Skilled Labor Job Mobility during the Second Industrial Revolution

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Abstract

We analyze the job matching process for 19th-century labor markets using a lengthy panel dataset of naval officer careers. Estimates of a dynamic model indicate that an increase in job tenure or an increase in the distribution of external wage offers increases the probability of job separation. On the other hand an increase in *internal* relative wage offers decreases the probability of separation. The accumulation of job-specific human capital has relatively non-existent effects on mobility choices with the exception of skills related to technological or engineering aptitude. Aside from testing the job matching hypothesis, our results have important implications for policy makers who evaluate incentives designed to retain their best human capital. This is particularly applicable for understanding the price incentives for military and other personnel, but it should also matter for economies attempting to retain skilled workers as they experience rapid technological change.

Keywords: human capital; job mobility; military personnel; U.S. economic history.

JEL Classifications: J6, J45, J62, N31.

1 Introduction

Two strands of literature have developed in the study of labor markets to evaluate the relationship between wages, job tenure and mobility. The job training hypothesis outlined in Becker (1962, 1964) has numerous empirical examples that test the relationship between the growth of wages and job tenure. The more recently developed models stemming from work in Burdett (1978) and Jovanovic (1979a, 1979b) outline job matching models where workers have outside options and evaluate offers in search of the ideal job match. Poor matches in a current job lead to job searching and switching. Generalizing the framework to support empirical tests of both hypotheses, Mortensen (1988) details the equilibrium search process that leads to separations, while Topel and Ward (1992) modifications test for basic hypotheses in the Mortensen model. Their results indicate that worker turnover, especially early in a career, is common and workers repeatedly search for better outcomes until they find the optimal long-run match. Presumably these mobility models, if sound, should provide similar empirical results for earlier periods, assuming similar conditions of mobility and the fulfillment of other core assumptions of the market. A few examples exist in Reynolds (1951), Ginzberg (1951) and Parnes (1954), but none have updated these early studies using more recently developed tools to analyze job mobility prior to the mid-twentieth century.

Given this lack of historical support for the efficacy of, or even the testing of matching models prior to the mid-twentieth century, we ask the question of how the development of general and firm-specific human capital affected job separations during the second industrial revolution. To answer this, we use an extensive administrative dataset that includes career data for every U.S. naval officer who graduated from the Naval Academy between 1866 and 1900. This data includes measures of cumulative firm-specific human capital, academic performance, annual earnings and time of job separation. We also include three different measures of earnings from non-military labor markets to analyze how changes in the distribution of external wage offers affect the job-switching decisions of officers. The job mobility decision is empirically modeled in a survival framework, and our results indicate two key outcomes consistent with core theoretical predictions of matching models that include job training. First, we find that the conditional probability of separation increases as job tenure increases. Second, increases in current job earnings relative to external labor market earnings decrease job separation probabilities. These results generally support predictions of the Mortensen (1988) model and further elaborated and empirically estimated by in Topel and Ward (1992).

Our results suggest that factors affecting worker tenure decisions over a century ago remain relevant today. The military often serves as a leader in the development and implementation of the newest technologies. Skilled workers (i.e. officers) trained to work with these technologies continuously face the decision of whether they should take their human capital and leave for jobs in the private sector. Our research here follows-up on questions posed by the job mobility literature and serves as an outline for additional studies on the career decisions of military personnel[1]. Even today, government budget analysts grapple with issues that balance the desire for controlled spending with the need to efficiently provide incentives for retaining the best personnel. In fiscal year 2011, the defense budget will approach $800 billion with personnel accounting for approximately 2/3 of this cost. Perhaps ideal for the government would be the case where individuals choose a military career based on their degree of patriotic zeal and other non-pecuniary factors. Our results however provide supporting evidence that even military personnel for whom the non-pecuniary factors (e.g. patriotism) play large roles, relative earnings do affect career-mobility decisions. Only the naive, or those truly blinded by love of country and service, would believe otherwise.

The rest of the paper provides historical background in section 2 and a description of the data in section 3. Section 4 gives an overview of the model and section 5 discusses the empirical results and sensitivity checks. Section 6 provides a brief conclusion and areas to

[1] Empirical evidence of job mobility for military personnel remains scant, with only a few dynamic models such as Gotz and McCall (1984), Mattock and Arkes (2007) and Glaser (2010) analyzing the job mobility decision of officers.

extend research.

2 Background

As discussed in O'Brien (2001), navies historically have served as laboratories and vanguards of technological progress, and the post-antebellum era in the United States was certainly no exception. The United States emerged from the Civil War with the most technologically advanced navy in the world. The decline of wood hulled ships was most clearly demonstrated during the Civil War with the clash of iron clads *Merrimac* and *Monitor*, and this continued shortly thereafter with the development and construction of steel-hulled ships and advances in steam powered propulsion. These advances in naval technology coincided with economy-wide technological advances in steel manufacturing, chemicals and electricity during the second industrial revolution (Mokyr 1990). At the same time, the corps of officers in the Navy not only had the experience to work with this technology, but their experience and education gave them a head start towards understanding the physics, mechanics and chemistry that was accelerating nationwide industrial growth. Their accumulated human capital positioned them perfectly to take advantage of changes in the economy.

One often thinks of a naval officer as a master of seamanship, navigation and gunnery. Beyond this, 19th century naval officers had opportunities to develop skills as liaisons to iron and steel foundries and ship building yards, supply and ordnance logistics, lighthouse inspectors, lawyers, engineers and bureaucrats. This training enabled them to develop skills in the art of diplomacy and negotiation, mathematics, chemistry, electricity, telecommunications and numerous other fundamental tools useful to the industry of their day. Their military jobs undoubtedly enhanced their general human capital as well, and made them attractive candidates for jobs in rapidly expanding private sectors. Anecdotally this is supported by words from the Navy Chief of the Bureau of Construction and Repair in 1913, who blamed the loss of human capital principally on the private sector's preferable options for the technically proficient (McBride 2000).[2] Just as officers today have the option to exit after the fulfillment of initial service obligations, historically officers could freely take their human capital elsewhere into the private sector.

The poignancy to the Navy of losing valuable human capital especially arose during the 1880s and later during the early 1900s. With national priorities turned in other directions such as reconstruction and westward expansion, the Navy suffered through a period of stagnation. Ship development declined and antiquated internal methods of promotion and job selection inhibited the efficient use and turnover of human capital. Externally, the volatile and often recessed economy during the 1870s may have prevented the accelerated exit of many officers during this time. Internally however, the situation appeared even worse. Officer in-fighting, arising from ineffective and myopic senior leadership, damaged morale and stymied innovation, not only for those most well equipped to develop uses for new technology including engineers and constructors, but also young line officers with more training with the new technology (Bennett 1896). By the 1890s, the once proud United States Navy had fallen behind most European and even many South American fleets in terms of numbers, tonnage and technology (Coletta 1987). Certainly many officers viewed patriotism and service as the predominant incentive in their career decisions, but it would be naive of us to think that a reservation wage did not exist for many if not most officers. For the right price, options always existed for them to take their talents elsewhere, especially if the Navy could not or would not use those talents appropriately or pay them accordingly.

