

Article

Closure and matching payoffs from college majors

Dirk Witteveen^{1,*} and Paul Attewell²

¹Department of Sociology, University of Oxford, Oxford, UK and ²The Graduate Center, Department of Sociology, City University of New York, New York, NY, USA

*Corresponding author. Department of Sociology, University of Oxford, 42–43 Park End Street, OX1 1JD Oxford, UK. E-mail: dirk.witteveen@sociology.ox.ac.uk

Abstract

This article examines the undergraduate major as a closure mechanism in occupations among college graduates, using the American Community Surveys. We measure the college major density of occupations, termed “major specialization”, finding that greater major specialization of an occupation is associated with higher earnings, over and above previously identified closure devices (licensure, unionization, and vertical educational credentialing), and college selectivity. We conclude that major specialization operates as a powerful earnings-boosting closure device within higher-educated labor markets. Additional analyses regarding premiums from individuals matching their own college major with their occupation’s typical major indicate comparatively small earnings payoffs. Hence, deviating from one’s occupation’s usual credential does not generate a substantial earnings penalty. Furthermore, payoffs from major-occupation matching have a ceiling: there is no further payoff above the average match level. These findings demonstrate how occupational closure theory helps explain the substantial earnings advantages of certain college majors in the labor force.

Key words: occupations; closure; college majors; high-skill; earnings inequality; matching.

JEL classification: J3 (wages, compensation, and labor costs), J5 (labor–management relations, trade unions, and collective bargaining), J24 (human capital, skills, occupational choice, and labor productivity)

1. Introduction

College degree holders enjoy substantially higher earnings throughout their careers than high school graduates and those with incomplete degrees. This college degree premium has been growing steadily over recent decades, which to a large extent has been attributed to the human capital demands in the service sector and high-tech industry (Goldin and Katz 2008;

Autor 2014). Social scientists have also raised concerns about over-education and the impact of allocation of college graduates to low pay economic niches (Cappelli 2015; Horowitz 2018). Earnings variation between individuals, occupations, and degree levels has been studied extensively in the social sciences (Checchi and Van de Werfhorst 2018; Kalleberg and Mouw 2018). However, the mechanisms behind earnings differentials *among* college-educated workers remain understudied. Scholarship has only recently focused on the college major as an important nexus in explaining earnings differentials. We know that there are large differences in the average earnings of employees with different majors from descriptive analyses. One study found that the earnings gap between the highest and lowest paying majors exceeds the pay differential between high school graduates and bachelor's degree holders (Carnevale, Cheah, and Hanson 2015). Others found smaller but still substantial gaps between high- and low-paying majors (Altonji, Blom, and Meghir 2012).

In this article, we advance knowledge of how undergraduate majors matter for earnings variation within the US college-educated population. We develop a comprehensive picture of payoff mechanisms, distinguishing the role of college majors in their capacity as (1) credentials in the possession of individuals (to be matched with jobs) from (2) as being used collectively by occupational incumbents to control entry into their profession (analogous to a license or registration). We measure the earnings payoffs from major-occupation matching at the individual level and payoffs from the density of majors ("specialization") at the occupational level, net of the direct effect of college major on earnings. Our analyses examine these inter-connected mechanisms that give rise to earnings variation across occupations *and* within occupations, thereby quantifying two important roles of the college major for post-college earnings.

First, occupational closure theory implies that entry into certain occupations is restricted via institutionalized credentialism, licensure, and unionization. Sociologists have highlighted earnings variation that is caused by a collective upgrading of certain occupations through the efforts of occupational incumbents (Weeden 2002). This stream of research theorizes that, by limiting the labor supply and competition to especially "qualified" individuals (i.e. those holding educational credentials), some occupational groups are much more successful than others in bidding up the price of their services over and above their nominal skill pay-offs in the market.

A second mechanism emphasizes the payoffs that come from matching of individuals' educational preparation—their acquired degree level and field of study—with job requirements. From this theoretical perspective, earnings variation should be understood as a function of how well educational programs provide skill acquisition pathways into secure and well-paid jobs (DiPrete et al. 2017), as well as a function of how individuals' own degrees and diplomas are matched with their current occupation and industry (Bol et al. 2019). Individuals who have entered a job that matches their specific educational preparation—or major—are believed to earn more than others whose credentials and major do not fit their occupation, because the latter do not make full use of their training (human capital).

In this article, we first discuss how the mechanisms of closure and matching matter for occupational earnings variation and payoffs from college majors. We then introduce two new measures of college major payoffs that, together, can answer questions about how earnings variation across majors comes about in the college-educated segment of the labor market. Specifically, we distinguish between and evaluate two sequential payoff mechanisms:

occupational closure (i.e. rewards from the degree of specialization of *occupations*) and job matching (i.e. rewards from the match of *individuals'* education within their occupations).

We find strong support for an additional occupational closure mechanism that operates specifically through college majors, over and above other known forms of closure, such as licensure, unionization, vertical educational level, and college selectivity, and well as occupation skill level. However, we also find that, conditional on having entered a particular occupation, the extent to which an individual matches their college major with the typical major in that occupation is only weakly positively associated with earnings. In other words, once college graduates are employed in a relatively closed and well-remunerated occupation, any “mismatch”—defined as having a different major compared to most of one’s colleagues—does not lead to a substantial earnings penalty, in contradiction to some prior research.

2. Theoretical background

2.1 College majors’ payoffs

It is well known that college graduates’ earnings vary substantially by major field of study (Monaghan and Jang 2017). Moreover, major typically trumps the impact of college selectivity on labor market outcomes (Garman and Loury 1995; Kim, Tamborini, and Sakamoto 2015). The dominant explanation is that different college majors carry markedly different types or levels of human capital. College majors vary in the extent to which they provide students with economic, cultural, communicative, and technical resources (Van de Werfhorst and Kraaykamp 2001). The skills and abilities that college students acquire depend to a large degree on their college major, which are related to their productivity in the labor market. As a result, variation in college major earnings is thought to reflect variation in the labor market demand for particular skillsets (Grogger and Eide 1995). This should be considered the *direct effect* of college major on labor market earnings.

However, stratification scholars have pointed to several additional mechanisms by which earnings variation may be linked to college majors—the focus of the current study. Most prominently, some have argued that, in addition to the skill premiums, college majors should be considered as status markers that can function as legal or social barriers to entry into high-skill occupations (Kerckhoff 2001). Furthermore, human capital theorists have argued that there should be a payoff from the “match” between one’s major and the occupation one holds, over and above the returns to the educational credential and to the occupation itself. The earnings premium from education–occupation matching is believed to be rooted, at least to a large extent, in optimization of skill-use (Levels et al. 2014).

We argue that, for the *higher-educated* segment of workforce specifically, college majors function as a powerful component of earnings variation because of (1) occupational closure and (2) major-occupation matching. With regard to understanding the role of occupational closure in earnings variation, we are interested in measuring the association between an occupation’s college major specialization (i.e. density) and its earnings, while controlling for the (direct) individual-level effect of college major. Similarly, we also examine the association between college major-occupation matching and earnings, at the individual level, over and above the direct effect of college major. We next introduce the theoretical framework underlying these mechanisms: occupational closure (focusing on occupational effects) and matching (focusing on individual effects).

2.2 Occupational closure

One major contribution to the understanding of earnings variation across occupations redirected sociological attention toward the link between positions and their rewards, rather than the allocation process into jobs or human capital payoffs. Using a neo-Weberian perspective, the value-generating mechanisms of occupations themselves highlight their collective capacity to control and manipulate their labor supply. Weeden (2002) pioneered this line of research by documenting the social and legal barriers around some occupations and by measuring their unique impact on earnings variation beyond individual-level factors.

Drawing from social closure literature (Parkin 1971; Weber 1978 [1922]; Murphy 1988; Tilly 1988), and to some extent the exploitation literature (Wright 1979; Sørensen 1996), Weeden (2002) lays out the principles and dynamics of *collective* upgrading by occupations. This process is termed “occupational closure” and should be understood as a form of social closure whereby occupations use a variety of strategies to protect incumbents’ collective interests (Weeden and Grusky 2005). Weeden (2002) identifies and discusses a range of institutionalized “closure devices” that generate income over and above the occupation’s skill-level (called “excess rents”), including those of higher-skilled workers (“top-end rents”). In other words, occupations differ in the extent to which they can generate earnings boosts over and above their supply-and-demand-based rewards to skill and knowledge (Sørensen 2000; Weeden 2002; Tomaskovic-Devey and Lin 2011; Weeden and Grusky 2014; Bol and Weeden 2015).

Institutional closure devices can be separated into different strategies that have in common the interest of maintaining or increasing the status of an occupation (Grusky and Sørensen 1998; Grusky and Weeden 2001). These strategies include enhancing diffuse demand (a long-term strategy to market the necessity of that occupation’s services), channeling demand (competing with other occupations for being the sole producer of a service), and signaling quality to the public (Abbott 1988; Weeden 2002). However, by far the most powerful closure strategy of occupations to maintain high earnings levels and to extract additional payoffs is based on restricting the occupation’s labor supply. Restricting the number of persons able to enter the occupation occurs primarily through three distinct mechanisms—educational credentialing, licensing, and unionization (Collins 1979; Weeden 2002).

