Do Double Majors Face Less Risk? An Analysis of Human Capital Diversification*

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Abstract

We study how human capital diversification, in the form of double majoring, affects the response of earnings to labor market shocks. Double majors experience substantial protection against earnings shocks, of 56%. This finding holds across different model specifications and data sets. Furthermore, the protection double majors experience is more pronounced when the two majors are more distantly related, highlighting the importance of diverse skill sets. Additional analyses demonstrate that double majors are more likely to work in jobs that require a diverse set of skills and knowledge and are less likely to work in occupations that are closely related to their majors.

Keywords: Human capital, Diversification, Double major, Earnings shock
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1 Introduction

Following Ben-Porath (1967), Mincer (1974), and Becker (2009), studies of the returns to human capital overwhelmingly focus on its expected returns. By contrast, studies of financial capital place considerable emphasis on portfolio risk and on how to reduce it (Markowitz, 1952; Sharpe, 1964; Wagner & Lau, 1971). While human capital has an important quantity dimension, it also varies widely in terms of its substantive content, especially at the postsecondary level, an insight that has gained prominence as economists focus more on tasks and skills. It is therefore surprising that given the large amount of human capital (Christian, 2014), researchers have paid minimal attention to the benefits of diversifying it. To begin to address this gap, we ask whether a specific form of human capital diversification is associated with protection from labor market shocks.

Specifically, we use double majors in college to measure human capital diversification (Del Rossi & Hersch, 2008, 2016) and estimate shocks to earnings using deviations of earnings from expected (i.e., mean) levels based on geography, time, and major. With data from the American Community Survey (ACS) and the National Survey of College Graduates (NSCG), we show that a diversified portfolio of human capital, in the form of a double major, is associated with lower sensitivity to earnings shocks. Our baseline estimates show that double majors experience 56% less risk than similar single majors. To the best of our knowledge, we are the first to study this phenomenon.

We hypothesize that double majors possess a wider range of knowledge and skills than single majors and that this diversified set of human capital is a buffer against earnings shocks. If so, the extent of human capital diversification would likely be related to the amount of protection from labor market shocks. The ACS and NSCG categorize majors into coarse and fine fields. We use the two-tier classification to categorize double majors as "local," where both fine fields lie within the same coarse field (e.g., two social sciences), and "global," where the two fine majors are in different coarse fields (e.g., a social science and a natural science). Our estimates indicate that while local double majors are shielded against shocks, global double majors are even more protected.

We propose two ways in which human capital diversification might be associated with less sensitivity to earnings shocks. First, the broader range of skills possessed by double majors may position them for different jobs that are more protected from labor market fluctuations. Second, double majors may generate an option value. For instance, if one major experiences a negative shock in labor demand while the other remains unaffected, a double major can pursue a job related to the unaffected major, thereby mitigating the impact of the adverse shock to their other major on their earnings.[1] We explore this

[1]If double majors generate an option value, it seems likely that the option value would be greatest for people who have recently entered the labor market and who have not yet developed reputations, networks, or specific skills that would tether them to a specific occupation and/or industry (Neal, 1995; Weinberg, 2001).

possibility by estimating the response of earnings to shocks in the major with the higher earnings shock, in addition to the first and second majors. There may be some indication of an option value in that the shock to the earnings in the major with the higher earnings shock being positively but weakly related to earnings.

As indicated, we hypothesize that double majors may be protected from shocks because they possess a wider range of skills and that this range of skills allows them to work in different occupations than their single major counterparts. We explore these hypotheses and study how the occupations held by double majors differ from those held by single majors. We first link skill and knowledge measures from the Occupational Information Network (O*NET) database to the ACS sample and find that double majors, when compared to single majors, tend to work in occupations that are associated with a wider set of high-level skills and knowledge. Put differently, double majors go into occupations that demand a greater breadth of skills. The results are stronger for those whose double majors span more distantly related fields (global double majors), reinforcing our main conclusion that people with broader skill sets are relatively better protected. Second, using the occupation data in the ACS, we construct a measure of major-occupation concentration (Altonji et al., 2012; Blom et al., 2021) based on the share of single majors placing in each occupation. We show that double majors are employed in a wider array of occupations relative to single majors that share one of their majors, which may be a source of protection from shocks.

A natural question is whether completing a double major *per se* reduces risk or if people who choose double majors have unobservable characteristics that reduce the effects of earnings shocks. To be clear, our goal is not to estimate the causal effect of being a double major on risk. Rather, it is to see if diverse human capital including, for instance, the type of broad interests and abilities that might lead someone to acquire a wider range of skills, is associated with less risk exposure. That is, our emphasis is on whether diversified human capital portfolios, regardless of whether that diversification comes from being a double major or from the initial breadth of interests and abilities that leads people to become double majors, shield people from risk.

We distinguish two further sources of endogeneity. The first is that the specific majors people choose may be a response to anticipated shocks. We seek to address this concern by focusing on outcomes for people who are over 30, for whom anticipating earnings shocks to specific majors is likely to be quite difficult given the time gap between major choices and the shocks that we focus on. A second possibility is that vertical differences in ability, as opposed to variations in initial breadth, are associated with less exposure to shocks and a higher probability of obtaining a double major. This argument is a threat in that the underlying factor that reduces sensitivity to shocks is not breadth (regardless of source). In the broad spirit of Murphy & Topel (1990), Altonji et al. (2005), and Oster

(2019), we use the relationship between observed skills and the responsiveness to earnings shocks to gauge the effect of unobserved skills on the responsiveness of earnings to shocks. Specifically, we leverage data from the NSCG to include parental education and college type, which can proxy for skills. Providing some reassurance that our estimates are not driven by unobserved differences in vertical ability, these measures of human capital are unrelated to the sensitivity of earnings to labor market shocks. Moreover, our main results are robust to controls for parental education and college type, as measures of "ability."

Empirically, we follow a two-stage strategy introduced in Hanks et al. (2022). In our novel and easy-to-implement approach, we treat earnings of double majors as a linear combination of the wages in their first and second field of studies, along with the earnings of the higher-paying major. This method allows us to capture the effects of majors on earnings parsimoniously and provides a natural way to estimate and incorporate earnings shocks, which we estimate as residuals for combinations of location, year, and major.