2.1 Training

In 1864, Secretary of the Navy Gideon Welles argued that all Naval Academy students should study engineering, formally introducing the technologies of the industrial revolution

[2]This is also supported by our cursory examination of U.S. census records for those few ex-officers we can track after they leave the service. Self-reported professions include such skilled jobs as banker, "capitalist" (presumably this meant he was an independent businessman), lawyer, moulder, and civil, consulting or mechanical engineer.

to the development of officer human capital (McBride 2000). This call formally signaled the inevitable need for the Navy to switch training of human capital away from old-guard wood and sail technology to a new era of grease, oil, steel and ultimately electricity. Still, it would take decades to complete the transformation of the Navy's human capital through an evolutionary process that involved everything from Executive Orders, to Acts of Congress and even rulings by the United States Supreme Court. We can not detail this rich history here; instead we highlight the general tone of the discussion that effected both pecuniary and non-pecuniary options for personnel. Secretary Welles' declaration indicates the prescience of at least some leaders to the changes ahead for the country and the military. Although investment in the enhancement of skilled human capital had begun, the mechanisms for efficiently retaining these investments remained deficient. Congress controlled military budgets and appropriated painfully rare pay increases. Promotions occurred with inconsistent and haphazard frequency and bonuses were non-existent.

Until 1899, naval officers were tracked into two separate lines with separate duties, training, education and culture. Line officers represented the traditional role of sailors as masters of navigation, sailing, seamanship and warfare. Staff officers on the other hand typically worked behind the scenes or under the deck in engine rooms with little fanfare or glory. Their jobs included engineering, naval construction, serving as paymasters, or other miscellany with an officer's commission. Thus prior to 1899, the corps of naval officers could be simplistically split into those who understood and embraced new technology and those who did not. Aside from differing jobs, staff officers possessed different titles and ranks, but earned similar pay based on a system of "relative rank". Unfortunately and in spite of "relative rank" equality, engineers received promotions less frequently and thus did not receive wage increases commensurate with line officers (Bennett 1896, Glaser and Rahman 2010).

During the years of the Civil War and reconstruction, engineers rarely possessed college educations and generally arose from more humble socioeconomic roots. Their limited social pedigree combined with less glorious military service during the Civil War positioned them as second-class citizens within the ranks of the corps of Naval officers. For decades, older line officers treated them with condescension and derision with numerous recorded instances of engineers suffering not only prejudice, but outright changes in the system of staff officer ranks that reduced their status and eroded attempts at achieving a more equitable and meritocratic position. General Order No. 120, dated in 1869 effectively reduced the ranks of nearly every engineer in the Navy by at least one rank (Bennett 1896). Pay remained the same, but the move was humiliating to many and reflected the overall obtuse attitude of senior line officers to the plights of engineers and the technological changes occurring in world around them.

The aristocratic attitude towards fellow staff officers that mirrored attitudes towards technology in general affected not only engineers and naval constructors, but discouraged younger line officers with enhanced training in the sciences at the Naval Academy from exploring new ideas, inventing or innovating. Changes in technology such as sail to steam were perceived as antithetic to the culture and lifestyle of a line officer as sailing masters of the sea. Line officers did not understand and could therefore not control the emerging technologies. The new engineering technology, understood only by younger line officers, and staff officers could only receive the stamp of approval from senior leadership by performing well at sea or at war but tests under such conditions were nearly non-existent (McBride 2000). This attitude coincided with a period when the Navy floundered for attention and a role while the nation focused on reconstruction and continental expansion (Coletta 1987). This era of budgetary stagnation left the United States with a Navy ranked in technological and numerical power well below most European and even some South American countries by the mid-1880s.

In 1899, engineers and constructors combined with line officers to form an amalgamated line. This step formally recognized the importance of officers having multiple skill sets[3]. While all naval officers potentially had incentive to work elsewhere, we can gauge whether more technically-oriented staff officers had even greater incentive than line officers, given their human capital differences.

2.2 Career Stagnation

Over the same time-frame, the naval officers languished for years with limited opportunities for promotion and less frequent tours at sea. In the reconstruction era, a glut of officers competed for limited positions on ships in a fleet that had declined in number. This influenced earnings, since serving at sea (or at an international station) resulted in a wage bump for the officer. With few promotions available, officers' best means to increase earnings were by either serving at sea or exiting for a higher paying job in the private sector.

The Navy accelerated the construction of new ships during the late 1880s and early 1890s, and many of these new ships implemented some of the best and newest technology. The traditional role of line officers had diminished relative to engineers and constructors, but the duties and workload of all accelerated as internal labor supply forces, even from the new technologically proficient officers graduating from the Naval Academy, could not keep up with the demand required to man all of the new ships. Ships were undermanned and personnel overworked, at least relative to the peers who served in the preceding decades.

Unlike the U.S. Army which based promotions more heavily on merit, naval promotions remained stuck in an archaic system partly weighted by within-class rank, but heavily weighted on seniority. Without a system to periodically clear out the deadwood, morale among all officers sank. President Roosevelt, who at one time served as Assistant Secretary of the Navy, claimed that the promotion system within the Navy "sacrifices the good of the service to individual mediocrity" (Coletta 1987). With common frequency, officers stagnated

[3]Engineers were required to pass examinations in seamanship. Line officers, in contrast to this were not immediately required to study "engineering" per-se. In spite of this, a perusal of the academic rigor and required courses at the Naval Academy during the postbellum period indicates the enhanced rigor of the core curriculum for all cadets in mathematics and the sciences.

at the rank of Lieutenant for 15 or 20 years without promotion[4]. Table 1 highlights this stagnation, indicating the distribution of officers across various ranks by years of service.

Table 1: Density Across Rank (conditional on years served)

	years of service				
rank	10 yrs	15 yrs	20 yrs	25 yrs	30 yrs
O-1 (ensign)	29.67	-	-	-	-
O-2 (lieutenant junior grade)	22.78	22.25	-	-	-
O-3 (lieutenant)	47.56	72.11	87.55	48.35	3.17
O-4 (lieutenant commander)	-	5.49	12.08	50.63	55.28
O-5 (commander)	-	0.14	0.38	1.01	41.55
# officers	900	692	530	395	285

Frequencies reported for line officers serving from 1866 to 1905.

Not until President Taft's administration did the navy begin to alleviate the problem of stagnating promotions. Even as late as 1913, the Chief of the Bureau of Construction and Repair (an engineering-focused naval bureaucracy) complained that the seniority based system not only limited the technologically proficient officers from advancing through promotion (and thereby achieving higher wages), but it forced them sometimes to languish for as many as 15 years within a single rank (Coletta 1987). With fewer options for wage increases through internal advancement, the external labor market certainly provided options worth consideration. The degree to which these external factors influenced individual retention decisions is the principle focus of the remaining sections of this paper.

[4]In contrast to this, officers in the modern Navy typically spend 5 to 6 years at the rank of Lieutenant before either receiving a promotion to Lieutenant Commander or being forced into retirement.