First, the idea that educational credentials can certify the skill and quality of work in a cost-effective way is well-established within sociology and economics (Freidson 1986; Bills, Di Stasio, and Gërzhani 2017). Signaling theory contends that labor market allocation operates through hiring based on a variety of signals that are indicative of individuals’ true skills or productivity. Since employers know little about job applicants, and obtaining detailed information on skills is costly, they rely on indirect indicators of individuals’ ability (Arrow 1973; Spence 1974). While these signals also include skills or experience acquired outside of the educational system, formal credentials remain the most important signals considered by employers seeking to fill a vacancy. Closure theorists state that licensure, certification, and formal educational credentialing function as signals of quality of service to future employers (Weeden 2002). However, other Neo-Weberian scholars argue that degrees and certifications should also—or even exclusively—be considered as “cultural control” (Brown 2001). Central to their view on labor market allocation is that, for prospective employers, educational credentials serve first and foremost as a form of “cultural currency” to gain access, which is only loosely connected to workers’ actual skills and productivity needed in the job (Collins 1979).

Regardless of the balance between educational credentials reflecting true skills, signaling skills or productivity, or primarily cultural or symbolic capital (i.e. credentialism), occupations use the status function of educational credentials to deny lower- or differently credentialed workers the possibility of entering that occupation. We posit that *among bachelor's degree graduates*, the college major constitutes a powerful closure “device” because an occupation's incumbents—acting within organizations (i.e. firms) and holding power over access—can rely on industry-wide and nation-wide reputations of applicants' type of educational credential, college major and institution. The type of educational credential is the basis of legitimized “codes of exclusion” (Murphy 1988), in part because credentials are conferred by state-certified institutions (Parkin 1979). Activating the college major as a means of exclusion is a form of monopolization of economic advantages by status groups. As shown by Sørensen (2000) and Weeden and Grusky (2014), when the labor supply for an occupation falls short of demand due to access control, the mean wages of degree holders in the occupation will be artificially raised. Furthermore, we argue that it is easier to hoard opportunities based on educational credentials within organizations that have to fill vacancies for “narrow” occupations (Tomaskovic-Devey and Avent-Holt 2019). Occupations oriented toward comparably specific job tasks are common within the higher-educated segment of the labor market, such as finance, accounting, and law.

A second mechanism, licensure, allows occupations to control their labor supply and access in a similar way as educational degrees, but the US states, rather than schools and colleges, are the institutional actors responsible issuing these titles and rights. Most state occupational licenses require specific education preparation. The standards for licensing exams are typically set by members of the occupation or their representatives. These assessments create additional access barriers in the form of nationality and residence requirements, and even monetary fees. Licensure may enhance demand for the occupation's output because it is said to promote quality (MacDonald 1985; Zhou 1993). Licensure enables occupations to not only restrict their labor supply, thereby boosting earnings collectively, but also grants them the sole right to exercise their skills (Bol and Weeden 2015). However, using interstate variability in licensure within the *same* occupation, Redbird (2017) found that an occupation's licensure premium is often small or null, and that licensure *enhances* entry into occupations for historically disadvantaged groups. There is, however, far less cross-state variation in licensure requirements among occupations that usually require a bachelor's degree or higher compared to the entire workforce (Cunningham 2019). Licensure requirements are also less common for occupations that typically employ higher-educated individuals. We therefore expect a relatively weak association between an occupation's licensure density and the earnings of college graduates in multivariate analyses.

The union density of an occupation is a third closure device that enhances the collective bargaining power of workers to attain a relatively larger share of firms' profits. Union density of individual occupations is therefore associated with higher occupational earnings, positively impacting earnings for union members in those occupations, as well as for non-union members through a spill-over effect (Curme and MacPherson 1991; Dinardo and Lemieux 1997). Furthermore, unions protect the status of the occupation(s) indirectly, thereby contributing to the control over occupational access, and the monetary rewards for the in-group (Hout 2012). As noted by Bol and Weeden (2015), the impact of union density on the earnings level of occupations is generally stronger for unions that represent specific occupations. This is quite rare in the current US labor market and even more so within its highly educated

segments. Furthermore, [Western and Rosenfeld \(2011\)](#), who study deunionization in the past decades, show that unions were primarily able to raise wages among less-educated workers. Similar to licensure, we therefore expect unionization to be a weaker closure device within the higher-educated segment of the US workforce.

Empirical research by [Weeden \(2002\)](#), [Bol and Weeden \(2015\)](#), and [Bol \(2014\)](#) confirms the substantial positive effect of all three occupational closure strategies on occupational earnings throughout the workforce. [Weeden \(2002\)](#) finds that although 66 per cent of earnings variation occurs within occupations, between-occupation pay gaps are primarily explained by occupations' credentialism (proportion college-attended), certification and licensing (proportion of workers in states that require licenses), and unionization (proportion of an occupation's incumbents who are union members). These occupation-level effects appear net of occupations' level of skill and working conditions, which would be expected to explain all occupational earnings variation if human capital theory were to exclusively determine payoffs in the market. [Bol and Weeden \(2015\)](#) document these mechanisms in both Germany and the UK. They further argue that the gender distribution of an occupation should be included as a control variable in analyses of occupational closure because it is an important correlate of mean occupational earnings.

2.3 Matching and linkage

The match between education and occupation has been studied extensively by economists who distinguish between vertical matching and horizontal matching. With regard to the former, both overeducation and undereducation—relative to the normative *level* or amount of education for one's occupation—result in mismatches, which create earnings premiums or disadvantages compared to correctly matched workers ([Duncan and Hoffman 1981](#); [Groot and Maassen van den Brink 2000](#)). In contrast, our study concerns “horizontal matching”, which is broadly defined as the alignment of the field of study with either the demands of the occupation or with the sector of the occupation. Early empirical research indicated a substantial earnings premium for horizontally matched workers, over and above the returns to the characteristics of educational programs ([Van de Werfhorst 2002](#)). Using a similar methodological approach and US data from the National Survey of College Graduates (NSCG) 1993, [Robst \(2007\)](#) found an earnings penalty of about 20 per cent from a self-reported mismatch between college major and occupation.

Studying the pathways from school to work in the USA, Germany, and France, [DiPrete et al. \(2017\)](#) argue that in order to understand the structural connection between educational and work institutions, one has to focus on the extent to which specific educational programs are linked with labor market allocation, which they term “linkage strength”. Linkage strength indicates the extent to which workers with the same educational background become clustered in a small number of occupations. [DiPrete et al.'s \(2017\)](#) empirical analyses indicate that some credentials yield much higher payoffs *because* they are linked to a small number of occupations—the strength measure. The implication is that highly productive and specific skills, obtained in education, provide substantially higher returns in a competitive labor market.¹

Building on the concept of linkage strength, [Bol et al. \(2019\)](#) define a version of educational matching based on the probability of working in a specific occupation, given one's educational level and field, compared to what would be the case if one's occupation were statistically independent of one's educational field (conditional on level). Importantly, this

measurement of educational matching is a characteristic of the individual. Bol et al.'s (2019) procedure to define an education–occupation match is based on a ranking of the top ten “best matching occupations” for each major (and degree level), using data from France, Germany, and the USA. They define individuals as being “matched to an occupation” (a dichotomous variable) if they have entered one of the two highest ranked matching occupations, given the individual's educational field *and* degree level. As expected, the probability of being in a matched occupation is considerably higher for workers whose credential also has a stronger linkage strength. Across their three countries of study, they find that (1) holding a credential with a high linkage strength boosts earnings and (2) that being in a matched occupation (versus not matched) is also associated with an additional earnings advantage. Furthermore, the interaction between the credential's linkage strength and being in a matched occupation is positive and significant.

Following the tradition of educational classifications, DiPrete et al.'s (2017) concept of linkage strength provides a measure of how strongly educational programs are linked to occupational destinations. This bridges a gap in the literature because it connects education and work in a holistic manner. In addition, educational matching as defined by Bol et al. (2019) takes the commonality of the destinations of workers with the same credential as the point of reference for having “matched” or “mismatched” prior education and current work. Our study expands on this individual-level mechanism in an empirical manner and develops a more fine-grained continuous measure of *occupational* matching; the level of commonality of one's college major in the occupation.

Importantly, constructing a continuous measure of the major-occupation match (on a 0–100 per cent scale) allows us to examine whether its relationship with earnings is linear or possibly curvilinear. A stronger match could indeed be predictive of (ever) higher earnings because the workers credentials and skills overlap (even more perfectly) with job demands. However, there is no theoretical reason to believe a priori that the association between matching strength and earnings is linear. It may have a ceiling. For example, one could imagine that an extremely high degree of major-occupation matching is also indicative of having less opportunity for a college-educated worker to be a “specialist”—to supply generic skills or skills obtained outside of the college major—and reap the benefits of this status within occupations.