While previous studies of college majors and how they relate to earnings have proposed measures of intellectual diversity such as the Herfindahl-Hirschman Index (HHI) of occupational concentration for majors (Blom et al., 2021) or a modified Gini coefficient of earnings for each major across occupations (Leighton & Speer, 2020), we rely on double major pairs and the intellectual proximity of those pairs, which directly relates to the connection between educational training and knowledge acquisition in those majors. Although our measure of human capital diversification is discrete compared to more continuous measures based on transcript information (Lazear, 2005, 2012; Artz et al., 2014; Rakitan & Artz, 2015; Silos & Smith, 2015; Tchuente, 2016; Light & Schreiner, 2019), we are able to study double majors and intellectual distance between major pairs in massive and representative samples.

Our work also offers a new perspective on the relationship between double majors and labor market outcomes. The previous literature on the returns to double majors has focused on mean earnings as a function of the choice to complete two degrees (Del Rossi & Hersch, 2008) and that the returns vary across institutions (Hemelt, 2010), by gender (Del Rossi & Hersch, 2016), by field (Del Rossi & Hersch, 2016; Pfister et al., 2017; Uddin & Tout, 2020), and over time (Zhu & Zhang, 2021). Perhaps surprisingly, evidence regarding the expected returns to being a double major is quite mixed. While evidence exists that double major earners have statistically higher earnings than graduates with a single major (Del Rossi & Hersch, 2008; Abel & Deitz, 2016; Uddin & Tout, 2020; Zhu & Zhang, 2021), Jiang (2019) shows that there are no statistically significant differences. Furthermore, Pfister et al. (2017) find negative returns to being a double major. Our study suggests that the benefits of being a double major may take the form of less variable earnings. If so, it is possible that average earnings are not higher for double majors in part because the desire to reduce risk increases the supply of double majors.

The remainder of this study is organized as follows. Section 2 introduces the empirical framework and the model specification. Section 3 describes the data sets and construction of main variables and displays the summary statistics. In Section 4, we discuss the results, and concluding remarks are made in Section 5.

2 Methods

2.1 Empirical Specification

The returns to human capital are generally estimated from a regression of log earnings on education and demographic controls. Given our objective to study how human capital diversification mediates earnings risk, we include proxies for educational diversification and shocks to market earnings. We proxy for human capital diversification using double majors and shocks to earnings using residuals from earnings regressions. Our estimation procedure builds on an empirical strategy introduced in Hanks et al. (2022). This framework is appealing as it provides a flexible but parsimonious way of analyzing the earnings of people with one or more identities, which are majors in our context, and also implies a natural way to generate and incorporate measures of shocks.

The core of the Hanks et al. (2022) approach is to characterize the earnings of double majors as a function of the earnings in their first ($w_{1st,i}$) and second ($w_{2nd,i}$) majors as well as the earnings of their higher-paying major ($w_{max,i} = max\{w_{1st,i}, w_{2nd,i}\}$). For convenience, we represent these variables as $W_i = \{w_{1st,i},\, w_{2nd,i},\, w_{max,i}\}$. In this way, we use a relatively straightforward specification to account for the extent to which people's earnings depend on the market returns to each individual major. An alternative approach would be to include a full set of ordered major-pair fixed effects, but such a specification would include thousands of parameters, be hard to interpret, and not allow us to estimate the degree to which earnings depends on each individual major.

We build on this logic to estimate how earnings shocks affect double majors. Specifically, we allow earnings to depend on yearly shocks to the earnings in both majors. Similar to the way we present earnings W_{it}, we define the earnings shock in the first major as $s_{1st,it}$, the earnings shock in the second major as $s_{2nd,it}$, and the larger shock among the two majors as $s_{max,it} = max\{s_{1st,it}, s_{2nd,it}\}$. Given that our goal is to estimate how the response of individual earnings to earnings shocks ($S_{it} = \{s_{1st,it},\, s_{2nd,it},\, s_{max,it}\}$) depends on whether people are double majors, and the degree of similarity between the majors, we include our earnings shock measures and interactions between the earnings shock measures and whether a person is a double major (subject to colinearity restrictions detailed below). While we parameterize our models using major-specific earnings and shocks, our approach is more general and can allow for more complex functions of earnings shocks (or earnings).

Formally, our model is:

$$\begin{aligned} y_{it} = \beta_0 + \beta_1 s_{1st,it} + \beta_2 s_{2nd,it} + \beta_3 s_{max,it} + \beta_4 DM_i s_{1st,it} + \beta_5 DM_i s_{2nd,it} \\ + \beta_6 DM_i s_{max,it} + \beta_7 DM_i + W_i \Gamma + X_{it} \Upsilon + \lambda_o + \varphi_g + \theta_t + \omega_{it}. \end{aligned} \tag{1}$$

In this specification, y_{it} is the log earnings of individual i in year t; DM_i is an indicator variable equal to 1 if individual i reports two majors. As detailed below, for single majors, we set $w_{1st,i}$=$w_{2nd,i}$=$w_{max,i}$, so that in a sample of single majors, the relative importance of each component of W_{it} is unidentified and the sum of the coefficients on the three earning variables is 1. Thus, identification of the relative importance of the components of Γ, coefficients for the three earnings variables in W_{it}, comes from double majors. Our treatment of shocks is similar. Namely, we include an analogous set of shocks and set $s_{1st,it}$=$s_{2nd,it}$=$s_{max,it}$ for single majors, so that in a sample of single majors, the three shocks are not separately identified. Again, as detailed below, we construct the shocks in such a way that they have a combined coefficient of 1 in a sample of single majors. In addition to these variables, we include observed individual characteristics X_{it} including race (black), ethnicity (Hispanic), gender (woman), marital status (married), potential experience and its square, and hours of work per week[2]. Also included in our model are occupation fixed effects λ_o, geographical location level fixed effects φ_g (e.g., census division, census state, etc.), and year fixed effects θ_t. ω_{it} is the error term.

