productivity through the stratification of skills. Firms place individuals in the hierarchy to manage job responsibilities through span of control (Bandiera et al., 2012). Hence, hierarchies reflect organization by knowledge expertise. Since skill is heterogeneous across individuals and relative position in the hierarchy can be a key determinant of compensation patterns, this should lead to large differentials in managerial pay (Rosen, 1986). Managers at larger firms, like GE, will be of a higher quality since job responsibility increases for each level in the hierarchy by firm size. With returns to human capital, formal education should be a key determinant of position in the organization, of earnings, and span of control.

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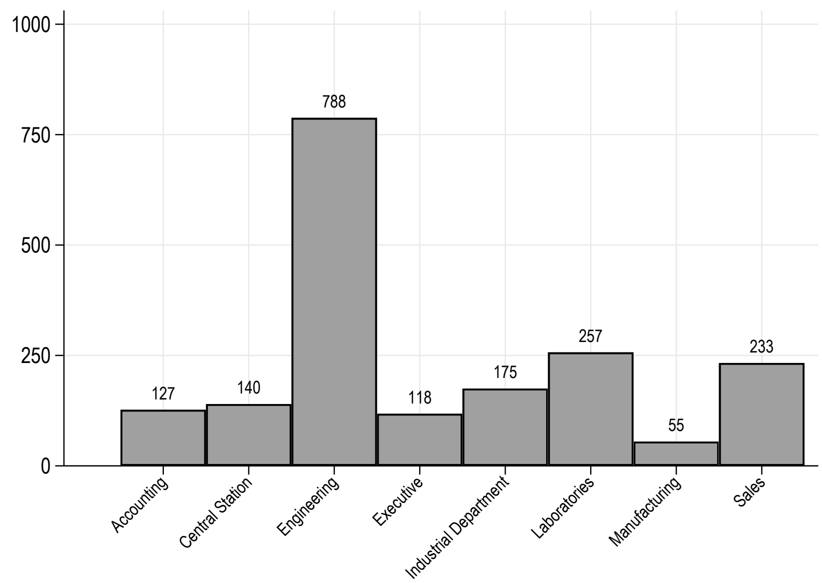
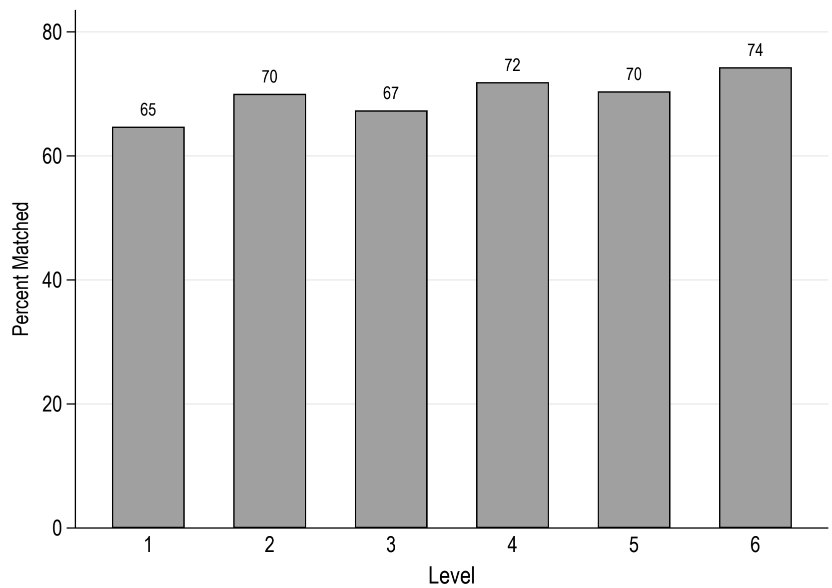
FIGURE A1: CORPORATE DEPARTMENTS

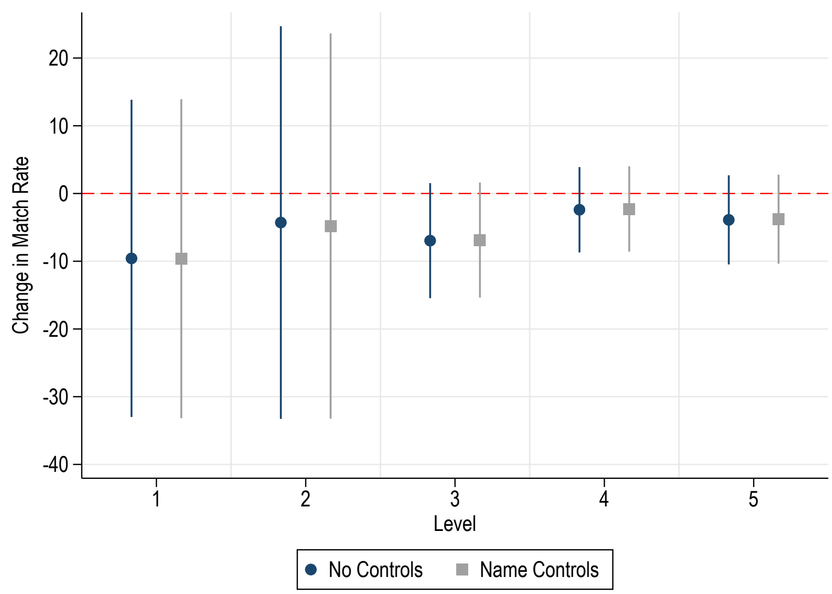


Notes: This figure shows the number of individuals in the dataset by corporate department. The Central Station included a variety of cross-functional activities.