2.4 College selectivity

A different literature in sociology and economics relates college characteristics to the earnings of college graduates. In line with signaling theory, credentials can be viewed as “positional goods” that are partially determined by their exclusivity (Hirsch 1977; Frank 1985). The value extracted from the exclusivity of the credential is likely to be most relevant for higher degrees (post-baccalaureate). The level of prestige or selectivity of the college one attended may operate as a relevant selection criterion for employers, given the asymmetric and incomplete information about the applicant, which may vary across occupational groups. This implies that college graduates may leverage the selectivity of their college to access to particular occupations in the higher-educated segment of the labor market. In other words, when measuring the occupation-level payoffs of closure devices, the college selectivity of the occupation may be an important confounder.

Empirical indicators of “college quality”—for example, the student–faculty ratio or expenditures per full-time student—suggest a small yet statistically significant association

with post-college earnings (Zhang 2005; Borgen 2014), with some outliers reporting a substantial premium (Brewer, Eide, and Ehrenberg 1999; Thomas and Zhang 2005). In addition, the concept of “college selectivity” may reflect the intelligence and academic ambition of a college’s student body as a whole, rather than the quality of education or instruction at the college (Pascarella et al. 2006). In the USA, the Carnegie classification includes the (size of) research activity and the Barron’s index emphasizes the (ratio of) mean SAT scores of admitted students. Although some studies have reported a near-zero effect of college selectivity on earnings (Dale and Krueger 2002, 2014), others have shown a substantial payoff of college selectivity for employed college graduates (Witteveen and Attewell 2017).

3. Analytical approach

Our analyses address two research questions that, individually and in combination, reveal the mechanisms by which college majors impact college graduates’ earnings.

First, we ask to what extent earnings variation is dependent on the *occupation’s* level of “major specialization”. That is, are individuals employed in occupations that rely on a narrower set of higher education preparation (college majors) associated with higher earnings or not? As demonstrated by Weeden (2002), one important component for understanding stratified payoffs is the occupational variation in capacity to extract rents over and above the skill-level productivity value. This happens mainly through educational closure (level and type of credentials) and social closure (e.g. licensing) because these mechanisms restrict access.

We argue that *among college-educated workers*, where there is much less variation based on educational level and where we assume less powerful closure mechanisms via licensing and unionization, educational closure happens primarily through the credential’s specific major. In other words, for jobs typically accessible to the college-educated population, controlling access relies much more on the qualitative dimension (i.e. the major) of a job applicant’s educational background. If this assumption holds, more specialized occupations would require a particular major in order to control access. Following Weeden (2002), the models presented below test for this mechanism while controlling for other important closure indicators at the occupational level, including unionization and licensing. We thus hypothesize that the level of major specialization of an occupation operates as an earnings-boosting closure device for the higher-educated segment of the labor market (Hypothesis 1).

The second research question concentrates on individual-level earnings variation, asking whether a worker’s match between their own college major and the most common majors within their occupation matters for individual payoffs, conditional on having entered an occupation. Importantly, the indicator for major-occupation match is empirically derived by calculating, for each individual, the percentage of workers in the individual’s occupation who hold a bachelor’s degree in the same field of study as that individual. It thus measures the extent to which an individual’s credential is located *within the context of the occupation*—that is, whether credentials matter (more) for rewards within the occupation in which one is employed. Based on Bol et al. (2019), we expect to observe higher earnings for individuals whose field of study “matches” that of the occupation because of the specific skill requirements of the occupation (Hypothesis 2).

We argue that our approach to major-occupation measurement relies on an improved indicator of an individual’s “match”. The major-occupation matching variable employed in

this study contains an interpretable *strength* of match within an occupation rather than a dummy variable (matched versus not matched based on one's educational history) that Bol et al. (2019) operationalized. This allows us to examine additional dimensions of major-occupation matching and earnings payoffs within occupations. Specifically, we can formally test whether a major-occupation match continues to yield higher individual-level earnings—that is, the strength of the linear effect of matching. We can additionally test whether the relationship between the major-occupation matches and earnings has a ceiling: Would an extremely high degree of major-occupation match still be advantageous to a college graduate's earnings or possibly suppress earnings at these levels?

3.1 Data and variables

Analyses are based on a pooled sample of American Community Survey (ACS) microdata for 2013–7 (Ruggles et al. 2020). The 5-year ACS automatically standardizes both earnings and occupational categories across observation years. The ACS occupation schema used until 2017 allows one to merge occupation aggregates from the Current Population Surveys (CPSs) and the NSCG. We initially select individuals between 25 and 64 years old who hold a bachelor's degree or higher. The study sample consists of employed individuals who hold a baccalaureate or above, reside in the USA, who worked for more than 12 h per week for pay in the year prior to the survey, and who are not currently enrolled in education ($N = 1,417,017$).

The dependent variable is the logged individual annual earnings from salaries and wages (“incwage”). The analytical models that predict earnings therefore exclude self-employed workers. We also exclude immigrants who moved to the USA at age 18 or later because their higher education credentials (i.e. college majors) are often not comparable or unavailable in the data.

With regard to selecting occupations, we use the ACS' four-digit “occ” variable, which identifies 478 unique jobs within the data. This variable is based on the respondent's “primary occupation” and follows the job classification scheme of the 2010 Census. Since we are concerned with payoffs dynamics among *higher-educated* workers, occupations that are unlikely destinations of 4-year college graduates are excluded. We drop an occupation from the analysis if fewer than 25 per cent of workers within the occupation hold a bachelor's degree or higher. Given the fact that 38 per cent of active members of the workforce holds a bachelor's degree (as per own calculations in the ACS), we argue that a 25 per cent cut-off represents a liberal definition for selection on the higher educated segment of the workforce. We later discuss a sensitivity analysis using cut-offs ranging from 15 per cent to 35 per cent in Section 4.4. In addition, occupations with fewer than fifty observations (in the ACS subsample) and military occupations are excluded from the analysis.

3.1.1 Major specialization of occupation.

We design this key independent variable to measure the extent to which each occupation relies on a diverse or a more concentrated set of college majors. For college major, we use the ACS' variable for “field of study”, which consists of 37 exclusive labels for undergraduate majors (“degfield”). The major specialization variable is the normalized qualitative variance of college major as calculated by occupation (Mueller, Schuessler, and Costner 1970). This measure is analogous to the Blau Index (1977) or the “generalized variance” (GV). As shown in Equation (1), we can calculate for each occupation, the probability (P) that two

randomly paired cases (i.e. workers within the same occupation [j]) belong to two different college majors (C). However, we use the normalized version of this measure (normalized GV [NGV]) because it better suited for comparison across groups with different sizes, such as occupations. For the purpose of this study, and as shown in Equation (2), we employ the inverse of the occupation's NGV, multiplied by 100, so that the minimum (0) reflects perfect differentiation (all workers hold a different college major) and the maximum (100) reflects perfect homogeneity or "specialization" (all workers hold the same college major). In practice, our measure of occupations' major specialization ranges between 3.3 and 62.3 (mean 22.1). Since we can only calculate college major specialization of occupations among bachelor's degree holders, we add an additional control for the occupation's share of workers who do not hold a bachelor's degree.

$$GV = \sum_{j=1}^C P_j(P_j - 1) = 1 - \sum_{j=1}^C P_j^2. \quad (1)$$

Major specialization of each occupation can be found through:

$$\text{inverse NGV}_j = \left(\frac{C}{(C-1)} \left(1 - \sum_{j=1}^C P_j^2 \right) \right)^{-1} \times 100. \quad (2)$$

3.1.2 Major-occupation matching of workers

This is a characteristic of individuals and is conditional on their specific occupation. Similar to using a "realized matches" approach to measure an occupation's educational requirements (Verdugo and Verdugo 1989), it calculates the percent of workers within the respondent's occupation that hold the *same* college major as the respondent. This measure's range is therefore between a theoretical 0 per cent (no other worker holds the same college major as the individual) to a theoretical 100 per cent (all other workers hold the individual's college major). In practice, major-occupation matching ranges between 0 and 72.3 per cent. We apply the same 37-field of study version available in the ACS.

3.1.3 Controls

Models are run for men and women separately because of the large earnings differences by gender. The predictive models include socioeconomic and demographic controls (D) for race/ethnicity (five categories), age (and its squared term), marital status (five categories), usual hours worked, number of weeks worked (six categories), geographical region (nine categories), and the respondent's own highest completed level of education (bachelor's, master's, professional degree, or doctoral degree).

The ACS does not record the field of study for those who attained an advanced degree (about 38 per cent). We assume that, among advanced degree holders, the field of graduate studies is correlated with both the undergraduate major and post-college employment. In other words, occupational choices, advanced degree attainment probability, and advanced degree field are to a large extent dependent on the initial choice of college major (Bedard and Herman 2008). While some of the advanced degree major stratification mechanism remains unobserved (a limitation discussed later), we believe that inclusion of advanced degree holders in the analysis is unlikely to drive the results based on a series of robustness

checks discussed below. All analyses of occupations' payoffs from major specialization (level-2) additionally control for individuals' degree of major-occupation matching (level-1). [Supplementary Appendix A](#) documents all predictor variable categories, as well as the coefficients for the main prediction model.