3 Data

We compile the data used in this analysis from publicly available naval officer career records stored in the National Archives and in the historical archives of the United States Naval Academy library. Published annually, the *Navy Register* contains data on the job assignments, rank and duty station of every officer for every year of their career, and also the deployment status of ship on which officers served. These also include tables which outline how rank, station and job assignment affect annual pay. Combining this information, we determine whether an officer served on a ship in international waters, on a ship in domestic waters, or held a shore position at a shipyard, an office bureau, a steel foundry, a lighthouse, or other shore position. To build our career-length panel, we can use this information to construct measures of year-specific and cumulative human capital as well as annual pay. For instance, in any given year we know exactly how many years an officer served on a ship in international waters, in domestic waters, or served in some other capacity. We also have information from each officer's time at the Naval Academy. In particular, we know how their performance academically affected their Academy performance and within-class ranking. In this sense, for every officer we have a standardized measure of academic ability. Our summary of officer human capital appears in table 2 below. This includes cumulative ship experience in both international and national waters and cumulative experience in command of a ship or in charge of a station. Cumulative experience variables each gradually increase as years of service increases, but the average of amount of service in each of these variable across time changes little. The exception appears with international sea experience, where as a career advances, an officer becomes less and less likely to serve time in international waters. Even after selection over time, the distribution of officers based on Academy order of merit remains unchanged.

Table 2: Descriptive Statistics (conditional on years served)

rank	years of service 10 yrs	15 yrs	20 yrs	25 yrs	30 yrs
ship experience (domestic)					
mean (std. error)	2.081 (1.519)	3.166 (2.026)	4.117 (2.514)	5.081 (2.783)	5.817 (3.045)
% of years served	0.208	0.211	0.206	0.203	0.194
ship experience (international)					
mean (std. error)	4.351 (1.618)	5.877 (2.116)	7.238 (2.365)	8.942 (2.569)	10.57 (2.906)
% of years served	0.435	0.392	0.362	0.356	0.352
command experience					
mean (std. error)	0.071 (0.336)	0.150 (0.569)	0.294 (0.780)	0.496 (1.107)	0.529 (1.537)
% of years served	0.071	0.01	0.015	0.02	0.018
Academy order of merit percentile					
mean (std. error)	0.520 (0.277)	0.533 (0.277)	0.534 (0.278)	0.529 (0.290)	0.529 (0.294)
# observations	1027	801	626	395	284

3.1 Relative earnings

We define relative earnings for each officer, i, during year τ as

$$e_{i\tau} = \frac{w_{i\tau}}{w_\tau} . \tag{1}$$

Each individual's τ-specific pay, $w_{i\tau}$, is constructed by combining information on his rank, years within rank and type of job (sea, international shore, domestic shore or awaiting orders) with annual pay tables published in the *Navy Register* mentioned above. We use three alternative measures for w_τ, the average wage from external labor markets during the year τ, drawing on historical wage statistics published in Long (1960) and Rees (1961)[5].

For the regressions reported in table 3, we build our measure of relative earnings from methods outlined in Brown and Browne (1968), who adjust the overall manufacturing wages reported in Long (1960) and Rees (1961) to construct a time series of average annual earnings from 1866-1905.

Since we hope to determine effects principally in markets for skilled labor, we include

[5]We analyze several other alternative measures of relative earnings from these same sources and generate results similar to information reported in the paper. For brevity we do not included these additional results.

two measures of wages for the external labor market more closely aligned with naval officers' human capital. We turn to Long (1960) for the earlier stretch of skilled labor earnings data from 1866-1890, which summarizes statistics originally compiled for the Labor Department[6]. Unfortunately, no data exists for clerical or managerial employees during this time, but Long (1960) compiles annual weighted averages of 5 skilled occupations (blacksmiths, carpenters, engineers, machinists and painters) for firms located in the Northeastern and Mid-Atlantic states[7]. The results using this measure of relative earnings appear in table 4.

For the second span of time from 1890 to 1905, we turn to data summarized in Rees (1961) which draws from information originally outlined in Douglas (1930). We use the Douglas data, since it includes information on a specific sector of skilled unionized workers, foundry workers and machinists[8]. Results using this measure of relative earnings appear in table 5.

Figure 1 depicts different measures of relative earnings, using a Navy Lieutenant serving in a shore duty position as a reference category. It is worth noting several historical factors that affected relative earnings. First, the U.S. economy underwent a severe depression from 1873-1879, a time during which baseline officer wages did not change. This results in the corresponding run-up in the relative wage prior to 1880. Although less severe, recessions also hit in 1893 and 1896, indicated by the second spike in the relative wage towards the end of the 19th century. In contrast to economy-wide price deflation during several spans of time, naval officers earnings remained relatively stable, occasionally with modest increases but never a decrease.

Figure 2 supplements this story with year-over-year earnings growth rates for each subset

[6] The Aldrich report, created by the Labor Department in 1893, reported and summarized actual payroll data of over 5000 employees in 13 manufacturing industries from 1860-1890. We use the Aldrich series rather than alternative series avaialable to us from the same era since it covers the lengthiest period of continuous reporting.

[7] Most naval bases existed in these regions, and we suggest that localized relative earnings are what would matter most to worker considering a job switch.

[8] We ran out of time for this draft, but it has come to our attention that wage information on salaried workers from 1890-1905 exists that could provide an additional sensitivity check.

of data and demonstrates the volatility of earnings in careers outside of the Navy. In general, skilled wages follow similar, but not perfectly correlated patterns of wage growth over time. Not surprisingly given the discussion of data on unionized workers in Wolman (1932), shocks are particularly less severe in the Douglas data.

4 Econometric Model

The job mobility literature contains a number of theoretical and empirical studies which highlight the job switching process, including a useful and extensive meta-discussion in Gibbons and Waldman (1999). Additional work from Bernhardt (1995) and McCue (1996) on promotions proved especially helpful for developing our empirical framework. Particularly, we build our empirical model from the work of Mortensen (1988) and Topel and Ward (1992), who synthesize job-training and job-matching hypotheses under a single framework. This allows us to connect separation decisions of naval officers with factors that define the distributions of external and internal job offers during the late 19th and early 20th centuries. Underlying this, officers will always search for the optimal wealth enhancing career path[9].

4.1 Framing the separation decision

Following Topel and Ward (1992), we begin with the primal underlying assumption that workers base mobility decisions on the maximization of the net present value of lifetime wealth. Wage offers from the private sector generate from a known distribution and vary as careers progress due to the nature of work experience. The distribution of *private*-sector offers is given as

$$Prob(w^p < z) = G(z) \ . \tag{2}$$

Additionally, the *occurrence* of private sector job offers follow a Poisson distribution with parameter π.

[9] See also Burdett (1978) and Jovanavic (1979a, 1979b).