Figure A2: Matching to the Census



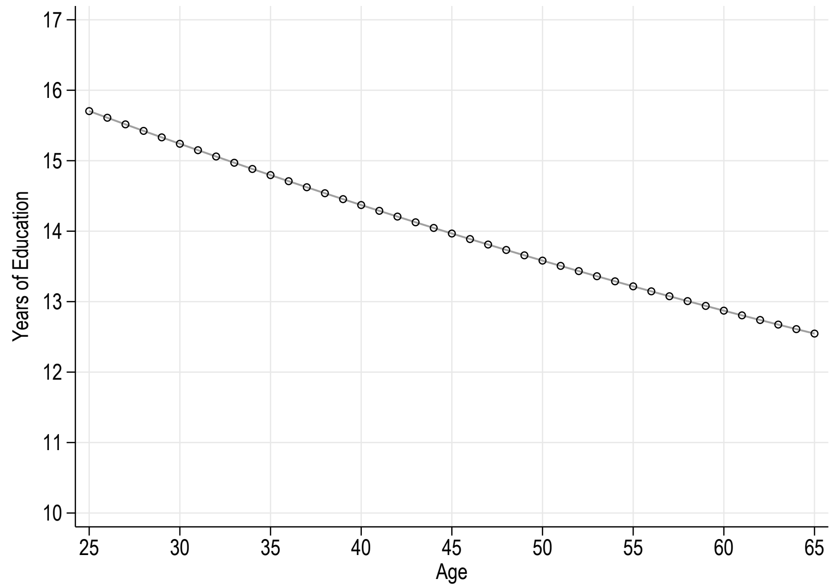
A: Match Rates by Level



B: Relative Changes in Match Rates

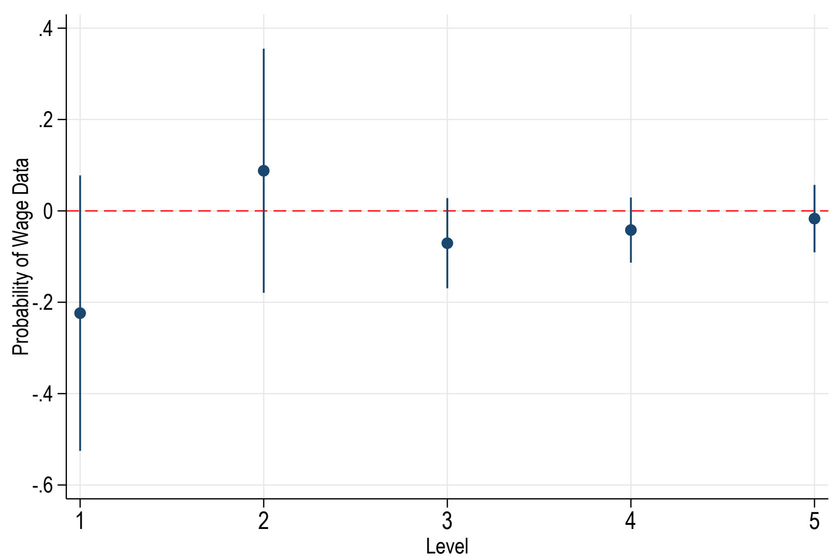
Notes: Figure A2A shows the match rate between individuals in GE's *Organization Directory* and the 1940 census. Figure A2B plots point estimates and 95 percent confidence intervals from a linear probability regression of an indicator for being matched on indicators for levels in the hierarchy, both unconditionally and controlling for the length of an individual's surname, its commonness (defined by a count of equivalent surnames in the directory), or the number of initials in a name. The baseline is Level 6.

FIGURE A3: THE DISTRIBUTION OF EDUCATION BY AGE



Notes: This figure plots point estimates from a regression of years of education on a quadratic in age controlling for gender and immigrants.