With the exception of college major specialization, all occupation-level variables are built using a dataset that represents the entire US workforce (i.e. employed for more than 12 h a week and between ages 25 and 64, $N = 5,318,968$). The level-2 control variables reflect theorized occupational closure mechanisms: "vertical educational credentialing" (percent of workers holding 'less than bachelor's degree' and percent of workers holding a "master's degree or more"), "union density" (percent of workers who are either a member of or are represented by a union), "licensure" (percent of workers who require a license on the job), "gender distribution" (percent female workers), and a robustness check with "college selectivity" (percent of graduates from research-1 or doctoral-1 institutions). Occupation union density and licensure variables were constructed using a pooled sample of the monthly CPSs between 2013 and 2017 ([Flood et al. 2020](#)), which contain 7,825,622 observations and the same Census-based occupational categories.²

The occupation's percentage of graduates from R-1 or doctoral-1 undergraduate institutions (Carnegie Classification 1994 [[Indiana University 2021](#)]) is calculated using a large sample ($N = 91,000$) of the NSCG of 2015. For each NSCG-coded occupation, we derived the percentage of R-1 or doctorate-1 college graduates and labeled this as "selective". About 33 per cent of the NSCG respondents completed their (first) bachelor's at a selective institution. We applied an NSCG-to-Census occupation crosswalk before linking the selectivity variable to the pooled ACS-based sample. However, the NSCG occupational codes are considerably cruder in several labor market sectors, such as financial services and retail, while offering much more detailed labels for occupations in STEM and education. We therefore only include the occupational-level college selectivity associations as a robustness check for confounding with the occupational closure dynamics that are of key interest to this study. These estimates should be interpreted with some caution.

As argued by some scholars, the payoffs from occupational closure are better understood if models additionally control for indicators of occupation-level skill (aggregate human capital). Following [Bol and Weeden \(2015\)](#), our analysis therefore tests whether college major specialization still operates as a closure payoff mechanism when occupational skill level is added to the model. These variables are derived from the O*NET database ([National Center for ONET Development 2023](#)). These variables (0–100 scale) are operationalized as the average skill-level requirements of each occupation according to surveyed experts ([Fleisher and Tsacoumis 2018](#)). Similar to the NSCG variables, crosswalks are necessary to match the O*NET SOC code-based variables with the Census occupational coding of the ACS. This leads to a smaller number of occupations available for models that additionally control for occupation-level skills, which should therefore be considered as a robustness check. [Supplementary Appendix B1](#) presents the descriptive statistics of occupational-level basic skills (mathematics, science, writing, speaking, and active listening) and process skills (critical thinking, learning strategies, and monitoring).

These occupation-level effects appear net of occupations' level of skill and working conditions, which would be expected to explain all occupational earnings variation if human capital theory were to exclusively determine payoffs in the market.

3.2 Methods

The study sample consists of 1.4 million college-graduate individuals nested in 230 higher education-level occupations. Before presenting the results from these models, the descriptive statistics of these selected occupations are discussed. A first series of hierarchical linear models focuses on the impact of major specialization (X)—at the occupation level (j)—on logged earnings (Y_{ij}), while adjusting for all theorized competing occupational closure mechanisms (O), all individuals' sociodemographics (D), college major-fixed effects (C), and our individual-level indicator of major-occupation matching (M):

$$Y_{ij} = \beta_0 + X_j\beta_1 + O_j\delta + D_{ij}\gamma + C_{ij}\omega + M_{ij}\phi + u_j + \varepsilon_{ij}. \quad (3)$$

We control for college major-fixed effects to account for the direct impact of a college major on earnings (see Monaghan and Jang 2017). This implies that the estimated association between occupations' major specialization and earnings level is net of the direct relationship between skill acquisition through college majors and labor market payoffs.

The second series of models presents estimates for the association between major-occupation matching (M)—at the individual level—and logged earnings (Equation (4)). These associations are adjusted for all individual-level factors (D) and college major-fixed effects (C). We also add occupation-fixed effects (L), thereby adjusting for all closure mechanisms and other unobserved factors at the occupation level. The third series contains these same predictors and includes only individuals who are employed in highly specialized occupations (inverse-NGV > 0.20), for whom major-occupation matching is expected to be beneficial for earnings.

$$Y_i = \beta_{0j} + M_i\beta_1 + D_i\gamma + C_i\omega + L_j\phi + \varepsilon_i. \quad (4)$$

One limitation of the ACS data is that its cross-sectional structure does not allow us to carefully address selection pathways of individuals into occupations. The results—which are reported as associations rather than causal estimates—therefore reflect the relative payoffs of occupational closure and major-occupation matching conditional on the selection pathways into occupations. A wide range of socio-demographics and indicators of human capital mitigate some of the distortion in estimates that is due to selection. Furthermore, a series of robustness checks shed light on closure and matching dynamics among subgroups and presents sensitivity tests for omitted variable bias.

4. Results

4.1 Descriptive statistics

Table 1 lists a selection of occupations with different levels of college major specialization and ranked by broad high, middle, and low clusters of specialization. The columns include distributional figures for the measures of occupational closure in the predictive analysis. Aside from our main occupational variable of interest, college major specialization, we include occupational averages for licensure, union density, vertical educational credentialing, gender distribution, and college selectivity. The leftmost columns present the median earnings by gender.

Table 1. Occupations' closure indicators and earnings by major specialization tier.

		Major specialization	Licensure	Union density	Vertical credentialing		Gender distribution	College selectivity	Median earnings	
			Per cent required	Per cent member or represented	Per cent less than BA	Per cent MA or more	Per cent female	Per cent R-1 or Doc-1	Men	Women
Highest major specialization level		38.5	14.3%	3.1%	20.2%	40.7%	63.1%	34.8%	\$87,948	\$57,942
rank	top10									
1	Chemical engineers	62.3	6.4%	1.3%	10.8%	31.0%	10.0%	50.3%	\$109,618	\$100,000
2	Marine engineers	62.3	10.6%	6.9%	26.9%	23.2%	16.7%	27.0%	\$97,000	\$81,720
3	Civil engineers	61.3	17.5%	2.5%	12.7%	29.9%	14.0%	42.4%	\$91,935	\$77,735
4	Mechanical engineers	58.3	5.8%	1.4%	23.8%	23.8%	7.7%	40.5%	\$89,591	\$83,134
5	Electrical engineers	57.9	6.1%	1.7%	20.2%	30.8%	8.9%	35.2%	\$103,293	\$90,017
6	Petroleum engineers	56.6	5.5%	0.3%	18.0%	26.0%	12.0%	40.2%	\$124,162	\$115,047
7	Accountants and auditors	55.8	8.1%	1.5%	19.9%	23.9%	63.3%	32.3%	\$80,000	\$62,187
8	Nurse anesthetists	55.5	32.0%	1.7%	3.6%	86.0%	58.8%	25.0%	\$165,549	\$145,105
9	Registered nurses	55.4	34.0%	4.7%	41.7%	10.6%	90.1%	25.0%	\$71,516	\$62,312
10	Aerospace engineers	54.9	3.5%	3.1%	12.5%	38.1%	11.1%	55.2%	\$111,344	\$97,714
Middle major specialization level		15.8	8.9%	2.8%	42.6%	21.5%	47.0%	30.8%	\$85,000	\$61,133
rank	median 10									
110	First-line supervisors retail	14.0	1.9%	0.9%	73.5%	4.7%	45.0%	24.0%	\$60,000	\$45,000
111	Claim adjusters, examiners	14.1	12.1%	1.6%	51.7%	8.5%	59.7%	35.6%	\$65,241	\$55,863
112	Physical scientists	14.1	5.2%	1.5%	0.3%	75.8%	41.8%	36.7%	\$94,861	\$67,254
113	Editors	14.2	0.3%	1.5%	16.4%	24.9%	53.9%	34.1%	\$61,290	\$53,803
114	Human resource assistants	14.2	1.5%	2.2%	68.1%	7.9%	84.4%	26.9%	\$55,000	\$42,000
115	Property and real estate managers	14.6	6.9%	1.0%	57.2%	11.0%	47.6%	36.8%	\$82,774	\$54,838
116	Food service managers	14.6	4.4%	0.6%	74.2%	4.2%	51.3%	36.8%	\$51,823	\$42,903
117	Producers and directors	14.7	2.2%	2.6%	24.0%	16.9%	36.3%	34.1%	\$73,548	\$63,241