Within the postbellum Navy, wage changes for individual officers occur through one of three different mechanisms. First, promotion guarantees an increase in wages. A deterministic mechanism for promotions does not exist on record, with only anecdotal discussions that relate it to seniority and merit. One might expect that Academic order of merit plays an important role; historically the Navy ranked officers according to their overall Academy class standing, and tended to advance those with the highest "ranks" first. It is also possible that promotions were related to the type and amount of fleet experience as demonstrated in table 2[10]. Without a promotion, officers face stochastic year-to-year changes in wages due to job assignments on ships, on international shores (e.g. embassy work), or if awaiting orders without a specific assignment. The distribution of internal *navy* wage offers (job assignments), w^n, depends on current wages, w, naval experience, and the overall years since an officer was commissioned, t. Furthermore even without a promotion, an officer received a guaranteed wage increase when he stagnated *within* the same rank for 5, 10, 15 or 20 years. These 5 year (pentennial) interval wage changes are known to the officer and controlled through the variable s. Hence the distribution of internal offers is defined by:

$$Prob(w^n < y; w, s, t) = F(y; w, s, t) \ . \tag{3}$$

As Mortensen (1988) details, a higher current wage increases the entire distribution of internal offers such that stochastically $F_w(\cdot) < 0$. Additionally if internal wage growth is non-increasing (concave) with tenure, then stochastically $F_t(\cdot) \geq 0$. Finally, the automatic pay raises due to officers who stagnate within rank would indicate $F_s(\cdot) < 0$ during the pentennial years. As with external offers, the distribution of offers for internal wages also follows a Poisson process.

Assuming a discrete choice between extending his career in the Navy or separating, the offer distributions given by (2) and (3) jointly capture the characteristics of the current career

[10]The appendix includes estimates from ordered logit specifications to indicate which factors affected promotions.

outcome of the officer, given his set of alternatives[11]. With both sides of the search market defined, the value function, $v(w, s, t)$, represents the expected present discounted value of lifetime wealth for officers paid a wage of w at time t. Given this and an external private wage offer w^p, a separation occurs when $v(w, s, t) < v(w^p, s, 0)$. In other words, an exit occurs when the outside job in which the officer has no experience ($t = 0$) has greater expected wealth than the current naval job with t years of experience. This decision rule captures reservation offers, $r(w, s, t)$, satisfying $v(r(w, s, t), s, 0) = v(w, s, t)$. Any private sector offer, w^p, exceeding the reservation wage leads to separation. The probability of receiving a new offer is π, so the hazard of a separation from the Navy at t, conditional on the officer not leaving before t is given by

$$h(w, s, t) \;=\; \pi Prob(w^p > r(w, s, t)) \;=\; \pi \left[1 - G(r(w, s, t))\right] \; . \tag{4}$$

For discussion, assume $r(\cdot)$ is differentiable and let $g(z) = G_z(z)$ give the density of wage offers. A change in the current wage affects the hazard by

$$h_w(w, s, t) = \; -\pi g(r) r_w(w, s, t) \; . \tag{5}$$

A larger current wage increases the net present value of the current job and bumps-up the reservation wage. This also implies that $h_w(w, s, t) < 0$. In other words, increasing the current internal wage should decrease the conditional probability of separations.

Secondly, the effect of service time on the hazard appears as

$$h_t(w, s, t) = \; -\pi g(r) r_t(w, s, t) \; . \tag{6}$$

If we assume concave wage-profiles over time from on-the-job training, then we must have the result that $r_t < 0$ for $t > 0$. All else equal, this implies that switching jobs becomes optimal over time, since private sector jobs offer larger growth in expected wages. Officers may even choose to accept a wage cut with the separation simply because the potential for wage

[11] A competing risks model may also be employed for officers making transitions to unemployment or into another paying job. We may explore this in a later draft if we can find supporting data.

growth on the new job over time would lead to higher lifetime wealth (see Bernhardt 1995 for additional exposition and discussion). This indicates a result in which $h_t(w, s, t) > 0$. Finally, note that a guaranteed increase in wages due to career stagnation within one's own rank implies an increase in the reservation wage. This gives the result $r_s(w, s, t) > 0$. Hence, an officer awaiting a pay raise due to stagnation within rank implies that $h_s(w, s, t) < 0$.

4.2 Empirical methodology

Estimation of the dynamic process in (4) follows from methods originally outlined in Gloeckler (1978), Kalbfleisch and Prentice (1980) and systematically summarized in Kiefer (1988). We specify the econometric model below based on work ultimately from Heckman and Singer (1984), but further developed by Meyer (1990) and McCall (1994). Their formalizations in particular allow for the analysis of the conditional probability of labor market events, including the evolution of wages and career mobility decisions. In particular, duration models help researchers analyze the evolution of choices as risk-set changes[12].

Duration models are natural empirical specifications for the analysis of careers, since human capital accumulates (or depreciates) and therefore decisions to stay or leave a job at different points in time may change. Outlining this methodology, the unconditional (i.e. no covariates) hazard is defined by a simple conditional probability that an officer separates for a private sector job during the t^{th} year of his career, conditional on the cumulative that he remained for t years.

Aside from dishonorable discharges or discharges due to death, illness or injury, most officers serve a minimum of 5 years before considering separation to the private sector. For this reason, we concentrate our analysis on careers lasting at least 5 years. To capture evolving effects on the baseline hazard as careers advance, we include a baseline stepwise hazard changing on 5 year intervals. Step-function intervals defining the general experience spline span the years $[[6, 10), [11, 15), ..., [36, \infty)$.

[12] The *risk-set* includes the set of observations at risk of failure (i.e. ending a spell).

Assuming covariates remains constant on the intervals between t and $t+1$, the log-likelihood function for both censored ($\delta = 0$) and uncensored ($\delta = 1$) careers for N officers is given by

$$log\ L(\gamma,\beta) = \sum_{i=1}^{N}\left[\delta_i log\left[1 - exp\left\{-exp\left[\mathbf{x}_i(T_i)'\beta_x + e_i(T_i)\beta_e + \gamma(T_i)\right]\right\}\right] - \sum_{t=1}^{T_i-\delta_i} exp\left[\mathbf{x}_i(t)'\beta_x + e_i(t)\beta_e + \gamma(t)\right]\right] . \quad (7)$$

The probability of officer i separating from the Navy in the T^{th} year appears as the left-side of this function, while the probability of remaining for all years preceding T appear as the right-side[13]. The spline for job tenure generates from the estimates γ[14]. Control variables in the vector $\mathbf{x}_i$ include cumulative experience at sea and in command, dummy variables taking into account the length of time an officer stagnates within rank and a dummy variable capturing status as an engineer. The variable e_i represents the relative earnings of an officer based on the construction outlined in (1).

5 Results

The theoretical results discussed in section (4) outline 3 core hypotheses about separation behavior that we wish to test. These include the effects from the evolving value of firm-specific human capital, the effect of wage changes due to promotion stagnation, and the effect of relative wage shocks. Table 3 includes estimates on the full dataset of officers whose careers last at least 5 years from United States Naval Academy classes of 1860 to 1900. We consider this our baseline specification, since we also use average wages in manufacturing from these years to construct measures of relative earnings. Table 4 includes hazard model estimates on a subset of officers who had careers begin between 1860 and 1885 and lasted at least 5 years. These estimates use average wages in skilled occupations to construct measures of relative earnings for the officers based on the Aldrich report and outlined in Long (1960). Results from the specification outlined in equation (4) appear in columns (**1**) of tables 3

[13] The log-likelihood appears as a discrete time model with incompletely observed continuous hazards.