We are interested in the way earnings respond to the earnings shocks, which is reflected by β_1, β_2, and β_3, and especially how the effects of the shocks interact with double major status, DM_i, as reflected by β_4, β_5, and β_6. Due to collinearity, we can identify only one interaction between major level shocks and the double major indicator (i.e., only one of β_4, β_5, and β_6) when we control for all three major level shocks (i.e., when we estimate β_1, β_2, and β_3). Intuitively, the three earnings shock variables can be separately identified for double majors, but only the sum of the earnings shocks is identified among single majors. So if all three earnings shocks are included in the model (i.e., when estimating β_1, β_2, and β_3), one shock will be identified from single majors, the other two earnings shocks will be identified from double majors as will the interaction between double major and one earnings shock (i.e., only one of β_4, β_5, and β_6). On the other hand, if only one earnings shock is included (i.e., estimating only β_1, β_2, or β_3), its effect can be identified from single majors, and interactions between double major and three earnings shocks can be identified from double majors (i.e., we can estimate β_4, β_5, and β_6). As detailed when we present our empirical results, our preferred specification involves estimating all three main effects of shocks (i.e., β_1, β_2, and β_3), and only the interaction between double

[2]Note that while we restrict our sample to people who work at least 35 hours per week, we control for hours per week to account for people who work significantly more than 35 hours per week.

major and the first earnings shock β_4. In this specification, the sum of β_1, β_2, and β_3 is 1 for single majors, and $\hat{\beta}_4$, which is expected to be negative, indicates the differential response to earnings shocks between double majors and single majors.

2.2 Estimating Earnings and Earnings Shocks by Major

As indicated, we estimate earnings, W_{it}, following Hanks et al. (2022) and follow the spirit of that approach to generate our measures of shocks, S_{it}. Our approach involves estimating a "first stage" equation for single majors in which log earnings are regressed on all observed individual characteristics in X_{it}, major fixed effects, occupation fixed effects λ_o, geographical location level fixed effects φ_g, and year fixed effects θ_t. Formally, our first stage model can be expressed as follows:

$$y_{it} = X_i\Gamma + \mu_m + \lambda_o + \varphi_g + \theta_t + \omega_{it}. \tag{2}$$

In this model, the μ_m represents the premium associated with major m, which we use to generate the major-specific earnings, W_i, ($\hat{w}_{1st,i}$, $\hat{w}_{2nd,i}$, and $\hat{w}_{max,i}$). Given that we define the earnings as the mean of the regression-adjusted deviation of earnings from that of other majors, the sum of the coefficients on $\hat{w}_{1st,i}$, $\hat{w}_{2nd,i}$, and $\hat{w}_{max,i}$ in Equation (1) would equal 1 in a sample of single majors (although the separate coefficients would not be identified). In other words, we are estimating the value of major dummies over single majors, so that if we regress the earnings of single majors on those values, they will, by construction, have a (combined) coefficient of 1.

Following Heaton & Lucas (2000), Angerer & Lam (2009), Betermier et al. (2012), Palia et al. (2014), and Fagereng et al. (2018), we measure shocks to majors using the mean residuals from Equation (2) by combinations of geography, year, and major, as the S_{it}, ($\hat{s}_{1st,it}$, $\hat{s}_{2nd,it}$, and $\hat{s}_{max,it}$). We generate these shocks using single majors, which allows us to generate earnings shocks for specific majors.

More formally, we bin the individual error terms, $\hat{\omega}_{it}$, into cells based on combinations of geography, year, and major. We choose the census division of birth as the basic level of geography, but explore specifications using location of residence (instead of birth) and state (instead of division). We take the mean of the residuals in each cell to be our shocks $\hat{s}_{1st,it}$, $\hat{s}_{2nd,it}$, and $\hat{s}_{max,it}$, which are birth division (d), year (t), and major (m) aggregates. Formally, we write $\bar{\omega}_{mdt} = \frac{\sum \hat{\omega}_{it(md)}}{N_{mdt}}$ to capture variation by geography, year, and major, where N_{mdt} denotes the total number of single majors from the relevant (birth) division, year, and major. As robustness checks, we create additional earning risk measures at the birth division-year level $\bar{\omega}_{dt} = \frac{\sum \hat{\omega}_{it(md)}}{N_{dt}}$, major-year level $\bar{\omega}_{mt} = \frac{\sum \hat{\omega}_{it(md)}}{N_{mt}}$, birth state ($s$)-year-major level $\bar{\omega}_{mst} = \frac{\sum \hat{\omega}_{it(ms)}}{N_{mst}}$, birth state-year level $\bar{\omega}_{st} = \frac{\sum \hat{\omega}_{it(ms)}}{N_{st}}$, and division of residence (d_r)-year-major level $\bar{\omega}_{md_rt} = \frac{\sum \hat{\omega}_{it(md_r)}}{N_{md_rt}}$.

One issue with these measures is that single majors enter the calculation of the shocks but double majors do not. As a consequence, shocks will be more highly correlated with earnings of single majors than double majors. This mechanical relationship declines with the size of the cells. To mitigate this concern, we limit our analysis to division-year-major cells with a minimum number of single majors. We present results below to determine the appropriate threshold for inclusion.[3] These analyses (presented below) suggest that a threshold of 100 per division-year-major in the ACS and of 15 in the NSCG produces consistent estimates with the smallest reduction in the sample size and hence precision.

We acknowledge that due to self-selection double majors are likely different from single majors in terms of unobserved "ability." While we do not seek to causally identify the choice to become a double major, we construct earnings shocks by division of birth and match earnings shocks to people using their birth division to address the concern that current location is a result of selection and may be affected by earnings shocks for the main analysis.[4]

3 Data

3.1 Data Source

Our primary analysis uses data from the American Community Survey (ACS), an ongoing annual survey conducted by the U.S. Census Bureau. The ACS is nationally representative and collects information on a rich set of demographics, education, employment, and income for 1% of the U.S. population each year. The ACS also records up to two (ordered) undergraduate fields of study for college graduates, which allows us to generate our measure of human capital diversification. Our sample period is from 2009, when field of study is first included in the ACS, to 2019. We focus on individuals whose highest degree is a bachelor's degree to maximize uniformity since we do not have information on the field of specialization for people with advanced degrees. The sample is further restricted to individuals who are employed, work at least 40 weeks a year and at least 35 hours a week, and are between the ages of 30 and 65. We purposefully start the sample well after most people complete school and discard the first years after graduation for most people to reduce the likelihood that majors are chosen in response to anticipated earnings shocks. We further remove those who are born in U.S. outlying areas/territories to ensure a well-defined division/state of birth. We drop those whose annual earnings (CPI deflated to 2009 dollars) are less than 2,000 dollars to eliminate outliers. After

[3] An alternative would be to use a leave-self-out estimator. Unfortunately, in small cells, such estimators are biased in the opposite direction (i.e., downward), necessitating a minimum cell size too.