continued

Table 1. *Continued*

		Major specialization	Licensure	Union density	Vertical credentialing		Gender distribution	College selectivity	Median earnings	
			Per cent required	Per cent member or represented	Per cent less than BA	Per cent MA or more			Per cent female	Per cent R-1 or Doc-1
118	Gaming managers	14.8	7.5%	0.6%	72.0%	4.4%	40.6%	36.8%	\$63,241	\$57,061
119	Chiropractors	14.9	25.1%	1.0%	2.4%	92.7%	29.8%	25.0%	\$64,000	\$46,989
Lowest rank	major specialization level bottom 10	7.0	7.0%	3.0%	46.8%	21.0%	50.3%	28.3%	\$77,735	\$56,183
221	Tour and travel guides	3.3	4.6%	1.2%	54.9%	10.8%	69.5%	28.0%	\$24,000	\$20,000
222	Lifeguards	3.6	10.4%	5.4%	61.6%	7.2%	70.2%	19.9%	\$39,318	\$32,007
223	Postsecondary teachers	3.7	10.3%	5.3%	5.8%	81.6%	82.5%	30.5%	\$72,428	\$60,011
224	Library technicians	4.2	1.6%	6.0%	65.6%	11.7%	67.7%	26.8%	\$35,753	\$25,703
225	Animal trainers	4.3	4.8%	0.7%	68.1%	5.0%	71.4%	28.0%	\$41,774	\$31,040
226	Media/communication workers	4.5	9.5%	2.7%	44.8%	20.4%	57.6%	34.1%	\$50,054	\$42,055
227	Community/social service specialists	4.6	4.6%	3.3%	41.2%	24.6%	81.5%	24.5%	\$52,701	\$46,561
228	Massage therapists	5.0	30.5%	0.4%	73.2%	6.2%	51.5%	25.0%	\$30,326	\$26,350
229	Social/community service managers	5.2	5.0%	1.1%	26.9%	34.6%	47.3%	36.8%	\$70,479	\$56,183
230	Interviewers, except eligibility/loans	5.3	3.2%	2.4%	72.9%	7.2%	38.6%	26.9%	\$39,920	\$33,110

Notes: Inverse NGV levels: highest (≥ 25.0), middle (≥ 10.0 and < 25.0), lowest (< 10.0). Calculations include 230 occupations, with exception of college selectivity (226). The major specialization tier averages (bold) are drawn from an occupation-means dataset.
Source. Authors' calculations of the American Community Surveys 2013–7, selecting occupations with at least 25 per cent BA graduates. CPSs: union coverage (2013–7) and licensure requirement (2016–7). NSCG 2015: college selectivity (Carnegie Classification 1994).

As shown in the first columns of [Table 1](#), chemical and marine engineering (62.3), as well as other engineering occupations, display the highest levels of college major specialization. Accountants and auditors (55.8), nurse anesthetists (55.5), and registered nurses (55.4), as the most major-specialized occupations. We find that about 50 out of the 230 high-skill occupations have a distinctly higher inverse NGV (>25) and should be considered as highly major-specialized. As shown in [Table 1](#), there is little descriptive evidence of a pattern between the degree of major specialization of the occupation and its alternative closure devices. Licensure is slightly higher within highly major-specialized occupations (14.3 per cent) as compared to the middle cluster (8.9 per cent) and lower cluster (7 per cent). Among these 230 occupations in the higher-educated segment of the labor force, union density does not appear to be a critical closure divider between lower and higher levels of major specialization. Union membership and coverage ranges between 2.8 and 3.1 per cent. Occupations that are more major-specialized appear to have a higher share of women, but there is large variation across between occupations within clusters. However, highly major-specialized occupations contain fewer workers who do not hold a bachelor's degree (20.2 per cent versus 42.6 per cent in the middle cluster) and more individuals who hold a master's degree or higher (40.7 per cent versus 21.5 per cent in the middle cluster). There is a slightly larger representation of graduates from selective institutions in the high major specialization cluster (34.8 per cent) compared to the middle cluster (30.8 per cent) and low cluster (28.3 per cent).

4.2 Closure: major specialization of occupations

The results from the mixed models with workers nested within occupations are presented in [Fig. 1](#), split by men (A) and women (B). The figure graphically presents the margins estimates of the occupation-level degree of major specialization of occupations on logged earnings, at different levels of college major specialization. We plot a range of 0–40 on the inverse-NGV scale in [Fig. 1](#). The coefficients of the individual-level predictors are documented in [Supplementary Appendix A](#).

We make two key observations. First, for both genders, a higher level of major specialization—greater concentration of the same field of study in the occupation—is associated with higher earnings, net of other occupational closure mechanisms (licensure, union density, vertical credentialing, and gender distribution) and net of individual-level covariates of earnings, including the level of major-occupation matching of respondents. The effect size of the college major density variable is substantial given the large point estimate jumps when comparing to the relatively small increments on the inverse NGV scale, as shown in both panels of [Fig. 1](#). The strength of the association between occupational major specialization and earnings appears to be similar for men (A) and women (B), though women earn less on average. For example, workers employed in occupations with a low degree of major specialization (inverse NGV = 4) display a predicted earnings level of \$67,000 (men) and \$48,000 (women). In contrast, adjusting for the same covariates, the earnings level in occupations that are about five times more concentrated in terms of college majors (inverse NGV = 20) is significantly higher for both genders: \$81,000 and \$57,000, respectively.

Second, the margins estimates plotted in [Fig. 1](#) also demonstrate that major specialization does not pay off *more* among the most highly major-specialized occupations, either for men or women. The increasing earnings rewards of occupational major specialization plateaus at an inverse NGV of about 20–25. The plateau effect persists at the extremes of the scale

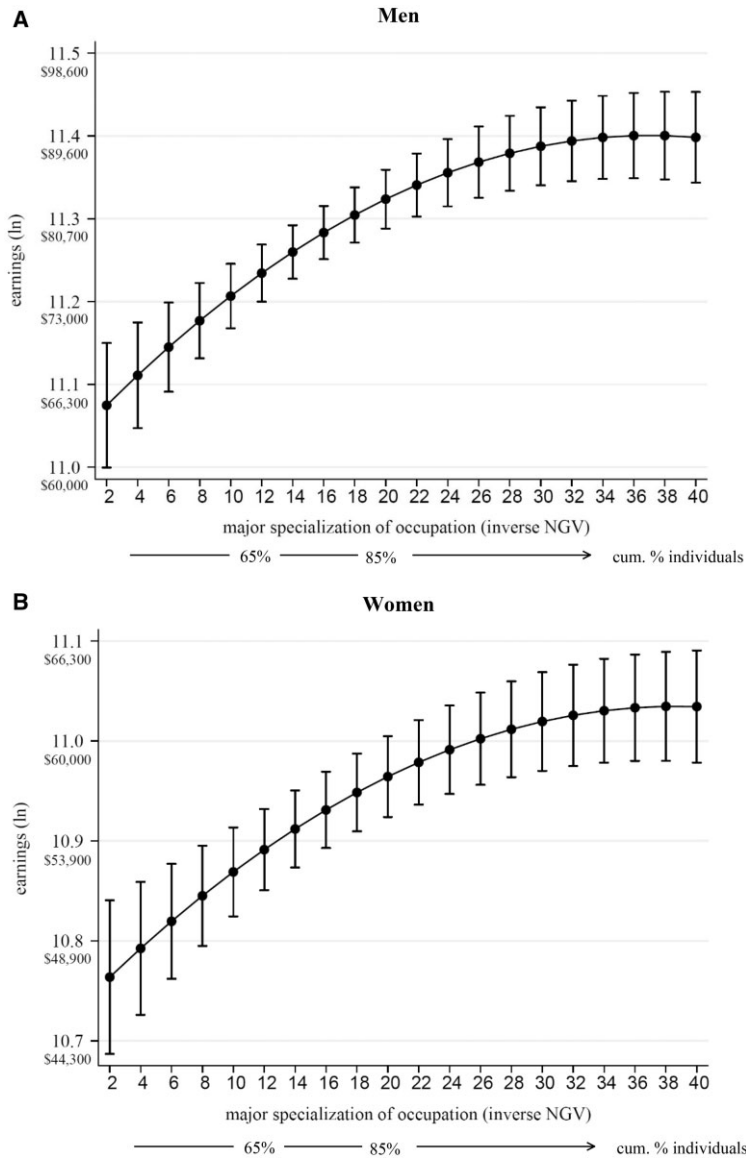


Figure 1. Marginal effects of major specialization of occupations (occupation random intercepts). (A) Men. (B) Women.

Notes: Level-1 predictors: race, age, age-squared, marital status hours worked, weeks worked, highest education credential, college major, region, and major-occupation match (coefficients in [Supplementary Appendix A](#)). Level-2 controls: squared term of major specialization, occupational licensing, union density, vertical credentialing, and gender distribution. See [Supplementary Appendix B1](#) for a model that includes a triple and quadruple term for inverse NGV to test the plateau effect among the highest levels of college major specialization. 95 per cent confidence interval (two-tailed tests).

Source: Authors' calculations of the American Community Surveys 2013–7 (BA graduates). CPSs: union coverage (2013–7) and licensure requirement (2016–7).