[14] We choose five year intervals for tractability and for presentation. In general, the results presented throughout the paper are not sensitive to the choice of job tenure splines divided on 5 year intervals.

and 4. Column (**2**) includes estimates without either wage or rank stagnation control variables for purposes of comparison, while additional robustness checks are provided in columns (**3**)-(**7**). Table 5 includes estimates using the average wage of skilled and unionized workers in foundries and machine shops based on the work of Douglas (1930) and outlined in Rees (1961).

5.1 Job tenure

We first draw attention to the odds-ratios reported for the experience spline. Recall a-priori that we expect $h_t(\cdot) > 0$, which is to say that the hazard should increase as officers acquire more experience (i.e. job tenure). Regardless of specification, our results support this hypothesis such that the hazard increases across most 5 year splines within each specification. This result is consistent with the empirical result in Topel and Ward (1992). Despite potential non-pecuniary benefits of military seniority, the wage stagnation that accompanied such seniority appears to matter more.[15] We report p-values on the hypothesis that each spline statistically does not increase relative to base years $6-10$. An examination of the results in column (**1**) of table 3 indicates that separation rates relative to years $6-10$ are 20% greater for years $11-15$, 26% greater for years $16-20$, twice as large for years $21-25$, three times as large for years $26-35$ and nearly 7 times as large after year 35.

Table 4 covers a shorter time frame with less robust outcomes; however, the results remain generally consistent with at least a non-decreasing hazard over job tenure. Again all relative to years $6-10$, officers are approximately twice as likely to separate during years $11-15$ and about 2 to 3 times as likely during years $16-25$. Regardless of model specification and the inclusion or exclusion of unobserved heterogeneity controls, these results remain the same using both sets of data. The results in Table 5 are similarly supportive of this non-decreasing hypothesis, albeit with effects nearly twice as strong especially after 20 years.

[15] See Melese et al. (1992) and Hartley and Sandler (2007) for more discussion on the non-pecuniary benefits for military personnel.

5.2 Relative earnings

We depict shocks to relative wages in our data for lieutenants in figures 1 and 2[16]. The earnings in the manufacturing sector represents a sector not necessarily analogous to a naval officer's peer group, but we still expect that it serves as an important indicator of the overall state of worker-earnings in the economy. That is, we assume that a decline (increase) in manufacturing earnings represents a decline (increase) in the earnings of skilled workers sharing the same labor market as naval officers. We also include relative earnings using skilled labor as the reference.

As indicated in equation (5), higher wages in the current job decrease the hazard. Our results not only support this conjecture, but the outcome remains remarkably robust across all specifications. Each additional fold of the earnings ratio decreases the probability of a separation by approximately 20%.

5.2.1 Earnings sensitivity during a career

Our basic specifications assume a constant ratio of hazards for any two individuals with distinct values of $\mathbf{x}_i$ (even if covariates do not change over time). This restrictive assumption may lead to inconsistent estimates if the ratio of hazards for any two individuals changes over time. To test whether the marginal effects of earnings change, we allow for the flexibile effect of relative earnings on the hazard as time passes across the span of a career. Specifically, we replace the parameter in $e_i(t)\beta_e$ with a time varying coefficient such that $\mathbf{e}_i(t)'\beta_{te}$ appears in equation (7). This broader specification implies that the manner in which naval officers respond to price incentives may change as their careers progress. To estimate possible changes in the effects of relative earnings over time, we re-specify the likelihood to allow for 5 year splines in *relative earnings*, such that

$$\beta_{te} = \beta_{1w} + \beta_{2e}I(t > 5) + \beta_{3e}I(t > 10) + \cdots + \beta_{7e}I(t > 30) + \beta_{8e}I(t > 35) , \quad (8)$$

16 Relative wages follow similar patterns for other ranks, albeit on smaller or larger scales depending on the duties and ranks of the officers.

and $I(\cdot)$ serves as an indicator function. Results of these broader specifications appear in table 6.

Our results inclusive of earnings splines indicate only modest changes in the effect of earnings at different times during a career. A one unit change in relative earnings decreases the hazard by 15 to 30% in our model including all manufacturing labor earnings. Regressions that control for skilled labor earnings are substantially larger where a one fold increase in the relative wage decreases the hazard by 50 to 70%. Regardless of the specification, results solidly support the hypothesis $h_w < 0$ implied by equation (5).

5.3 Career malaise

Aside from changes in earnings arising from different job assignments, officers can receive pay increases through two avenues: by getting promoted to a higher rank or, ironically, by stagnating within the same rank for too long. That is in the absence of a promotion, a 10% pay-step increase occurs each time an officer achieves within-rank milestones of 5, 10, 15 or 20 years of service. We expect that 5 year bumps in earnings should influence decisions similarly to increases in w, in that officers pentennially increase their reservation wage in the absence of a promotion. This subsequently indicates a shift in the distribution of offers and implies that $h_s < 0$. When not in a pentennial year, officers expect zero growth from internal wage offers and thus $h_s \geq 0$.

We estimate the stagnation effect on the reservation wage with a dummy variable for whether the officer is serving in his pentennial year within rank. Although the coefficient appears slightly positive, for the manufacturing-sector specifications reported in table 3, the hypothesis that promotion stagnation has no effect on separations cannot be rejected. For skilled-sector specifications, the odds-ratio estimate indicates that an officer stagnating one additional year within rank is 4.5% more likely to separate. Results from estimations of an ordered logit model (reported in the appendix) indicate that promotions appear somewhat correlated with the accumulation of job-specific human capital. This collinearity may effect standard errors and estimates of coefficients, so we include specifications without these additional control variables in column (**6**). The overall results of these alternative specifications do not change the core results of our paper in any meaningful manner. Importantly with respect to the original theoretical framework, an expected bump in the reservation wage decreases the probability of separation. Officers serving in their pentennial year are 20 to 25% less likely to separate. This result has a p-value of approximately 0.03 for manufacturing sector models but appears less statistically significant for the skilled-sector models. These results appear slightly larger in the unionize skilled labor models.

5.4 Specific measures of human capital

Finally we analyze the human capital effects on retention and separation decisions. Interestingly, overall Academy ranking appears to have no statistically discernable effect on hazards.[17]

In manufacturing-sector models, officers who accumulate experience on domestic ships appear more likely to separate earlier, but these results also do not appear statistically different from zero. This result reverses for models with skilled-sectors, where serving on ships in domestic waters decreases the hazard by approximately 6 to 8% per year of experience. From 1866-1890, the Navy confined most of its operations to domestic shores, so it should not surprise us that the only means of enhancing job-specific human capital during this era decreases mobility. International experience at sea also has a negative effect on separations, decreasing the hazard by 3 to 6%, but this result only appears statistically significant when we include service for all years up until 1905, when the United States began to build its influence more in international waters and on international shores. Increasing command experience also decreases the hazard, but this result also appears to statistically matter during the earlier years of our data. Within skilled-sector models, each additional year of command decreased the separation rate for an officer by 30%. After 1890, this effect appears

[17] This finding is consistent with our career duration analysis in Glaser and Rahman (2010) - overall merit is a poor predictor of whether or not an officer will decide to stay in the Navy.

to lose significance. In general, the accumulation of certain industry-specific human capital can increase retention.