[4] We note that time-invariant differences in the composition of majors born in a given division will be absorbed by our fixed effects.

removing missing values,[5] our final pooled ACS sample has 1,429,573 observations.

We also use the National Survey of College Graduates (NSCG) to probe the robustness of our ACS results and address potential ability bias in our estimates. The NSCG is a biennial, U.S.-based, cross-sectional survey that provides rich data on education history, including the first and second majors of bachelor's degrees. Although the sample is considerably smaller than that of the ACS, it has the advantage of including information on parental education levels and the Carnegie classification of institutions where respondents received their bachelor's degrees. This information is useful for examining whether "vertical ability" drives our estimated effects of double majors.

When constructing our sample from the NSCG, we apply similar rules to those used with the ACS. We pool the 2003, 2010, 2013, 2015, 2017, and 2019 waves and restrict the sample to individuals whose highest degree is a bachelor's degree. We also remove those who are not employed, work less than 35 hours a week or above 85 hours a week, are self-employed, or are working towards a degree when completing the survey. Furthermore, we exclude individuals who are below the age of 30 or above the age of 65, whose salary is less than 2,000 dollars (CPI deflated to 2009 dollars), and those who are born outside of the U.S. After removing observations with missing values for variables, the NSCG sample includes 95,413 observations.

To understand the relationship between human capital diversification and earnings shocks, we construct occupation-specific skill and knowledge measures using the Occupational Information Network (O*NET) data. We use these O*NET measures to test the hypothesis that double majors tend to work in jobs with a wider range of skills and knowledge requirements than single majors. The O*NET data are constructed under the sponsorship of the U.S. Department of Labor/Employment and Training Administration. These data include skills-based measures defined as "developed capacities that facilitate learning or the more rapid acquisition of knowledge" and cross-functional skills as "developed capacities that facilitate performance of activities that occur across jobs."[6] Taken together, there are 35 bottom-level skill components including skills such as reading comprehension, writing, programming, and management of financial resources. Similarly, the O*NET defines knowledge as "organized sets of principles and facts applied in general domains," and contains 33 knowledge measures that include English language, administration and management, and mathematics (see Table A.1 for all skills and knowledge categories). The O*NET skill and knowledge dataset contains 873 bottom-level Standard Occupational Classification (SOC) codes, which do not align exactly and exceed the number of unique SOC codes available in the ACS. Hence, we re-categorize the O*NET job classifications into 95 top-level occupations using the first

[5] We drop some double majors (less than 0.4% of the sample) whose division-year-major combinations do not exist for single majors since we use the single major population to generate shocks.

[6] See https://www.onetonline.org/.

three digits of the O*NET-SOC occupation classification codes and match them to the ACS-SOC occupation classification at the three-digit level. Following Aedo et al. (2013), we then compute the weighted average of the skill and knowledge level scores for each three-digit occupation.

3.2 Measuring Double Majors and Summary Statistics

Our measure of human capital diversification is whether a person is a double major. In the ACS, people are identified as double majors if they hold a bachelor's degree in a second field. The variable description in the ACS is "the second field in which the person received a Bachelor's degree, if the person holds a Bachelor's degree in a second field." Without further information on degrees and fields of study, we are not able to distinguish between individuals who hold two bachelor's degrees (also referred to as double degrees) and those who list a second major for their single bachelor's degree (which is the common definition of double majors). Thus, double majors defined in our study likely combine individuals who have two bachelor's degrees and those who have one bachelor's degree and two majors. Regardless of the number of degrees, both of these two groups of individuals have two majors.

To proxy for the academic distance between two major fields, we follow Kniffin & Hanks (2017) and create "global double major" and "local double major" indicators. These measures are constructed based on the hierarchical structure of the degree fields classification in which "bottom-level" fields are classified into more aggregated "top-level" categories. Top-level fields of study are presented in Table A.2 along with how we aggregate some of the smaller fields.[7] A global double major combines two majors across different top-level fields (e.g., sociology and biology), while a local double major has two majors within the same top-level area (e.g., economics and political science, both categorized as social sciences). We assume that, on average, global double majors have a more diversified human capital portfolio compared to local double majors.

In our ACS sample, 10.2% of respondents are classified as double majors. The percentage of double majors found in previous studies varies based on sample representativeness, survey year, and the measurement of a double major. For example, Abel & Deitz (2016) use the 2009-2013 waves of the ACS and find that 12.1% of their sample are double majors, while Zafar (2012) relies on survey evidence from a single university and finds that 45% of their sample are pursuing more than one major. Among all double majors in our ACS sample, 70% are global and 30% are local double majors. Table A.3 reports the 20 most common double major pairs in our ACS sample, using the bottom-level fields of study. Among the 145,826 individuals with a double major, the most commonly ordered pairing is "Business Management and

[7] In the ACS, there are 38 top-level fields of study and 175 bottom-level fields of study in our sample.

Administration" and "Accounting" with 2,533 people (1.74% of the double majors). The most commonly ordered global double major combination is "History" and "Political Science and Government," accounting for 1091 people or 0.75% of all double majors.

To further explore the distribution of college majors in our ACS sample and provide a more direct illustration, based on the top-level fields in the ACS, we further aggregate college majors into 18 categories (see Table A.2). Table A.4 reports the share of single majors for each major in column (1). Column (2) shows the percentage of people with each major (either as their first or second major) who are double majors. Column (3) presents the percentage of double majors listing each major as their first major and column (4) displays the percentage of double majors listing each major as their second major. Business is the most popular college major choice, among single majors and for both the first and second major of double majors, followed by Humanities and Social Science. For example, 28.9% of our single majors choose Business as their major, and 36% of double majors choose Business either as their first major or second major.

In the NSCG, we define double majors as individuals who have a second major for their Bachelor's degree,[8] which is similar to the definition used in Del Rossi & Hersch (2008) and Hemelt (2010). In our NSCG sample, the share of respondents who are double majors is 16.3%. The NSCG differs from the ACS in several ways. First, double majors are defined in the NSCG as individuals who report both a primary field and a secondary field for their bachelor's degree. Thus, double majors in the NSCG may include those who have a minor rather than a second major in college, and unfortunately, we cannot distinguish between the two. Indeed, this difference may account for the higher share of double majors in the NSCG sample relative to the share in the ACS sample. Second, the NSCG public files do not report the state of birth (only Census division of birth), so we use Census division of birth for all analyses in the NSCG. Third, the NSCG sample is less than 5% of the size of the ACS sample and has a special focus on college graduates in science and engineering fields. Given the nature of the ACS data, we believe that the share of double majors based on the ACS is more representative of double majors overall.