(>40) when using triple and quadruple terms (shown in [Supplementary Appendix C1](#)). This implies that occupation-level earnings associated with major specialization remain the same once this high level is reached. The horizontal axes in [Fig. 1](#) include the cumulative share of individuals in the ACS occupations. These indicate that fewer than 10 per cent of college graduates are employed in the occupations with an inverse NGV of 25 or higher (rightmost in [Fig. 1](#))—among which major specialization does not yield additional earnings. However, for a vast majority of higher-educated workers (inverse NGV <25), a higher concentration of college majors is associated with higher earnings levels.

[Table 2](#) reports all coefficients of occupational closure on logged earnings in both bivariate and multivariate models. The bivariate models in the first columns display a small but positive significant association between licensure and earnings (0.0073 for men, 0.0067 for women). In other words, a 1 per cent higher licensure in the occupation is associated with roughly 0.73 per cent and 0.67 per cent higher earnings. An occupation's union density is negatively associated with earnings for men (−0.0207) and not associated with earnings for women in the bivariate models. We find significant associations for vertical credentialing in the expected directions: a negative coefficient for the percent of bachelor's degree holders and earnings (−0.0083 and −0.0085) and a positive coefficient for the percent of master's degree or more and earnings (0.0064 and 0.0062). Following previous studies, the percentage of women in an occupation is negatively associated with earnings levels for both genders (−0.0069 and −0.0074). College selectivity is positively associated with occupation earnings levels: a 1 per cent higher share of R-1 or Doc-1 college graduates is associated with about 2.3 per cent higher earnings for both men and women.

Importantly, and of primary interest to answer our research question, the multivariate model indicates a significant and large positive linear association between occupations' major specialization and earnings after accounting for the squared term and all other individual-level and occupational-level variables: 0.0205 ($P < .001$) for men and 0.0161 ($P < .001$) for women. The results of this model are visually presented in [Fig. 1](#). The linear component of the multivariate model hence indicates that a one-unit increase in an occupation's major specialization (inverse NGV) yields 2.1 per cent and 1.6 per cent higher earnings for men and women, respectively.

One important robustness check is presented in the third columns of [Table 2](#), where we add the occupation's level of college selectivity to the multivariate models—a variable available for 225 occupations. We still find an evident positive linear impact of major specialization on earnings of 0.0196 ($P < .001$) for men and of 0.0154 ($P < .001$) for women. We also note that the college selectivity estimate remains non-significant in the multivariate model. In other words, college selectivity—an important possible confounder of occupational closure mechanisms in the higher-skill segment of the labor market—only marginally attenuates the relationship between college major specialization and occupational earnings. We observe some moderation of the occupation-level control variables when comparing the bivariate and this most complete multivariate model, yet there are no substantive shifts in the coefficients.

A second robustness check, which additionally accounts for occupation skill level (as measured by O*NET via expert surveys), is presented in the rightmost column of [Table 2](#). These models add all selected basic skills and process skills to the full model. [Supplementary Appendix B2](#) presents the bivariate and multivariate estimates of each occupation skill level indicating positive associations in the former and, as expected, moderated associations in

Table 2. Occupation-level effects on earnings.

	Men				Women			
	Bivariate	Multivariate (Fig. 1)	Multivariate (+ college selectivity)	Multivariate (+ skill level)	Bivariate	Multivariate (Fig. 1)	Multivariate (+ college selectivity)	Multivariate (+ skill level)
Major specialization								
Inverse NGV	0.0353*** (.0061)	0.0197*** (.0037)	0.0188*** (.0036)	0.0144*** (.0037)	0.0315*** (.0060)	0.0161*** (.0039)	0.0154*** (.0039)	0.0131*** (.0036)
Inverse NGV—squared	−0.0004*** (.0001)	−0.0003*** (.0001)	−0.0003*** (.0001)	−0.0002** (.0001)	−0.0003** (.0001)	−0.0002** (.0001)	−0.0002** (.0001)	−0.0002** (.0001)
Licensure								
Per cent with license requirement	0.0073** (.0026)	0.0030 (.0017)	0.0038* (.0017)	0.0031 (.0018)	0.0067** (.0025)	0.0034 (.0018)	0.0041* (.0019)	0.0025 (.0017)
Union density								
Per cent union member or represented	−0.0207* (.0085)	−0.0175*** (.0046)	−0.0184*** (.0047)	−0.0138*** (.0044)	−0.0108 (.0084)	−0.0113* (.0048)	−0.0125* (.0051)	−0.0068 (.0042)
Vertical credentialing								
Per cent less than bachelor’s degree	−0.0083*** (.0010)	−0.0040*** (.0011)	−0.0035** (.0011)	−0.0031** (.0012)	−0.0085*** (.0009)	−0.0047*** (.0012)	−0.0044*** (.0012)	−0.0026* (.0012)
Per cent master’s degree or more	0.0064*** (.0010)	−0.0013 (.0011)	−0.0013 (.0011)	−0.0005 (.0011)	0.0062*** (.0010)	−0.0016*** (.0012)	−0.0017 (.0012)	−0.0010 (.0011)

continued

Table 2. *Continued*

	Men				Women			
	Bivariate	Multivariate (Fig. 1)	Multivariate (+ college selectivity)	Multivariate (+ skill level)	Bivariate	Multivariate (Fig. 1)	Multivariate (+ college selectivity)	Multivariate (+ skill level)
Gender distribution								
Per cent female	−0.0069*** (.0010)	−0.0035*** (.0006)	−0.0031*** (.0006)	−0.0029*** (.0006)	−0.0074*** (.0010)	−0.0044*** (.0006)	−0.0040*** (.0007)	−0.0030*** (.0006)
College selectivity								
Per cent bachelor's from R-1 or Doc-1	0.0229*** (.0032)		0.0043 (.0024)		0.0226*** (.0031)		0.0038 (.0023)	
Occupation skill-level variables	No	No	No	Yes	No	No	No	Yes
Level-1 variables (individuals)	No	Yes	Yes	Yes	No	Yes	Yes	Yes
N (individuals)	680,335	680,335	677,532	665,506	736,746	736,746	735,887	724,439
N (occupations)	230	230	225	218	230	230	225	218

Notes: Level-1 predictors: race, age, age-squared, marital status hours worked, weeks worked, highest education credential, college major, region, and major-occupation match (coefficients in [Supplementary Appendix A](#)). Robustness checks in [Supplementary Appendix B](#) (occupational skill level) and [Supplementary Appendix C](#) (alternative specifications and subgroups).

* $P < .05$; ** $P < .01$; *** $P < .001$ (two-tailed tests).

Source: Authors' calculations of the American Community Surveys 2013–7 (BA graduates). CPSs: union coverage (2013–7) and licensure requirement (2016–7). NSCG 2015: college selectivity (Carnegie Classification 1994).

the latter. We note slightly smaller point estimates for the linear association between major specialization and earnings without losing statistical significance: from 0.0188 to 0.0144 for men and from 0.0154 to 0.0131 for women. In other words, using a crude measure of occupation skill level (i.e. human capital), major specialization is still positively associated with earnings.

4.3 Major-occupation matching of individuals

For our second research question, regarding individual workers' payoffs from occupational matching, we use occupation-fixed effects models. This means that all unique occupation-level factors that contribute to earnings variation are accounted for in the major-occupation estimates. We are exclusively concerned with the adjusted *individual-level* association between our continuous measure of major-occupation match—the percent of workers in the occupation who hold the same major as the individual—and the individual's earnings. These estimates should be interpreted as within-occupation matching payoffs as respondents have already been selected into the occupation.

Figure 2 plots the margins estimates for the major-occupation matching measure for different levels of matching (percentages ranging from 5 to 75) for men (A) and women (B) separately. We find a significant positive association between major matching within occupations and earnings: 0.00360 ($P < .001$) and 0.00479 ($P < .001$) for men and women, respectively. Concentrating on the linear component of the predictive model, this means that a 10 per cent increase in the share of workers holding the same college major within the occupation as the individual is associated with 3.6 per cent (men) to 4.8 per cent (women) higher earnings. These effect sizes translate to a couple of thousand dollars annually, as shown on the vertical axis of Fig. 2. Conversely, we estimate that the occupation-level college major specialization association with earnings reflects several tens of thousands of dollars annually (Fig. 1).

We also test the squared term of the major-occupation match, which is statistically significant. This implies that the relationship between major-occupation match and earnings reaches a ceiling around 50 per cent, as shown in Fig. 2. That is, the earnings payoffs from the strongest forms of occupational matching do not become statistically significantly higher beyond holding a college major that is held by more than half of other college-educated workers in the same occupation.