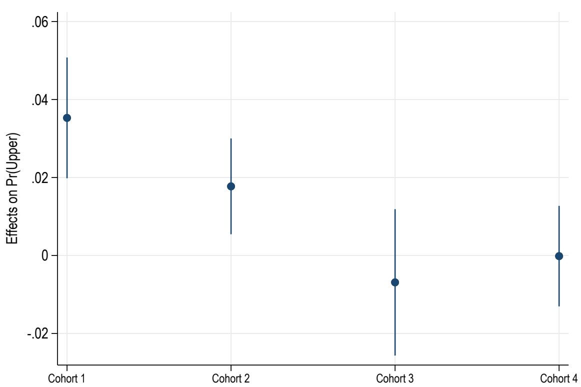
FIGURE A4: MATCH RATE OF OBSERVATIONS WITH COMPENSATION DATA



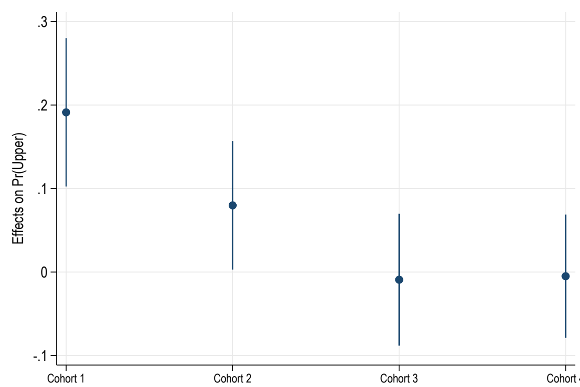
Notes: This figure plots point estimates and 95 percent confidence intervals from a linear probability regression of an indicator for being matched with compensation data available from the census on indicators for levels in the hierarchy. The baseline is Level 6.

FIGURE A5: POSITION IN THE HIERARCHY BY YEARS OF EDUCATION, COLLEGE ATTENDANCE AND BY BIRTH COHORT

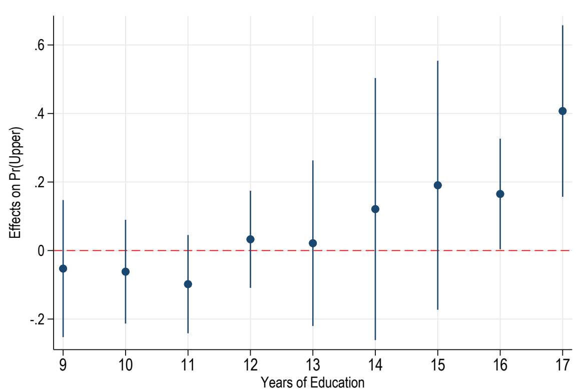
Figures A-B show the positional return to education for each cohort. 49 percent in the upper layer of the hierarchy were in the oldest cohort falling to 28, 18 and 5 percent in the remaining cohorts respectively. For those in the oldest cohort an additional year of education increases the probability of being in the upper levels by 3.5 percent whereas a college education increases the probability by 19 percent. For the second cohort of individuals, the effects are 1.8 percent and 8 percent respectively, and indistinguishable from zero in the third and fourth cohorts. Re-estimating the coefficients shown in Figure 6 of the main paper using observations for only the oldest cohort highlights the magnitude of the positional returns to education at the college-level. Figure C shows that the probability of being in the upper levels of the hierarchy increases by 41 percent for an individual with 17 or more years of education relative to an individual with 0 to 8 years.



A: COHORTS: YEARS OF EDUCATION



B: COHORTS: COLLEGE ATTENDANCE

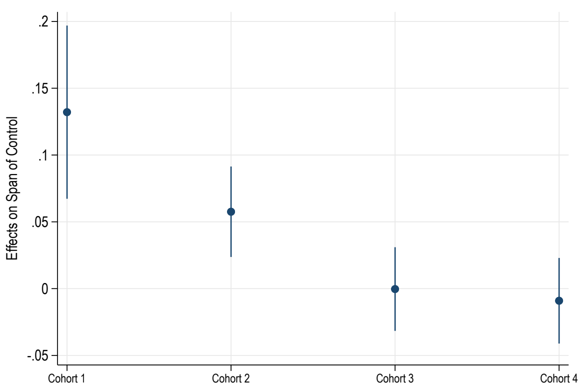


C: COHORT 1: EDUCATION INDICATORS

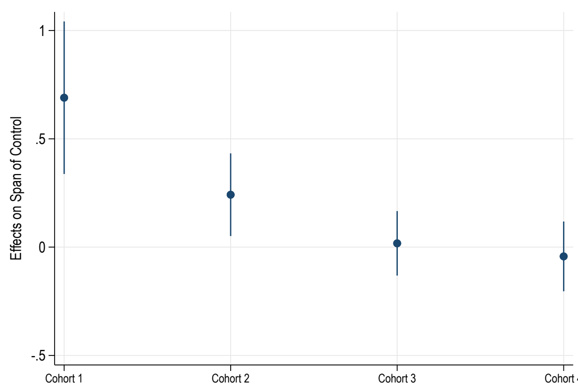
Notes: Figures A and B plot point estimates and 95 percent confidence intervals for each cohort (born 1857-1889, 1890-1899, 1900-1907 and 1908-1921) where cohort 1 is the oldest cohort and cohort 4 is the youngest. Figure A plots the return to a year of education whereas Figure B plots the return to college attendance relative to non-attendance. Figure C plots cohort-specific estimates, which can be compared to the estimates for all individuals in Figures 6 of the main paper.