We present demographic characteristics from the ACS and NSCG in Table 1. Panel A of Table 1 summarizes the main characteristics of respondents in our ACS sample. Compared to single majors, double majors are less likely to be black or Hispanic but more likely to be women. They tend to have a lower likelihood of being married and fewer years of potential work experience.[9] The unconditional earnings difference between single majors and double majors is statistically significant but relatively small at 1.2%. Panel B reports summary statistics for our NSCG sample. The NSCG includes data

[8] The corresponding variable descriptions in the NSCG are "field of second major (or minor) for first bachelor's degree (2003, 2010, 2013, 2015, 2017 NSCG)," and "field of study of second major for first bachelor's degree (2019 NSCG)."

[9] In our analysis, we measure experience from age 22.

on parental education and measures of the type of tertiary institution people attended, which are not available in the ACS. On average, double majors in the NSCG have lower levels of parental education and are more likely to graduate from comprehensive and liberal arts universities than single majors. From these summary statistics, it is not clear that double majors have, on average, higher "ability" than single majors. However, it is possible that individuals from families with lower parental education levels may be more motivated and ambitious to succeed academically, so that they may pursue two majors to enhance their knowledge, skills, and competitiveness in the job market. The differences in the prevalence of double majors across institutions may also reflect potential barriers to double majoring in research and doctorate-granting universities (Del Rossi & Hersch, 2016).

(Table 1 here)

3.3 Description of Earnings Shocks

Based on Equation (2), we generate our earnings shock proxies by using single majors. Our main specification uses residual earnings at the division-year-major level, but for our robustness checks, we also generate earnings shocks at various other levels. To provide a sense of our earnings shocks, we summarize their variation by census division, across time, and by major. Figure 1 plots the census division aggregates of the standard deviations of the earnings shocks. Figure 1 indicates that the shocks are greatest in the South Central (East and West). The East North Central, on the other hand, has the smallest shocks, with the other regions being intermediate.[10] Figure 2 shows the standard deviation of the shocks over time. The variability of these shocks only ranges between 0.43 and 0.48. Variation peaks during the 2010 financial crisis and climbs again in 2019.

(Figure 1 and Figure 2 here)

We also summarize variation in the shocks both within and between majors. Within each bottom-level field, we first generate the standard deviations of shocks. Figure 3 plots the distribution of the standard deviations of the shocks for each bottom-level field within each top-level field. On average, earnings shocks tend to be larger in fields such as Agriculture and Other STEM. They are smallest in Biology and Life Sciences, Psychology, Business, and, tellingly, Interdisciplinary majors.

(Figure 3 here)

[10]The population of the regions can influence the standard deviations. We (1) believe that this effect is small given that we set a threshold for the number of people in each division-year-major cell; (2) do not see an indication that regions with smaller populations have higher standard deviations; and (3) obtain similar results using procedures that control for differences in the size of cells.

4 Human Capital Diversification and Earnings Shocks

4.1 Baseline Results

Using our ACS sample, Table 2 shows how earnings are related to shocks in the first major, second major, and major with the higher shock, and how the relationship between individual earnings and earnings shocks differs between single and double majors. All earnings shocks are calculated at the birth division-year-major level. For all the regressions, we include the baseline controls in Equation (1). We also restrict the sample to birth division-single major-year cells with at least 100 observations based on the discussion below.

To illustrate our methods and main findings more clearly, column (1) limits the sample to single majors and reports the coefficients on shocks to earnings in the first major, second major, and major with the higher shock. With log earnings as our dependent variable and shocks to log earnings as our independent variables, the coefficients can be interpreted as elasticities. The coefficient equals one by construction, indicating that a shock that increases the earnings of single majors by 1% corresponds to a 1% increase in the earnings of single majors with that major. Moreover, all three major shocks are the same for single majors, so all but one are dropped.

The sample in column (2) includes both single and double majors. The estimates indicate that earnings are more strongly related to shocks to earnings in the first major than shocks in the second major or the major with the higher shock. Specifically, a 1% shock to earnings in the first major increases earnings by roughly 0.41%; a 1% shock to earnings in the second major increases earnings by roughly 0.35%; and a 1% shock to earnings in the major with the higher earnings shock raises earnings by 0.22% (not significant). The coefficients on log earnings in the first, second, and higher-paying majors are reported at the bottom of the table, where the first major (0.50) plays a larger role relative to the second major (0.26) and the higher-paying major (0.27). The earnings premium associated with a double major is small and statistically insignificant. Thus, for double majors, the choice of the first major plays a predominant role in earnings and the extent to which individuals are influenced by shocks. Additionally, the relative sizes of the coefficients of first and second major earnings implicitly indicate that the ordering of major choices reported in the ACS is informative because the coefficients on two randomly ordered majors should be equal (see Hanks et al. (2022) for additional evidence that the ordering is informative). Lastly, the positive (but insignificant) coefficient on the shock to the major with the higher shock may indicate a modest option value from moving to the major with the higher shock.

The remaining specifications in Table 2 examine how the response of individual earnings to division-year-major level earnings shocks differs between double and single majors. In column (3), we interact the shock to earnings in the first major with an indicator for being a double major. As discussed, due to collinearity and the construction of the shocks, the interaction between being a double major and only one shock is identified when all three earnings shocks are included. The results show that double majors are substantially buffered against earnings shocks in the first major. The coefficient on the interaction term between the first major shock and being a double major is negative, sizeable, and statistically significant. Specifically, it suggests that double majors are buffered against shocks to earnings in the first major by roughly 56%. Intuitively, the coefficient on the shocks for single majors is 1, so double majors are insulated from 56% of the shock.