We make two additional observations. First, we note that a relatively small proportion of college graduates are in an employment position characterized by holding a major alongside more than 50 per cent of other workers in the occupation. This share is about 15 per cent among men and 20 per cent among women, as indicated by the cumulative share (of individuals) arrow on the horizontal axes in Fig. 2. Thus, for a vast majority of higher-educated workers, the association between major-occupation match and earnings is positive and statistically significant. Second, the strongest major-occupation matches among men (65 per cent or more, representing only 8 per cent of the sample) and among women (75 per cent or more, representing only 3 per cent of the sample) display predictive earnings levels below the ceiling. We cannot exclude the possibility of unobserved individual characteristics and selection driving the weaker association in this small subgroup. Nonetheless, our results provide clear evidence for a ceiling effect in the association between major-occupation matching and earnings.

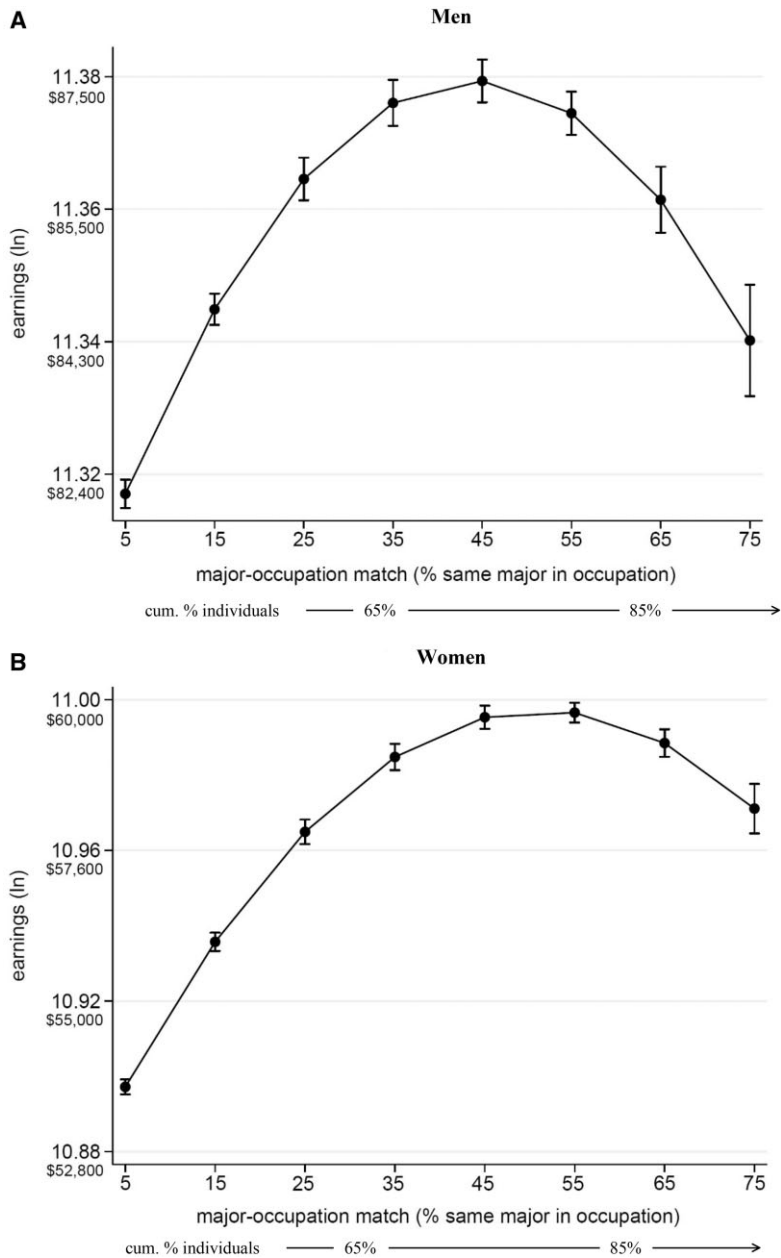


Figure 2. Marginal effects of major-occupation match on earnings (with occupation fixed-effects). (A) Men. (B) Women.

Notes: Controls: race, age, age-squared, marital status, hours worked, weeks worked highest education credential, region, college major fixed-effects, and occupation fixed-effects. 95 per cent confidence intervals (two-tailed tests).

Source. Authors' calculations of the American Community Surveys 2013–7 (BA graduates).

4.4 Robustness checks and limitations

We conducted several robustness checks in addition to adding a control variable for college selectivity (see [Table 2](#)). First, one critical analytical decision is to consider an occupation to be part of “higher educated segment” of the labor market if at least 25 per cent of workers hold a bachelor’s degree or higher. This is a liberal definition because on average 38 per cent of workers between ages 25 and 64 hold a bachelor’s degree (ACS 2013–7). A sensitivity analysis demonstrates that neither more liberal (15 per cent and 20 per cent) nor more conservative (30 per cent and 35 per cent) cut-offs have major consequences for the main findings regarding major specialization payoffs ([Supplementary Appendix C2](#)) and major-occupation matching payoffs ([Supplementary Appendix D1](#)).

Second, while our focus on the role of undergraduate majors in earnings gaps does not ignore graduate school attainment—which is added as an individual-level control—it does leave out the post-graduate field of study among college-educated workers who attained a master’s degree or higher. This variable is unfortunately not available in ACS data. We believe that selection into becoming an advanced degree holder is to a large extent a function of undergraduate majors and post-college employment ([Bedard and Herman 2008](#)), but this does not exclude the possibility of occupations relying heavily on advanced degree credentials and its embedded skills. [Supplementary Appendix C3](#) and [Supplementary Appendices D2/3](#) indicate that such mechanisms only marginally affect our estimates of major specialization payoffs and major-occupation matching payoffs. The main results hold among (individuals in) 133 occupations that contain an above average share of MA+ workers (>13.5 per cent).

Third, aside from controls for age and age-squared in all analytical models—a crude indicator of work experience—the life course effects of college majors on earnings differentials remain beyond the scope of the current study. Our approach relies on cross-sectional data and therefore cannot differentiate between current and cumulative payoffs from college majors. This seems particularly relevant to obtain a full picture of major-occupation matching as previous studies have shown age-specific payoffs from (non-) versus technology majors and general versus vocational majors ([Forster, Bol, and Van de Werfhorst 2016](#); [Hanushek et al. 2017](#); [Deming and Noray 2020](#)). Future studies may be able to employ longitudinal data to understand whether, for example, major-occupation matching yields differentials payoffs earlier or later into the career, depending on the field of study. We ensured that none of the reported closure and matching estimates are driven by either younger workers or older workers: [Supplementary Appendix C4](#) presents analyses of major specialization by age group (25–34, 35–44, 45–54, and 55–64), showing comparable marginal effects from [Fig. 1](#). [Supplementary Appendices D2 and D3](#) plot the curvilinear relationship between major-occupation match and earnings as shown in [Fig. 2](#) for four different age groups.

Fourth, we tested whether results hold for bachelor’s degree graduates who never attained graduate school and among college-educated workers who worked year-round and full-time (models control for typical hours worked and number of weeks worked). [Supplementary Appendices B5 and C4](#) demonstrate that the estimates and significance levels among these groups are comparable to the main results. This is also the case for most of four major racial-ethnic groups (White, Black, Hispanic, and Asian, by gender), as shown in the same [Supplementary Appendix](#) tables. The major-occupation effect sizes vary across groups as Hispanic men display a substantially higher positive association (0.00723) as compared to the study sample (0.00392). The occupation-level payoffs from major

specialization appear smaller for Black college graduates of both genders (around 0.010 vis-à-vis 0.0197 [men] and 0.0156 [women]) and cease to be statistically significant for Hispanic women. The latter might be attributable to a relatively small sample size (3,366 workers employed in only 183 out of the 230 occupations).

Fifth, this study of cross-sectional observational data cannot estimate causal effects of occupational closure via college majors and major-occupation matching. We mitigate the chance of the major specialization associations with earnings being driven by other occupation-specific patterns by controlling for indicators of alternative closure mechanisms (i.e. licensure), alternative drivers of occupation-specific matching (e.g. vertical credentialism), occupation-level human capital payoffs (i.e. O*NET indicators of skill level), and individual-level predictors of earnings (i.e. college major fixed effects). In addition, we run sensitivity tests to examine the strength of hypothetical unmeasured variables that would invalidate the significant associations of inverse NGV and major-occupation matching with earnings. Using Frank et al.'s (2013) method of calculating omitted variable bias in regression with observational data, we find that, to invalidate the positive association between major specialization and earnings, 97.1 per cent (for men) and 93.4 per cent (for women) of the observed cases would have to be replaced by counterfactual cases for which there is a zero effect.³ In other words, more than 90 per cent of cases would have to be replaced by counterfactual cases for which there are zero effect in order to invalidate our inference that major specialization leads to significantly higher earnings. Regarding the major-occupation matching estimates, we find that 90.9 per cent (for men) and 93.7 per cent (for women) of values/cases would have to be due to bias.