FIGURE A6: SPAN OF CONTROL BY YEARS OF EDUCATION, COLLEGE ATTENDANCE AND BY BIRTH COHORT

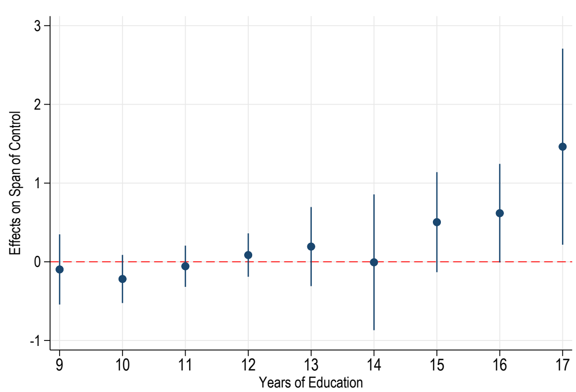
Figures A-B show the relationship between the standardized first principal component of the span of control measurers and education for each cohort. For those in the oldest cohort, who would have reached more of a permanent position, an additional year of education increases span of control by 0.13 standard deviations whereas a college education increases span of control by 0.69 standard deviations relative to the non-college educated. Re-estimating the coefficients shown in Figure 7 of the main paper in Figure C using observations for only the oldest cohort highlights the premium associated with several years of a college education in particular, relative to an individual with 0 to 8 years of education.



A: COHORTS: YEARS OF EDUCATION



B: COHORTS: COLLEGE ATTENDANCE

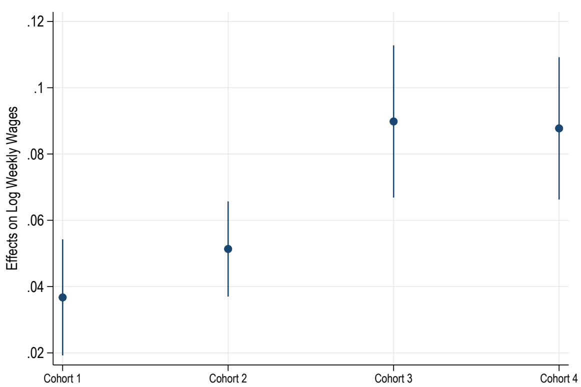


C: COHORT 1: EDUCATION INDICATORS

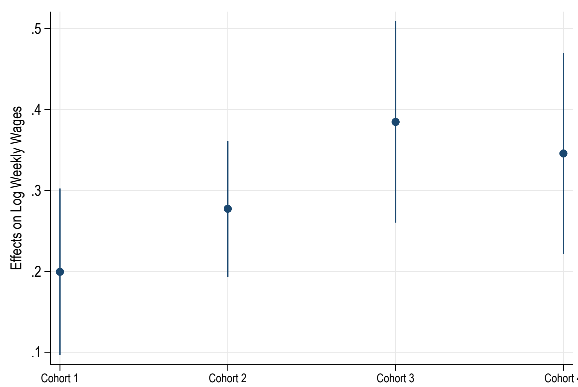
Notes: Figures A and B plot point estimates and 95 percent confidence intervals for each cohort (born 1857-1889, 1890-1899, 1900-1907 and 1908-1921) where cohort 1 is the oldest cohort and cohort 4 is the youngest. Figure A plots the return to a year of education whereas Figure B plots the return to college attendance relative to non-attendance. Figure C plots cohort-specific estimates, which can be compared to the estimates for all individuals in Figure 7.

FIGURE A7: COMPENSATION IN THE HIERARCHY BY YEARS OF EDUCATION, COLLEGE ATTENDANCE AND BY BIRTH COHORT

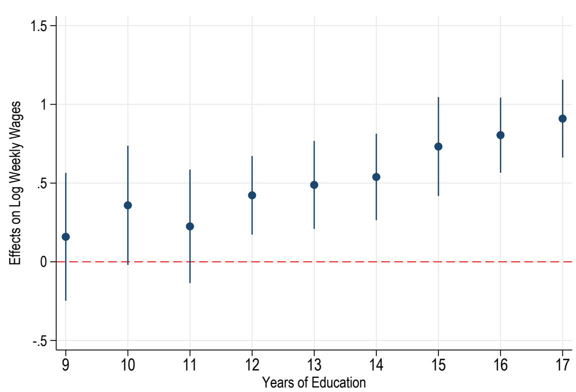
Figures A-B show the wage returns to education for each cohort with the largest effects among the youngest cohorts contrary to the results in Figure A5 and A6. For the youngest two cohorts (cohorts 3 and 4) the OLS return to a year of education is around 9 percent based on these point estimates, while the return to a college education is between 42 and 46 percent. Coefficients on the indicators for years of education on these cohorts in Figure C illustrate visually pronounced wage-returns. In these cohorts 16 years of education is associated with 124 percent higher wages compared to the baseline, whereas 17 or more years of education is associated with a 148 percent premium.