In the remaining columns, we report alternative specifications that are isomorphic to the one in column (3) and yield equivalent results just with different variables "turned on and off." Column (4) uses an alternative specification in which we interact the three earnings shock variables with the double major indicator and keep only the shock to earnings in the first major. As indicated, the presence of collinearity allows us to estimate the effects of only one of the main earnings shocks when we include interactions between all three earnings shocks and the double major indicator. In this case, the coefficient on the shock to the first major is identically equal to one (it is identified entirely from single majors) and the interactions between the double major indicator and the second and higher major shocks take on the values of the (uninteracted) shocks in column (3). The estimated coefficient on the interaction term is -0.84. When this coefficient is added to the interactions for the second major shock (0.127) and higher major shock (0.154), it reproduces the coefficient of -0.56 observed in column (3).

Column (5) only includes an interaction between the double major indicator and the second major shock. The offset associated with a double major is the same as column (3). Overall, Table 2 demonstrates that the effect of earnings shocks is considerably more muted for double majors compared to single majors. Given that the specifications in the last three columns are isomorphic and that the interaction between the double major indicator and the first major shock in column (3) is cleanly interpretable as the protection experienced by double majors, we use column (3) as our main specification.

(Table 2 here)

As indicated, to eliminate bias from calculating earnings shocks for single majors and then estimating the effects on earnings, we exclude small cells where the bias from including own earnings will be the largest. To assess the cell size at which this bias is effectively eliminated, we re-estimate the model in column (3) of Table 2 where we progressively increase the minimum cell size for inclusion in the regressions. Figure 4 illustrates that the coefficients on the first major shock decline until it stabilizes at a threshold of roughly 100. The coefficients for the second major shock appear hump-shaped in the cell threshold, while the coefficient on the higher major shock increases (because the sum of the coefficients on the shocks should be close to 1 and the first major shock is declining at low thresholds and the second major shock is declining at higher thresholds). The interaction with double major reaches a plateau at a threshold of 50 and a second peak near 100. Thus, it appears that by a threshold of 100, the coefficients on both the first major shock and its interaction with double majors stabilize. Consequently, we drop division-year-major cells with fewer than 100 observations, and we are also forced to drop double majors with one (or both) majors in any division-year-major cell that has fewer than 100 observations.

(Figure 4 here)

Table 3 investigates how our results vary with the unit at which we measure earnings shocks. Column (1) repeats the estimates from our main specification in column (3) of Table 2, where shocks are measured at the division-year-major level. In column (2), we use year-major shocks, which are constructed by averaging log earnings residuals at the year and major level. Our results show that double majors are insulated from earnings shocks by 31.9%.[11] In column (3), we measure shocks at the division-year level. This specification is challenging because there are only 99 levels of the shocks (9 divisions * 11 years). Not surprisingly, in this model, the insulation experienced by double majors is less precise. Columns (4) and (5) replicate the analysis in columns (1) and (3) using state of birth instead of division of birth. The insulation experienced by double majors in column (4) is quite close to that in column (1), indicating that the level of aggregation is not critical. The results in column (5) are considerably stronger and more precise than in column (3) as the number of levels of shocks increases from 99 to 550.

(Table 3 here)

The paring of majors varies in terms of their distance, which is likely related to the breadth of knowledge and skills a double major possesses. If possessing a wide range of knowledge and skills is a reason why double majors are buffered against shocks, it seems reasonable that the amount of protection might increase with the distance between the majors. To explore this hypothesis, we leverage the hierarchical nature of the classification of majors and assume that double majors in the same top-level category are, on average, closer together than those that span top-level fields. Table 4 divides double majors into global and local double majors using this approach and estimates the extent of protection experienced by each group in response to the shocks presented in the previous table.

[11] The sample sizes vary across the columns of the table due to the exclusion of cells with fewer than a certain number of observations, which varies depending on the level of aggregation. To account for these differences, we recompute the shocks for each specification.

Column (1) shows that global double majors are substantially better protected than local double majors. Specifically, global double majors are buffered against earnings shocks by almost 64% of first major shocks while local double majors are buffered by only 36%, with the difference being statistically significant at the 5% level. The results in column (2) for year-major shocks are quite similar. The estimates using division-year shocks in column (3) are (again) quite noisy as expected. However, when shocks are measured at the state-year-major (column (4)) or state-year level (column (5)), the difference between global and local double majors is large and statistically significant. Overall, global double majors seem to experience better protection against earnings shocks, suggesting the more diversified the college education, the greater the protection against earnings volatility in the labor market.

(Table 4 here)

4.2 Robustness Checks

This section explores a range of robustness checks. Our main specification, reproduced in column (1) of Table A.5, controls for fixed effects for 99 occupations. As we show below, double majors tend to enter different occupations compared to single majors. To explore the role of occupation choice, we re-estimate our models dropping the occupation fixed effects in column (2). The R-squared value decreases by 10 percentage points when the occupation controls are removed, indicating that the occupation controls improve the fit of the model considerably. The estimated premium associated with being a double major increases from 0.6% to 3.1% when the occupational dummies are removed. This suggests that part of the premium associated with being a double major is due to differences in occupations between double and single majors, a possibility that we explore further below. At the same time, the earnings protection associated with double majors remains essentially unchanged.

Our main analysis relies on the division of birth to generate earnings shocks, as division of current residence is likely to be endogenous. However, division of residence might better capture individuals' current labor market conditions. Column (3) replaces division of birth with division of residence when generating shocks. For this analysis, we re-estimate our shocks based on the division of residence (as well as year and major) and attach people to the shocks in their division of residence, year, and college major. The results are consistent, indicating that double majors are protected against earnings shocks when we measure the shocks based on respondents' division of residence. Because we construct division of residence from the state of residence, we can also explore whether using the state of residence affects our findings. Column (4) repeats our estimates based on state of birth and column (5) reports estimates based on state of residence, which are quite similar.

We further provide two subgroup analyses, dividing the ACS by gender and by race/ethnicity to investigate whether the effects vary across demographic characteristics in Table A.6. For this analysis, we regenerate the shocks by gender and by race/ethnicity and then estimate our models using these group-specific shocks.[12] Our estimates show that the protective benefits associated with being a double major apply to a wide range of demographic groups and are not limited to specific groups.