5. Conclusion

The sociology of work and occupations has addressed the returns to education and skills in several different accounts (Hout 2012). The mechanisms that explain “excess rewards”, over and above the direct returns from skill, have been theoretically developed and empirically tested at the occupational level (closure) and at the individual level (matching). The literature suggests that excess rewards and other relative earnings boosts should be understood as resulting from a combination of contextual dynamics. Net of individuals’ human capital (i.e. educational attainment and experience), earnings variation results from, first, individuals entering an occupation that contains varying levels of institutionalized educational credentialism, licensure, and unionization (Weeden 2002) and, second, from matching one’s educational level and field with those predominant within that occupation (Bol et al. 2019).

However, we argue that understanding the monetary returns to closure and matching processes for the college-graduate segment of the labor market requires a more specific set of measures and indicators than the prior literature provides. This is in part because “traditional” occupational closure via licensure and union density is less important among this subgroup of highly educated workers. These two closure devices are far less common among high-skill occupations. Empirically, we find a comparatively small—and in some models non-significant—association between licensure and earnings among “higher-educated occupations”. With regard to union density, we find a negative association with occupational earnings. This can be explained by the limited union representation of high-skill occupations in the USA (Western 1999; Western and Rosenfeld 2011), as well as their

reduced power to affect wages (Tomaskovic-Devey and Avent-Holt 2019). It also corresponds with Redbird's (2017) nuanced study, which challenges the notion that occupational licensure necessarily leads to higher earnings through more control, and argues that it leads primarily to occupational expansion.

For this reason, our analysis concentrates on the most important divider of job prospects *among* college graduates and *within* the higher-educated segment of the US labor market: the mechanisms of earnings variation through the college major or field of study. We contend that the horizontal educational credentialing available to college graduates can supplement or even substitute for traditional closure devices in the high-educated segment of labor markets. Our two key research questions build directly on recent frameworks regarding occupational closure and occupational matching.

First, whereas traditional occupational closure research covering the entire workforce conditions on educational *level*, we specify the educational component of closure by college majors among a highly educated group (all college graduates) to get a better sense of its capacity to boost earnings at the occupational level (i.e. "excess rents"). The indicator we designed to measure occupational closure via credentials is "college major specialization," which is the *inverse* of the qualitative variance of all majors represented in occupations commonly attained by college graduates. We find that, conditional on a range of socio-demographics, individual-level major-occupation match, and established occupational closure devices (licensure, union density, vertical educational credentialing, gender distribution, and college selectivity), an occupation's major specialization is positively and strongly associated with occupational earnings. Thus, building on mechanisms of occupational closure (Weeden 2002; Weeden and Bol 2015), we confirmed our hypothesis: college graduates in common occupational destinations for college graduates benefit from excess rents as maintained by educational closure based on particular college majors. Earnings premiums from exclusion in the higher-educated segment of the labor market require an understanding of the college major as a primary closure device. Our analysis further indicates that the association between college major closure and earnings has a ceiling—the major specialization does not pay off *more* among a small group of the most major-specialized occupations.

Second, having identified the role of college majors in occupational closure in the higher-educated section of the labor market, we asked whether at the individual-level matching one's college major—reflecting a combination of skills and status—with that of others in one's occupation yields an additional payoff at the individual level, *conditional* on having entered an occupation. Recent studies by DiPrete et al. (2017) and Bol et al. (2019) have shown that individuals obtain higher earnings if they match the common occupational destination of counterparts holding the same degree (level and field). Our measure of matching concentrates on the *major-occupation* match—the percent of workers in one's occupation with the same field of study as oneself (where the educational level—college-educated—is already the same). It also provides more easily interpretable (continuous) scale compared to the binary matched versus mismatched measure as proposed by Bol et al. (2019). We find, surprisingly, that matching one's own college major with the common fields represented in the occupation only modestly boosts earnings—ranging between 3.6 per cent and 4.8 per cent higher earnings per 10 per cent increase in the share of workers holding the same major.

One advantage of a continuous measure of a major-occupation matching is that it enables us to interpret the implications of "mismatching" for earnings differentials. Our fine-grained measure of major-occupation matching calls into question some previous findings

regarding an assumed substantial earnings penalty from horizontal *mismatching* among college-graduates. Concentrating on the USA, Robst (2007) used a binary indicator of mismatching (vis-à-vis matching) and found that not aligning one's field of study with the occupation yields a 20 per cent earnings penalty. Our analyses paint a different picture of the consequences of mismatching as the modest earnings boost from major-occupation matching simultaneously indicate that mismatching leads to small earnings penalties. In our theoretical model, as well as in our application, a major-occupation mismatch is defined on a scale—holding a relatively rare major compared to one's colleagues. Even if we were to compare the “least matched” college graduates with the “best matched” college graduates, earnings differentials would not be anywhere near a 20 per cent deficit.

Furthermore, we allowed predictive models to test for a curvilinear relationship between matching and earnings. We find that the small share of college graduates who are “best matched” do not additionally benefit from this status compared to those whose major is shared by about 50 per cent of other workers in the same occupation. While more research is necessary to understand this mechanism, our novel major-occupation measure is the first that enables researchers to observe this non-linear relationship. We test for this because there is no reason for major-occupation matching to be linearly predictive of earnings. Moreover, a strong major-occupation match might be beneficial to (perceived) productivity, but an even stronger match would reduce to opportunity for workers to bring in expertise, knowledge, or skills that (1) are relevant for employers and (2) remain external to the dominant college major in that occupation. While there might be an optimal level of being a “specialist” within one's occupation, as we speculate on here, there could be other unobserved factors that could account for the non-linear relationship. However, given our analytical strategy, these factors cannot relate to college major-specific or occupation-specific factors, as we include these fixed effects in the models.

The relatively small earnings premium from occupation matching aligns better with closure theory than with human capital theory, although they are not mutually exclusive. As mentioned in our discussion of signaling and credentialism, all it takes for closure mechanisms to arise is that college credentials—including majors—have a status or prestige value that can be employed as barriers to restrict labor supply. Thus, within the higher-educated segment of the labor market, the status rankings of college majors may reflect employer demand for “true” skill from higher education programs. However, the fact that we find only small earnings boosts from matching one's major with that of the occupation, for most of college graduates, implies that human capital plays a small role in explaining within-occupation earnings variation. In other words, insofar as human capital acquired in higher education explains earnings levels among college graduates, it does so via the closure mechanisms.

Taken together, we conclude that college majors remain important stratifiers of earnings among the college-educated population. We revealed the earnings-generating mechanism from closure and matching among this college-educated segment of the labor market. More precisely, our results demonstrate that college majors not only yield vastly different earnings levels (Altonji, Blom, and Meghir 2012) as a function of their skill value or demand, they also operate as educational closure devices generating an additional boost to one's earnings. This substantive conclusion supports the idea that choice of college major has far-reaching consequences for the graduates' financial returns, in particular because they provide access to payoffs over and above skill possession and through the occupational level (access rents). However, this does not mean that college graduates who change their mind and redirect their

professional career into a different occupational direction than originally planned face an inevitable earnings penalty. On the contrary, our results of matching imply that individuals who deviate from their co-workers' college major backgrounds have only marginally lower earnings. This means that college graduates who manage to enter an uncommon occupation enjoy very similar earnings levels from as compared to anyone else in that occupation.

Future research should expand on the features of successful college major-occupation "transfers" in longitudinal data—that is, sociodemographic variation or location variation. While our data predict that individuals who enter occupations as strangers by way of college major background earn almost the same as their colleagues, the pathway of such seemingly successful trajectories remained beyond the scope of our study. For instance, some individuals may have attempted a career switch but failed, while others succeeded because of a favorable timing or through on-the-job training opportunities. Finally, the current study applies to the US-educated college graduates and the higher-educated segment of the US labor market. The somewhat weaker linkage between formal training (higher education) and jobs fits the USA's position in various education system typologies (i.e. weak forms of standardization) and labor market classifications (i.e. internal labor markets as opposed to occupational labor markets) (Shavit and Müller 1998; Kerckhoff 2001). The absence of evidence for substantial mismatching earnings penalties in our study may be a unique feature of the relative flexibility of the American higher education system and labor market, which might operate differently in other high-income countries. More cross-national research would be required in order to examine the impact of educational and labor market systems on occupational matching of college graduates. This future research would extend Bol and Weeden's (2015) study that explored the stark differences in apprenticeships, unions, and licensure between Germany and the UK.

Supplementary data

Supplementary data are available at SOCECO Journal online.

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Notes

1. At least one application by Elbers, Bol, and DiPrete (2021) explores school-to-work linkages in greater detail for the European (German and French) context, while discussing important caveats for examining linkage strength in historical-comparative research.
2. The union density variable combines two categories: a member of a labor union or employee association similar to a union and not a union member but covered by a union or employee association contract. The licensure variable is based a follow-up question: "Earlier you told me you had a currently active professional certification or license. Was your certification or license required for your job?"
3. Frank et al. (2013) express the robustness of an inference by the percentage of the estimate that would have to be due to bias to invalidate the observed effect: $(\text{estimate} - \text{threshold}) / \text{estimate} =$

1—threshold/estimate. For major specialization—an occupation-level variable—sensitivity tests are run after OLS regressions with occupation-clustered standard errors.

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