A: COHORTS: YEARS OF EDUCATION



B: COHORTS: COLLEGE ATTENDANCE

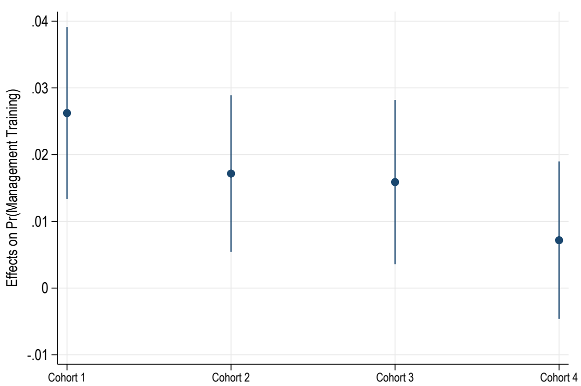


C: COHORTS 3 AND 4: EDUCATION INDICATORS

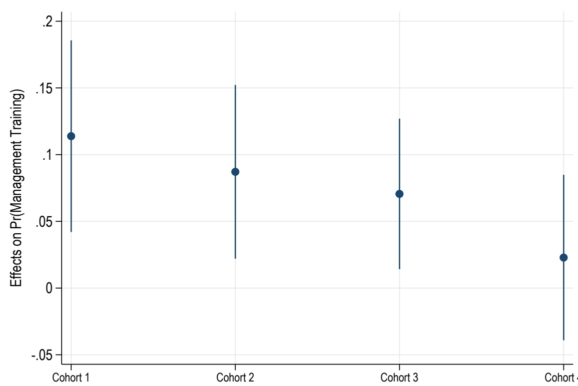
Notes: Figures A and B plot point estimates and 95 percent confidence intervals for each cohort (born 1857-1889, 1890-1899, 1900-1907 and 1908-1921) where cohort 1 is the oldest cohort and cohort 4 is the youngest. Figure A plots the return to a year of education whereas Figure B plots the return to college attendance relative to non-attendance. Figure C plots cohort-specific estimates, which can be compared to the estimates for all individuals in Figure 8 of the main paper.

FIGURE A8: MANAGEMENT TRAINING BY YEARS OF EDUCATION, COLLEGE ATTENDANCE AND BY BIRTH COHORT

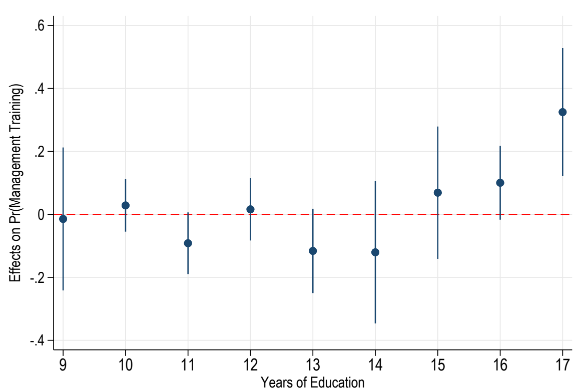
Figures A-B show the relationship between a binary indicator for receiving management training and education for each cohort. In the oldest two cohorts (cohorts 1 and 2) 24 percent and 17 percent of individuals had attended at least one management training camp respectively, compared to 7 and 1 percent in cohorts 3 and 4. For those in the oldest cohort an additional year of education increases the probability of receiving management training by 4.8 percent whereas a college education increases it by 23 percent relative to the non-college educated. Re-estimating the coefficients shown in Figure 9 of the main paper in Figure C using observations for only the oldest cohort shows a 57 percent increase in the probability of receiving management training for an individual with 17 or more years of education.



A: COHORTS: YEARS OF EDUCATION



B: COHORTS: COLLEGE ATTENDANCE



C: COHORT 1: EDUCATION INDICATORS

Notes: Figures A and B plot point estimates and 95 percent confidence intervals for each cohort (born 1857-1889, 1890-1899, 1900-1907 and 1908-1921) where cohort 1 is the oldest cohort and cohort 4 is the youngest. Figure A plots the return to a year of education whereas Figure B plots the return to college attendance relative to non-attendance. Figure C plots cohort-specific estimates, which can be compared to the estimates for all individuals in Figure 9.