Being an engineer, on the other hand, increases the hazard by 25 to 33%, a result that appears statistically significant in the larger manufacturing-sector models and to a lesser degree in other specifications that use alternative measures of relative earnigs. Although the skilled-sector models have larger standard errors, the parameters themselves demonstrate only small changes in magnitude. Figure 3 depicts a comparison of lifetime hazards estimated for engineers relative to line officers (i.e non-engineers). We also include the unconditional hazard for all officers on the left-side of this as a point of reference. The right-hand side generates from results estimated with time-varying splines for job tenure and wage effects, along with dummy variables for pentennial rank stagnation and engineers. The odds-ratio for engineers in this specification appears conservative compared to alternative specifications and indicates that across the span of a career, engineers were 22% more likely than line officers to separate.[18]

6 Conclusion

Empirical evidence that tests hypotheses of job matching models prior to the middle of the twentieth century is non-existent. Seemingly this void has existed due to the lack of career spanning individual-level data on careers that includes measures of human capital and pay. In an attempt to fill this gap and evaluate the effectiveness of matching models during a different era of industrial development, we estimate how late 19th and early 20th century naval officers responded to shocks in relative earnings while simultaneously conditioning on job tenure and the accumulation of human capital.

Our findings suggest that these officers comfortably belonged to the family of *homo economicus*.[19] Estimating a dynamic model of job mobility, we find that changes in relative

[18] See Glaser and Rahman (2010) for more discussion on the differing transferability of naval skills across industries.

[19] The term was coined by these officers' contemporary, John Stuart Mill, who suggested that such a creature is "a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means for obtaining that end" (Persky

earnings effect the probability of separation. We also show how increases in job tenure increase the probability of an officer choosing a career switch. These results remain robust regardless of the specification and whether we control for the accumulation of human capital or unobserved heterogeneity. Furthermore we find evidence that the technologically inclined were more likely to separate and take their embodied human capital into the private sector.

1995).

Table 3: Separation hazard estimates, officers with > 5 year careers
(earnings relative to all manufacturing, 1866-1905)

variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
relative earnings (manufacturing)	0.797 (<0.000)	-	0.804 (<0.000)	0.767 (<0.000)	0.813 (<0.000)	0.775 (<0.000)	0.812 (<0.000)
overall experience spline							
years 11-15	1.194 (0.158)	1.101 (0.253)	1.232 (0.108)	1.274 (0.046)	1.185 (0.159)	1.226 (0.080)	1.184 (0.161)
years 16-20	1.263 (0.080)	1.112 (0.225)	1.334 (0.040)	1.383 (0.035)	1.315 (0.045)	1.365 (0.042)	1.292 (0.053)
years 21-25	2.040 (<0.000)	1.913 (0.003)	2.233 (0.001)	2.322 (<0.000)	2.196 (0.002)	2.224 (<0.000)	2.155 (0.003)
years 26-30	3.037 (<0.000)	2.756 (0.002)	3.491 (<0.000)	3.804 (<0.000)	3.301 (0.001)	3.605 (<0.000)	3.329 (0.001)
years 31-35	2.995 (<0.000)	2.720 (0.002)	3.640 (<0.000)	3.875 (<0.000)	3.371 (0.001)	3.601 (<0.000)	3.529 (0.001)
years >35	6.719 (<0.000)	6.201 (<0.000)	8.605 (<0.000)	9.009 (<0.000)	7.982 (<0.000)	8.356 (<0.000)	8.381 (<0.000)
rank stagnation effects							
in rank: 5, 10, 15 or 20 years	-	-	-	-	0.748 (0.030)	0.740 (0.025)	-
in rank: total years	-	-	-	-	-	-	1.005 (0.357)
specific human capital							
overall USNA class percentile	-	0.802 (0.100)	0.896 (0.257)	0.886 (0.219)	0.896 (0.257)	-	0.894 (0.252)
ship experience (domestic)	-	1.018 (0.200)	1.023 (0.129)	1.022 (0.134)	1.026 (0.115)	-	1.025 (0.108)
ship experience (international)	-	0.957 (0.052)	0.965 (0.095)	0.963 (0.036)	0.967 (0.100)	-	0.967 (0.101)
command experience	-	0.963 (0.163)	0.983 (0.342)	0.973 (0.252)	0.987 (0.369)	-	0.984 (0.350)
engineer (y/n)	-	1.337 (0.004)	1.231 (0.036)	1.241 (0.020)	1.269 (0.031)	-	1.275 (0.017)
unobserved heterogeneiety	no	no	no	gamma	no	gamma	no
LR test of $\theta = 0$	-	-	-	4.48	-	4.93	-
log likelihood	-840	-887	-835	-833	-827	-825	-829
observations	17778	18664	17778	17778	17715	17715	17715
separations: officers	541:1267	570:1320	541:1267	541:1267	536:1267	536:1267	536:1267

Odds-ratios reported with one-sided p-values estimated on USNA class clusters shown in parentheses.
Includes all Naval officer careers lasting at least 5 years for USNA graduates from classes 1866-1900.

Table 4: Separation hazard estimates, officers with > 5 year careers

(earnings relative to skilled labor, 1866-1890)

variable	model (1)	(2)	(3)	(4)	(5)	(6)	(7)
relative earnings (skilled labor)	0.429	-	0.456	0.398	0.462	0.392	0.465
	(<0.000)		(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)
overall experience spline							
years 11-15	1.735	1.374	1.934	2.100	1.893	1.814	1.815
	(0.015)	(0.029)	(0.003)	(0.001)	(0.003)	(0.002)	(0.006)
years 16-20	2.135	1.941	2.855	3.034	2.820	2.228	2.198
	(0.001)	(0.016)	(0.001)	(<0.000)	(0.001)	(0.001)	(0.013)
years 21-25	1.843	1.892	2.855	2.924	2.763	1.807	2.047
	(<0.000)	(0.045)	(0.009)	(0.011)	(0.009)	(0.063)	(0.064)
rank stagnation effects							
in rank: $5, 10, 15$ or 20 years	-	-	-	-	0.808	0.796	
					(0.160)	(0.144)	
in rank: total years	-	-	-	-	-	-	1.045
							(0.030)
specific human capital							
overall class percentile	-	0.665	0.726	0.725	0.714	-	0.698
		(0.061)	(0.122)	(0.096)	(0.106)		(0.082)
ship experience (domestic)	-	0.922	0.941	0.941	0.944	-	0.935
		(0.051)	(0.105)	(0.091)	(0.119)		(0.079)
ship experience (international)	-	0.931	0.970	0.965	0.974	-	0.957
		(0.047)	(0.227)	(0.209)	(0.260)		(0.154)
command experience	-	0.678	0.707	0.686	0.710	-	0.680
		(0.005)	(0.007)	(0.036)	(0.018)		(0.002)
engineer (y/n)	-	1.334	1.242	1.273	1.263	-	1.242
		(0.060)	(0.138)	(0.129)	(0.119)		(0.116)
unobserved heterogeneiety	no	no	no	gamma	no	gamma	no
LR test of $\theta = 0$	-	-	-	2.56	-	1.98	-
log likelihood	-422	-428	-417	-416	-414	-418	-413
observations	7374	7374	7374	7374	7362	7362	7362
separations:officers	211:766	211:766	211:766	211:766	209:766	209:766	209:766

Odds-ratios reported with one sided p-values estimated on USNA class clusters shown in parentheses.
Includes all Naval officer careers lasting at least 5 years for USNA graduates from classes 1866-1890.