We also validate our findings of the protection against shocks associated with double majors using an entirely different dataset, the National Survey of College Graduates (NSCG). There are a number of reasons that this analysis is valuable. Firstly, it shows that our results are robust across datasets. Secondly, the NSCG defines double majors slightly differently than the ACS. Lastly, the NSCG offers a richer set of control variables compared to the ACS. However, it is worth noting that the NSCG sample is substantially smaller than the ACS. Similar to Figure 4, we first obtain the proper cell size that we use to exclude small division-year-major cells. Figure 5 shows that as we raise the minimum cell size for inclusion in the regressions, the coefficient on the first major shock declines until a threshold of about 15. The effect of the second major shock increases from zero and then stabilizes above 15. The coefficient on the higher major shock mostly remains close to zero with the opposite pattern of the first major. Meanwhile, the interaction effect with double majors grows until it reaches a threshold of 15. Therefore, when estimating using the NSCG sample, we drop division-year-major cells with fewer than 15 observations, as well as double majors with one or both majors matched to any division-year-major cell that has fewer than 15 observations.

(Figure 5 here)

Using the NSCG, Table 5 estimates the extent to which double majors are buffered against earnings shocks measured at the division-year-major level, year-major level, and division-year level respectively in columns (1) to (3).[13] The estimates for all three shock measures consistently indicate substantial and statistically significant protection associated with being a double major. Notably, the protection is larger in column (2), where the earnings shock is measured at the year-major level (i.e., not by divisions).

(Table 5 here)

Again, it is plausible that broader combinations of majors are associated with more protection than more narrow combinations. Table 6 follows Table 4 in dividing double

[12] Given that a larger share of our sample is men and non-Hispanic whites, our baseline shocks would be weighted toward the shocks experienced by men and by non-Hispanic whites. Re-estimating the shocks for each demographic group ensures that our shocks reflect the experiences of each specific group.

[13] Information on state of birth or residence, as well as the division of birth, is not available in the NSCG public use files. Consequently, we rely on information on division of residence, although using division of birth versus division of residence made little difference in the ACS.

majors into global and local double major categories and separately examining the extent to which the earnings of the two types of double major respond to shocks in the NSCG dataset. Given the smaller NSCG sample size, the results are less precise. At the same time, global double majors appear to be more protected against all three types of earnings shocks than local double majors even if the differences are not statistically significant at conventional levels.

(Table 6 here)

While our goal is not to distinguish the causal effect of having a double major from the breadth of interests and abilities that might cause someone to become a double major, it is possible that the protection associated with being a double major is due to the unobserved attributes (e.g., "vertical ability") of double majors. To address this concern, we utilize the richer set of information in the NSCG to control for latent individual "ability" by interacting the earnings shock variable with variables that potentially correlate with unobserved ability, such as parental education and school quality.[14] Note that in all NSCG regressions, we control for indicators for a highly-educated father/mother (a parent who has at least a high school diploma or equivalent) and the Carnegie classification of institutions (research, doctorate-granting, comprehensive, liberal arts, and specialized) where individuals receive their bachelor's degrees. Thus, the addition to the baseline model is to include interactions between proxies for ability and the shock measures.

Column (1) of Table 7 is the baseline NSCG specification. We add interaction terms between each additional variable (high-educated father, high-educated mother, research university, and doctorate-granting university) and earnings shocks in columns (2) to (5), respectively. Table 7 shows that the proxies for "ability" are strongly and positively related to earnings, but they provide little protection in their own right. The protective effect of a double major remains essentially unchanged after controlling for interactions between earnings shocks and the various proxies for ability, suggesting that the buffer against shocks experienced by double majors is not due to differences in ability as proxied by parental education or university type.

(Table 7 here)

To further probe the extent to which vertical "ability" may offer protection against shocks, we re-estimate these models using single majors. Table A.7 shows that having a highly-educated parent (or graduating from a research university or doctorate-granting university) is associated with a statistically significant increase in earnings, but provides little protection against earnings shocks. The coefficients on the interaction terms between the earnings shock and a highly educated parent (or school type) are small and, in most

[14] For instance, Hemelt (2010) shows that the return to a double major varies by the type of institution.

cases, insignificant. Therefore, it seems plausible that the protection associated with being a double major is not due to differences in vertical ability.

We examine whether the protective effect of double majors against earnings shocks depends on labor market experience. As individuals accumulate labor market experience, they tend to develop specific skills related to their work (Neal, 1995; Weinberg, 2001). For single majors, specialization in one field presumably leads to more human capital in tasks that are closely related to their college major. However, for double majors, investment in multiple fields may enable them to gain knowledge and skills across a wider range of domains, enhancing their versatility and adaptability in the labor market. They may also have a tendency to invest in a diverse set of human capital. Thus, while single majors may become more vulnerable to shocks as their careers advance, double majors may not show the same increased sensitivity. To examine whether the protection associated with double majors varies over the course of one's career, we introduce a triple-difference between earnings shocks, experience, and an indicator for double majors in Table 8. The model shows that, at the outset of the career, 0.57% of shocks are transmitted to single majors with insignificantly less sensitivity for double majors. The sensitivity to shocks increases by 0.7% per year for single majors but actually declines (by 1.7%) for double majors (the test of the difference between 0.7% and 1.7% yields a p-value of 0.15, suggesting that we cannot reject the hypothesis that the increase in protection experienced by double majors exactly offsets the increased exposure of single majors).[15] This finding provides evidence for the argument that double majors tend to maintain or further diversify their skill sets in their later careers relative to single majors.

(Table 8 here)

4.3 Differences in Occupations between Double and Single Majors

We explore two potential mechanisms for why double majors may be less affected by earnings shocks. First, given that double majors receive training in two distinct fields, they may well possess a broader spectrum of skills than single majors. If so, their wider range of skills could provide them with more career options and enhance their adaptability and value to employers even (or especially) in the face of adverse shocks. Second, we hypothesize that double majors have greater accessibility and are more likely to enter a wider range of occupations compared to single majors, who tend to be concentrated in specific occupations. If so, double majors are likely to be protected against shocks to occupations that are particularly associated with a given college major.

[15] While the sensitivity to shocks declines at 1% (=0.007-0.017) per year for double majors, given the coefficients on the first major shock and its interaction with double major, the coefficients imply that double majors are positively impacted by shocks until 38 years of experience.

These mechanisms are, of course, entirely consistent with each other. For instance, a broader skill set is a plausible reason why double majors may be employed in a wider range of occupations.