TABLE A1: ASSESSING THE MONOTONICITY ASSUMPTION

	1	2	3	4
	Years of Education		College	
A. Age	> Median	≤ Median	> Median	≤ Median
Land Grant College	0.492***	0.125*	0.079***	0.032**
	(0.056)	(0.067)	(0.012)	(0.014)
University <1800	-0.779**	-0.597***	-0.124**	-0.116***
	(0.306)	(0.163)	(0.049)	(0.033)
Observations	631	662	631	662
B. Labor Market Experience	> Median	≤ Median	> Median	≤ Median
Land Grant College	0.489***	0.136*	0.080***	0.032**
	(0.061)	(0.070)	(0.013)	(0.014)
University <1800	-1.109***	-0.596***	-0.179***	-0.109***
	(0.328)	(0.163)	(0.055)	(0.031)
Observations	631	662	631	662
C. Children	> Median	≤ Median	> Median	≤ Median
Land Grant College	0.324***	0.314***	0.059***	0.056***
	(0.078)	(0.061)	(0.012)	(0.014)
University <1800	-0.731**	-0.786***	-0.118***	-0.138***
	(0.279)	(0.199)	(0.042)	(0.037)
Observations	417	876	417	876
D. Marital Status	Married	Not Married	Married	Not Married
Land Grant College	0.327***	0.180	0.055***	0.066***
	(0.065)	(0.119)	(0.012)	(0.018)
University <1800	-0.754***	-1.074***	-0.127***	-0.190***
	(0.195)	(0.372)	(0.034)	(0.049)
Observations	1161	132	1161	132
E. Home	Owner	Renter	Owner	Renter
Land Grant College	0.320***	0.327***	0.057***	0.058***
	(0.065)	(0.073)	(0.012)	(0.017)
University <1800	-0.758***	-0.855***	-0.135***	-0.140***
	(0.216)	(0.201)	(0.037)	(0.042)
Observations	813	480	813	480

Notes: Following the specifications in columns 4 and 8 of Table 2 Panel B, this table reports first-stage coefficients for sub-samples of data by age, labor market experience, number of children, marital status and home ownership. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. Standard errors are clustered by birth state. *p<0.1, **p<0.05, ***p<0.01.

TABLE A2: ROBUSTNESS CHECKS: POSITION IN THE HIERARCHY

	1	2	3	4	5	6	7	8	9	10
					Panel A: Years of Education					
Years of Education	0.012***	0.016***	0.009**	0.016***	0.007***	0.022**	0.022**	0.024**	0.024**	0.024**
	(0.004)	(0.004)	(0.004)	(0.005)	(0.002)	(0.009)	(0.010)	(0.011)	(0.012)	(0.012)
R^2		0.093	0.092	0.084	0.063					
Observations	1,293	1,293	1,293	1,186	1,174	1,212	1,144	1,293	1,293	1,293
Mean of Dep. Var.		0.114	0.114	0.116	0.0264	0.113	0.111	0.114	0.114	0.114
First Stage Coefficients:										
Land Grant College						0.353***	0.327***			
						(0.049)	(0.052)			
University <1800						-0.882***	-0.949***			
						(0.171)	(0.189)			
Montiel-Pflueger F						62.1	60.1	17.1	17.1	
p-value (Hansen J)						0.318	0.330	0.263	0.266	
					Panel B: College					
College	0.074***	0.089***	0.057***	0.092***	0.035***	0.120**	0.125**	0.133**	0.137**	0.136*
	(0.021)	(0.023)	(0.020)	(0.025)	(0.012)	(0.053)	(0.058)	(0.063)	(0.069)	(0.071)
R^2		0.087	0.092	0.084	0.061					
Observations	1,293	1,293	1,293	1,186	1,173	1,212	1,144	1,293	1,293	1,293
Mean of Dep. Var.		0.114	0.114	0.116	0.0256	0.113	0.111	0.114	0.114	0.114
First Stage Coefficients:										
Land Grant College						0.063***	0.056***			
						(0.010)	(0.009)			
University <1800						-0.152***	-0.174***			
						(0.030)	(0.030)			
Montiel-Pflueger F						53.1	62.8	17.0	17.0	
p-value (Hansen J)						0.307	0.343	0.220	0.221	
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Robustness Check	Probit	Quartic Experience (OLS)	Age Instead of Experience (OLS)	Dropping Immigrants (OLS)	Dropping Outliers (OLS)	Drop 1 Cluster (PA) (2SLS)	Drop 2 Clusters (PA, MA) (2SLS)	Interactions as Instruments (2SLS)	Interactions as Instruments (LIML)	Interactions as Instruments (UJIVE)

Notes: This table reports robustness checks on the results in Table 2. Outliers are defined using Cook's Distance. The dependent variable is an indicator coded 1 for upper levels of the hierarchy (Levels 1, 2 and 3) and 0 for lower levels (Levels 4, 5 and 6). "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in columns 6 and 7 are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. In columns 8, 9 and 10 these instruments are interacted with socioeconomic variables from the 1940 census. Robust standard errors in parentheses. In the 2SLS and LIML specifications the standard errors are clustered by birth state. UJIVE is the version in Kolesár (2013). *p<0.1, **p<0.05, ***p<0.01.