Table 5: Separation hazard estimates, officers with > 5 year careers
(earnings relative to skilled union labor in foundries, 1890-1905)

variable	model (1)	(2)	(3)	(4)	(5)	(6)	(7)
relative earnings (skilled labor)	0.397 (<0.000)	-	0.401 (<0.000)	0.404 (<0.000)	0.411 (<0.000)	0.412 (<0.000)	0.393 (<0.000)
overall experience spline							
years 11-15	1.235 (0.424)	0.989 (0.966)	1.244 (0.421)	1.243 (0.349)	1.167 (0.576)	1.158 (0.526)	1.174 (0.562)
years 16-20	1.551 (0.152)	0.909 (0.759)	1.540 (0.194)	1.560 (0.099)	1.520 (0.213)	1.567 (0.080)	1.571 (0.170)
years 21-25	3.997 (<0.000)	2.082 (0.016)	4.051 (<0.000)	4.121 (<0.000)	4.033 (<0.000)	4.126 (<0.000)	4.523 (<0.000)
years 26-30	6.054 (<0.000)	2.654 (0.014)	6.311 (<0.000)	6.537 (<0.000)	6.011 (<0.000)	6.191 (<0.000)	6.456 (<0.000)
years 31-35	6.804 (<0.000)	2.439 (0.017)	7.142 (<0.000)	7.262 (<0.000)	6.594 (<0.000)	6.603 (<0.000)	6.913 (<0.000)
years >35	16.92 (<0.000)	5.249 (0.001)	17.48 (<0.000)	17.54 (<0.000)	16.10 (<0.000)	16.04 (<0.000)	16.82 (<0.000)
rank stagnation effects							
in rank: 5, 10, 15 or 20 years	-	-	-	-	0.632 (0.032)	0.625 (0.035)	-
in rank: total years	-	-	-	-	-	-	0.974 (0.065)
specific human capital							
overall class percentile	-	0.985 (0.940)	1.086 (0.692)	1.070 (0.733)	1.099 (0.658)	-	1.104 (0.639)
ship experience (domestic)	-	1.051 (0.030)	1.043 (0.071)	1.044 (0.050)	1.044 (0.068)	-	1.045 (0.066)
ship experience (international)	-	0.970 (0.304)	0.965 (0.245)	0.966 (0.142)	0.966 (0.256)	-	0.967 (0.258)
command experience	-	0.989 (0.776)	1.011 (0.775)	1.009 (0.826)	1.014 (0.720)	-	1.105 (0.709)
engineer (y/n)	-	1.338 (0.100)	1.335 (0.098)	1.329 (0.129)	1.382 (0.065)	-	1.354 (0.084)
unobserved heterogeneiety	no	no	no	gamma	no	gamma	no
LR test of $\theta = 0$	-	-	-	0.65	-	1.57	-
log likelihood	-417	-426	-411	-411	-412	-411	-406
observations	10964	10964	10964	10964	10913	10913	10913
separations:officers	342:1067	342:1067	342:1067	342:1067	339:1067	339:1067	339:1067

Odds-ratios reported with one sided p-values estimated on USNA class clusters shown in parentheses.
Includes all Naval officer careers lasting at least 5 years for USNA graduates from classes 1866-1890.

Table 6: Separation hazard estimates for officers with > 5 year careers
(relative earnings splines)

	years 6-10	**years 11-15**	**years 16-20**	**years 21-25**	**years 26-30**	**years 31-35**	**years > 35**
all manufacturing labor model							
(years: 1866-1905)							
individual coefficients	-0.179	0.032	-0.112	-0.050	-0.050	0.042	0.119
cumulative effect odds-ratios	0.836	0.863	0.772	0.735	0.692	0.723	0.814
cumulative effect p-values	(0.003)	(0.004)	(<0.000)	(<0.000)	(<0.000)	(<0.000)	0.013
all skilled labor model							
(years: 1866-1890)							
individual coefficients	-0.901	0.128	-0.126	0.294	-	-	-
cumulative effect odds-ratios	0.406	0.461	0.407	0.303	-	-	-
cumulative effect p-values	(<0.000)	(<0.000)	(<0.000)	(<0.000)	-	-	-
foundries-skilled union labor model							
(years: 1890-1905)							
individual coefficients	-0.627	-0.058	-0.391	0.170	-0.180	0.112	0.272
cumulative effect odds-ratios	0.534	0.504	0.341	0.404	0.338	0.379	0.496
cumulative effect p-values	(0.016)	(0.001)	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)

Models include overall Naval experience splines estimated for officers with careers lasting at least 5 years.

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A Promotion Factors

After commissioning from the Naval Academy, line officers began careers as ensigns (o-1). From this, they could advance through the ranks of lieutenant junior grade (o-2), lieutenant (o-3), lieutenant commander (o-4) and commander (o-5)[20]. For a line officer's rank w, we analyze the probability of promotion using a reduced form ordered logit model. Even though a promotion bump existed over an extensive span of time, particularly during the era of reconstruction (Coletta 1987), if a slot opened for promotion (usually due to retirement) officers occasionally demonstrated something to senior leadership that allowed them to advance in grade. That is, to the researcher, each officer appeared to receive the assignment of a latent variable q^* that determined the likelihood of promotion

$$q^* \ = \ A \ + \ \theta' x \ + \ \epsilon \ , \tag{9}$$

$$q \ = \ p \ , \quad if \ \ b_{p-1} < q^* < b_p \ , \quad \ p = 1, ..., P-1 \ , \tag{10}$$

where the random disturbance ϵ has a logistic distribution, θ' represents a vector of parameters, and $\boldsymbol{x}$ gives a vector of individual characteristics. The ranges defined by b_0 to b_{P-1} represent latent value thresholds of the function in equation (9) necessary for officers to achieve promotions. When $q^* < b_0$, officers were in the lowest rank[21]. As q^* increased, officers passed thresholds $b_0, b_1, ..., b_{P-1}$ and received promotions to the next rank. The distribution of ranks conditional on levels of experience appear in table 1.

The lack of change in the unconditional distributions of covariates across time is particularly interesting once we consider how factors affecting the likelihood of promotion changes. Table $A1$ reports estimates from the ordered logit specification outlined in (9).