TABLE A3: ROBUSTNESS CHECKS: SPAN OF CONTROL

	1	2	3	4	5	6	7	8	9
	Panel A: Years of Education								
Years of Education	0.061***	0.032**	0.062***	0.031***	0.084**	0.088*	0.101*	0.103*	0.102*
	(0.017)	(0.013)	(0.019)	(0.007)	(0.042)	(0.047)	(0.056)	(0.059)	(0.056)
R^2	0.097	0.099	0.093	0.118					
Observations	1,293	1,293	1,186	1,277	1,212	1,144	1,293	1,293	1,293
Mean of Dep. Var	-0.006	-0.006	0.001	-0.079	-0.014	-0.017	-0.006	-0.006	-0.006
First Stage Coefficients:									
Land Grant College					0.353***	0.327***			
					(0.049)	(0.052)			
University<1800					-0.882***	-0.949***			
					(0.171)	(0.189)			
Montiel-Pflueger F					62.1	60.1	17.1	17.1	
p-value (Hansen J)					0.338	0.371	0.752	0.763	
	Panel B: College Attendance								
College	0.310***	0.189***	0.328***	0.138***	0.468**	0.508*	0.561*	0.579*	0.568*
	(0.087)	(0.070)	(0.095)	(0.038)	(0.234)	(0.275)	(0.321)	(0.342)	(0.320)
R^2	0.093	0.099	0.090	0.113					
Observations	1,293	1293	1,186	1,276	1,212	1144	1,293	1,293	1,293
Mean of Dep. Var	-0.006	-0.006	0.001	-0.082	-0.014	-0.017	-0.006	-0.006	-0.006
First Stage Coefficients:									
Land Grant College					0.063***	0.056***			
					(0.010)	(0.009)			
University<1800					-0.152***	-0.174***			
					(0.030)	(0.030)			
Montiel-Pflueger F					53.1	62.8	17.0	17.0	
p-value (Hansen J)					0.334	0.384	0.517	0.529	
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Robustness Check	Quartic Experience (OLS)	Age Instead of Experience (OLS)	Dropping Immigrants (OLS)	Dropping Outliers (OLS)	Drop 1 Cluster (PA) (2SLS)	Drop 2 Clusters (PA, MA) (2SLS)	Interactions as Instruments (2SLS)	Interactions as Instruments (LIML)	Interactions as Instruments (UJIVE)

Notes: This table reports robustness checks on the results in Table 3. Outliers are defined using Cook's Distance. The dependent variable is the standardized principal component of span of control. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in columns 5 and 6 are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. In columns 7, 8 and 9 these instruments are interacted with socioeconomic variables from the 1940 census. Robust standard errors in parentheses. In the 2SLS and LIML specifications the standard errors are clustered by birth state. UJIVE is the version in Kolesár (2013). *p<0.1, **p<0.05, ***p<0.01.

TABLE A4: SPAN OF CONTROL UPPER LEVELS OF THE HIERARCHY

	1	2	3	4	5	6	7	8
Years of Education	0.068**	0.069***	0.059*	0.068*				
	(0.027)	(0.027)	(0.032)	(0.041)				
College					0.430***	0.439***	0.395*	0.422
					(0.162)	(0.163)	(0.207)	(0.258)
R^2	0.067	0.068	0.123	0.133	0.064	0.065	0.123	0.131
Observations	148	148	148	148	148	148	148	148
Mean of Dep. Var	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	N	Y	Y	Y	N	Y	Y	Y
Department FE	N	N	Y	Y	N	N	Y	Y
Background Controls	N	N	N	Y	N	N	N	Y

Notes: This table reports robustness checks on the results in Table 3. The dependent variable is the standardized principal component of span of control and the regressions are restricted to only upper levels of the hierarchy (Levels 1, 2 and 3). "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. *p<0.1, **p<0.05, ***p<0.01.

TABLE A5: SPAN OF CONTROL COMPONENT MEASURES

	1	2	3	4	5	6
Years of Education	0.061***	0.044***	0.047**			
	(0.015)	(0.015)	(0.021)			
College				0.313***	0.228***	0.245**
				(0.076)	(0.076)	(0.109)
R^2	0.169	0.086	0.039	0.165	0.083	0.037
Observations	1,293	1,293	1,293	1,293	1,293	1,293
Mean of Dep. Var	-0.005	-0.012	0.002	-0.005	-0.012	0.002
Experience Controls	Y	Y	Y	Y	Y	Y
GE Experience Control	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y
Component	$Span^a$	$Span^b$	$Span^c$	$Span^a$	$Span^b$	$Span^c$

Notes: This table reports robustness checks on the results in Table 3. The dependent variable is the standardized value of each component of span of control where $Span^a$ is the average number of subordinates in all levels below in the hierarchy, $Span^b$ in the next level below, and $Span^c$ in the next level below in the same department. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. *p<0.1, **p<0.05, ***p<0.01.

TABLE A6: ROBUSTNESS CHECKS: COMPENSATION

	1	2	3	4	5	6	7	8	9
	Panel A: Years of Education								
Years of Education	0.055***	0.044***	0.053***	0.051***	0.091***	0.093***	0.086***	0.088***	0.094***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)	(0.009)	(0.012)	(0.013)	(0.012)
R^2	0.446	0.452	0.439	0.584					
Observations	956	956	883	917	899	851	956	956	956
Mean of Dep. Var.	4.065	4.065	4.064	4.092	4.060	4.057	4.065	4.065	4.065
First Stage Coefficients:									
Land Grant College					0.342***	0.338***			
					(0.045)	(0.054)			
University <1800					-0.841***	-0.866***			
					(0.162)	(0.183)			
Montiel-Pflueger F					66.1	58.9	12.3	12.3	
p-value (Hansen J)					0.402	0.638	0.493	0.490	
	Panel B: College								
College	0.302***	0.256***	0.297***	0.250***	0.501***	0.525***	0.516***	0.528***	0.543***
	(0.028)	(0.026)	(0.029)	(0.023)	(0.047)	(0.046)	(0.051)	(0.052)	(0.072)
R^2	0.434	0.444	0.434	0.565					
Observations	956	956	883	921	899	851	956	956	956
Mean of Dep. Var.	4.065	4.065	4.064	4.094	4.060	4.057	4.065	4.065	4.065
First Stage Coefficients:									
Land Grant College					0.063***	0.057***			
					(0.009)	(0.010)			
University <1800					-0.146***	-0.163***			
					(0.030)	(0.031)			
Montiel-Pflueger F					57.4	56.9	14.4	14.4	
p-value (Hansen J)					0.422	0.881	0.771	0.769	
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
GE Experience Control	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hierarchical Level FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Robustness Check	Quartic Experience (OLS)	Age Instead of Experience (OLS)	Dropping Immigrants (OLS)	Dropping Outliers (OLS)	Drop 1 Cluster (PA) (2SLS)	Drop 2 Clusters (PA, MA) (2SLS)	Interactions as Instruments (2SLS)	Interactions as Instruments (LIML)	Interactions as Instruments (UJIVE)

Notes: This table reports robustness checks on the results in Table 4. Outliers are defined using Cook's Distance. The dependent variable is the log of weekly wages. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in columns 5 and 6 are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. In columns 7 and 8 these instruments are interacted with socioeconomic variables from the 1940 census. Robust standard errors in parentheses. In the 2SLS and LIML specifications the standard errors are clustered by birth state. UJIVE is the version in Kolesár (2013). *p<0.1, **p<0.05, ***p<0.01.

TABLE A7: ROBUSTNESS CHECKS: MANAGEMENT TRAINING

	1	2	3	4	5	6	7	8	9	10
	Panel A: Years of Education									
Years of Education	0.166***	0.020***	0.017***	0.020***	0.005***	0.035***	0.036***	0.036***	0.037***	0.037***
	(0.038)	(0.004)	(0.003)	(0.004)	(0.001)	(0.008)	(0.010)	(0.008)	(0.008)	(0.011)
R^2		0.425	0.421	0.421	0.815					
Observations	1293	1293	1293	1186	1185	1212	1144	1293	1293	1293
Mean of Dep. Var	0.330	0.125	0.125	0.128	0.078	0.125	0.122	0.125	0.125	0.125
First Stage Coefficients:										
Land Grant College						0.339***	0.318***			
						(0.047)	(0.051)			
University<1800						-0.838***	-0.898***			
						(0.164)	(0.182)			
Montiel-Pflueger F						60.7	58.0	15.5	15.5	
p-value (Hansen J)						0.252	0.287	0.762	0.763	
	Panel B: College									
College	0.682***	0.096***	0.087***	0.101***	0.028***	0.193***	0.205***	0.219***	0.225***	0.227***
	(0.200)	(0.020)	(0.017)	(0.020)	(0.009)	(0.049)	(0.058)	(0.051)	(0.054)	(0.066)
R^2		0.419	0.416	0.417	0.812					
Observations	1293	1293	1293	1186	1182	1212	1144	1293	1293	1293
Mean of Dep. Var.	0.330	0.125	0.125	0.128	0.077	0.125	0.122	0.125	0.125	0.125
First Stage Coefficients:										
Land Grant College						0.061***	0.054***			
						(0.010)	(0.009)			
University <1800						-0.145***	-0.166***			
						(0.029)	(0.029)			
Montiel-Pflueger F						53.0	60.9	15.9	15.9	
p-value (Hansen J)						0.255	0.328	0.839	0.843	
Experience Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Department FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Background Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hierarchical Level FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Robustness Check	Poisson	Quartic Experience (OLS)	Age Instead of Experience (OLS)	Dropping Immigrants (OLS)	Dropping Outliers (OLS)	Drop 1 Cluster (PA) (2SLS)	Drop 2 Clusters (PA, MA) (2SLS)	Interactions as Instruments (2SLS)	Interactions as Instruments (LIML)	Interactions as Instruments (UJIVE)

Notes: This table reports robustness checks on the results in Table 6. Outliers are defined using Cook's Distance. The dependent variable is a binary indicator for attendance at management training camps or a count of attendance in column 1. "Years of Education" is a continuous measure from the 1940 census and "College" is an indicator for 13 or more years of education. Background controls are number of children and indicators for marital status being an immigrant and home ownership. The instruments in columns 6 and 7 are the number of land grant colleges in the census division of an individual's birth state and an indicator for whether historical universities founded before 1800 are present in that state. In columns 8 and 9 these instruments are interacted with socioeconomic variables from the 1940 census. Robust standard errors in parentheses. In the 2SLS and LIML specifications the standard errors are clustered by birth state. UJIVE is the version in Kolesár (2013). *p<0.1, **p<0.05, ***p<0.01.