[20] We do not analyze the likelihood of promotion for engineers or constructors due to the complete intractability of determining engineer and constructor ranks across this analyzed period of time. Specifically, the definitions and ordering of ranks for these "staff" officers fluctuates from year to year, and a clear structure of rank comparable across this frame of time does not exist.

[21] The "lowest" ranks increased as careers lengthen. For instance, the "lowest" rank for line officers with 5 years of experience was ensign (o-1), while the "lowest" rank for line officers with 20 years of experience was lieutenant (o-3).

First note the role played by cumulative fleet experience on promotions. Serving on any type of ship had a slight positive effect on promotion likelihoods earlier in a career, but the type of service (international or national) did not matter. This effect diminishes over time as careers advanced beyond 15 years and even has a negative relationship for officers by their 20th year. Indeed, officers who spent too much time at sea especially without command experience stagnated in their careers with fewer promotions.

In contrast to this, command experience demonstrates a positive effect on promotions, a result which does not diminish over time. Achieving command serves as a gateway to better jobs later in a career, mitigating or perhaps preventing an officer from languishing on ships his entire career. Most notably, this demonstrates how even the smallest bit of command experience insulated officers from stagnating in the lowest ranks. While most officers (but not all) reached at least lieutenant by year 8, officers with any command experience *never* rank lower than lieutenant. After 15 year careers, the impact of command experience remained positive, albeit not quite as strong. After the initial round of sorting that occurred in the first 8 years, command experience had a dwindling effect. As it became more common for officers to achieve some command experience later in their careers, its value as a sorting mechanism for promotions commensurately became diluted.

Table A1: Officer promotion ordered logit estimates

Line officers, USNA classes of 1866-1897

Coefficients with standard errors clustered by USNA class year in parentheses

VARIABLES	year 10	year 15	year 20	year 25	year 30
ship experience (domestic)	0.233***	0.013	-0.098*	0.029	0.061
	(0.176)	(0.082)	(0.053)	(0.046)	(0.043)
ship experience (international)	0.278***	0.165**	0.045	-0.010	0.080
	(0.064)	(0.081)	(0.063)	(0.045)	(0.055)
command experience	2.229***	0.506***	0.154	-0.115	0.091
	(0.702)	(0.131)	(0.135)	(0.104)	(0.099)
Academy percentile	0.126	0.541	2.351**	0.407	1.132
	(0.293)	(0.461)	(1.024)	(0.389)	(0.697)
Academy class (1888-)	-2.166**	4.008***	-	-	-
	(0.926)	(0.947)			
o1-o2 cut	1.182***	-	-	-	-
	(0.598)				
o2-o3 cut	2.348***	0.202	-	-	-
	(0.639)	(0.898)			
o3-o4 cut	-	6.101***	3.401***	0.170	-1.581
		(1.251)	(1.151)	(0.691)	(1.701)
o4-o5 cut	-	-	-	-	2.257*
					(1.369)
observations	900	691	528	391	284
number of categories	3	3	2	2	3
pseudo-R^2	0.1290	0.1682	0.072	0.006	0.021
χ^2	40.31	45.29	13.10	3.92	3.58

*** p<0.01, ** p<0.05, * p<0.1

Figure 1: e_τ across time

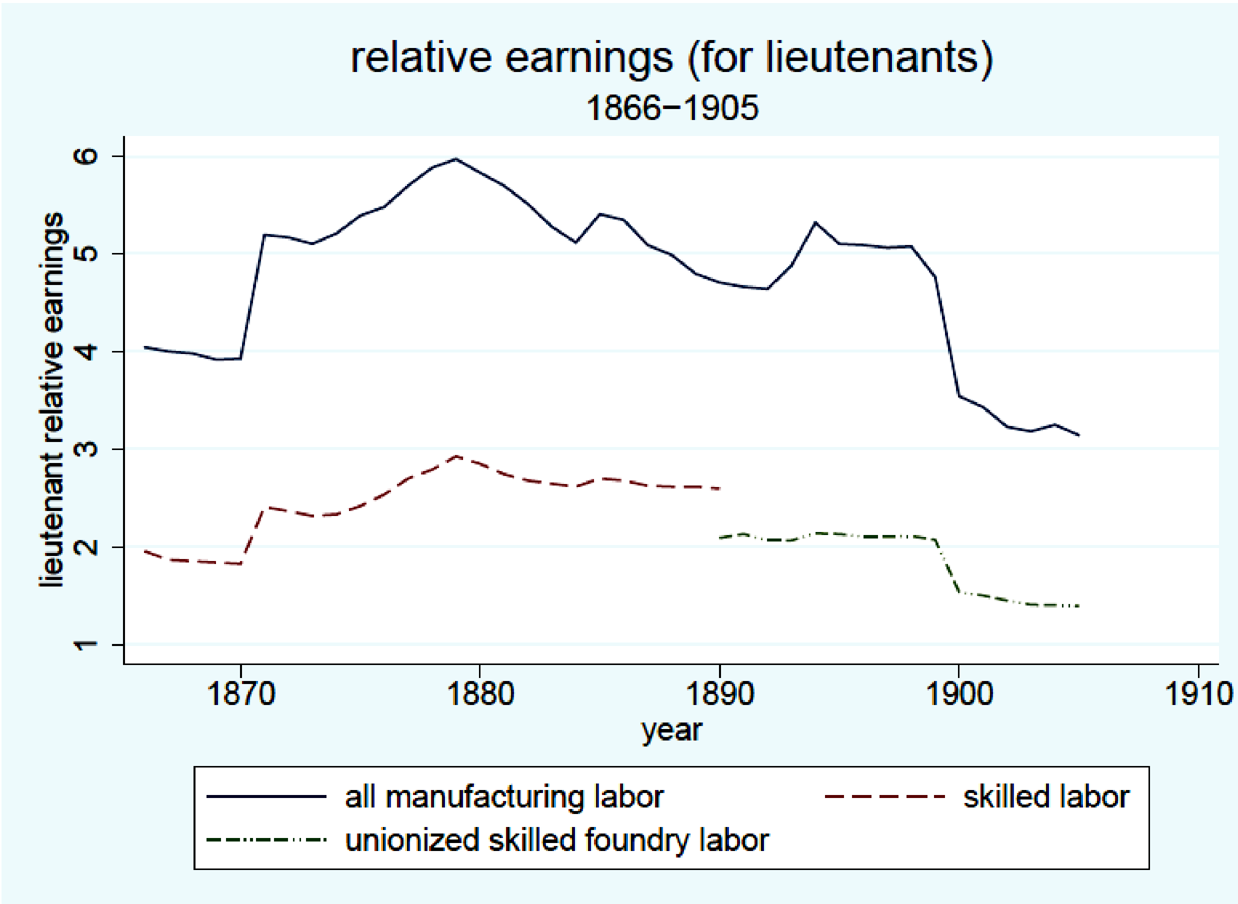

Figure 2: changes in w_τ across time

Figure 3: Engineers, line officers and job mobility