We hypothesize that double majors have a broader range of skills and tend to enter occupations that use a wider range of skills than single majors. We investigate this hypothesis using skill and knowledge scores from the O*NET data. We begin by defining a threshold for "high" skill/knowledge levels based on the population distribution of the skill/knowledge scores among single majors. For instance, an individual is classified as having "high" skill/knowledge if their occupational skill/knowledge is scored higher than the median among single majors, the 75^{th} percentile, or the 90^{th} percentile, respectively. Then, for each person, we calculate the total number of skill and knowledge categories in which their occupation is above the threshold as a share of the total number of O*NET skill and knowledge categories. The share of all skill and knowledge categories that each person's occupation exceeds the threshold among single majors is our dependent variable. A larger share indicates that individuals in that occupation require strengths in a wider range of skills and knowledge areas.

To explore the breadth of skill and knowledge used by double majors in their jobs, Table 9 estimates how the share of O*NET skill and knowledge categories that are "high" differs between double majors and single majors. Each set of columns reports estimates based on different thresholds used for defining what qualifies as "high". Columns (1) and (2) show that the average share of skills with above-median scores among double majors is 1.5 percentage points higher (3% relative to a base of 0.478) than single majors, while the share of knowledge categories with above-median scores among double majors is about 0.6 percentage points higher (1.3% compared to a base of 0.468) than single majors. As we raise the threshold to the 75^{th} percentile in columns (3) and (4), the increased share of "high" skills among double majors is about 1 percentage point higher (4.7% compared to a base of 0.214) and that of "high" knowledge among double majors is about 0.6 percentage points higher (2.8% compared to a base of 0.212) compared to single majors. Lastly, if the threshold of "high" skill/knowledge increases to the 90^{th} percentile (columns (5) and (6)), double majors still have a 0.2 percentage points higher (2.4% compared to a base of 0.083) share of "high" skills and a 0.2 percentage point higher (2.5% compared to a base of 0.078) share of "high" knowledge categories compared to single majors. Both Panel A and Panel B of Table 9 suggest that double majors, and global double majors in particular, tend to work in occupations where a larger share of skills and knowledge categories are high. We hypothesize that individuals capable of performing a wider range of skills and knowledge tasks at a high level are likely to be more versatile in response to shocks than those who are better in fewer skill or knowledge areas.

(Table 9 here)

If double majors excel across a wider range of skills and knowledge categories, they may enter a more diverse array of occupations and are less likely to enter typical occupations associated with their majors. To study the concentration of double majors in occupations, we begin by estimating the share of single majors with each major m who enter each occupation o: $share_{om} = \frac{Number\_SingleMajor_{om}}{Number\_SingleMajor_{m}}$. For each major, this measure indicates the concentration of people with that major in each occupation. We then assign to each individual our measure of concentration in that occupation based on their major. For double majors, we get the concentration of each occupation for both their first and second major. For example, if 90% of nursing majors work as nurses and the remaining 10% work as teachers, we assign a concentration measure of 0.9 to nursing majors who become nurses and 0.1 to nursing majors who become teachers. This approach is applied to both majors for double majors across all occupations.

We then regress the concentration of each occupation on our standard set of individual characteristics (race, ethnicity, gender, marital status, potential experience and its squared term, hours of work per week (above 35), year fixed effects, and birth division fixed effects), fixed effects for first and second majors among double majors, and an indicator for being a double major.[16] Intuitively, we estimate how the occupational concentration of double majors compares to that of single majors with the same first major, the same second major, and the average across single majors with either major.[17] Specifically, if our findings indicate that double majors are less concentrated in occupations that are typical of their majors (i.e., where fewer single majors with the same major are concentrated), it would suggest that double majors tend to enter less typical majors than single majors. Put differently, they are employed in a wider range of occupations relative to those with a similar, but single major.

Table 10 reports the estimates. Column (1) shows that all else equal, double majors are employed in occupations where 0.7 percentage points fewer (5% of the sample mean of 0.132) single majors are employed, based on their first majors. Column (2) performs the same analysis separating local and global double majors. Interestingly, the entire difference can be attributed to global double majors with no difference between local double majors and single majors. Because double majors have two different majors, there are options as to whether we attach the occupational share of a double major's first major (as seen in columns (1) and (2)), the occupation share of the second major (as in columns (3) and (4)), or even the mean share across the first and second major (columns

[16] As above, for single majors, we use their single major as both their first and second major for convenience in estimation.

[17] An alternative setup might involve estimating the concentration (e.g., using a Herfindahl index) of occupations that single majors and double majors enter. However, such an analysis is difficult because one would want to control for the specific major(s) as well as individual characteristics. Moreover, for many pairs of majors, the number of observations is small. Given these challenges, we take the present approach.

(5) and (6)). Regardless of the major that we use to measure occupation shares, the coefficient on the double major dummy is consistently negative indicating that double majors are less likely to work in occupations where a large proportion of single majors with that major are concentrated. Moreover, this result seems to be driven by double majors whose major fields are more intellectually diverse. Thus, Table 10 suggests that double majors, especially global double majors, are more likely to work in occupations that are distantly related to their majors compared to single majors.

(Table 10 here)

5 Conclusion

This paper provides a novel analysis of human capital diversification and illustrates how the number and relatedness of college majors are associated with protections against fluctuations in labor market conditions. College majors provide a valuable window into the diversification of human capital since college graduates acquire specialized skills in their chosen fields and may broaden their skill set by pursuing a second major. Our estimates demonstrate that double majors are largely buffered against earnings shocks to the majors they hold. This result remains robust across a wide range of measures, model specifications, and data sets. Additionally, we show that the protection associated with a double major is greater when two majors are less academically related. To understand further associations with skill development and occupational outcomes, we show that earning a double major is associated with occupations that demand a more diverse skill set and knowledge base. Double majors also tend to work in occupations with a lower concentration of individuals with the same single major. Both of these factors, skill development, and occupational outcomes, reinforce our findings, showing how diversified human capital protects individuals against earnings shocks.

Our goal has not been to estimate the causal effect of having a double major (as distinct from having the types of wide-ranging interests and skills that lead some people to become double majors) on earnings volatility, but rather to provide an early empirical analysis of whether, the extent to which, and how human capital diversification mediates the impact of earnings shocks. The choice of specific double major pairs is also likely affected by labor market expectations (Russell et al., 2008), students' own interests, and parents' opinions (Zafar, 2012). To address concerns with the endogenous major choice, we focus on labor market shocks that occur well after graduation, so that the choice of specific majors or the decision to pursue a double major is plausibly exogenous to realized shocks. At the same time, the choice of specific majors or to be a double major at all may be influenced by an overall sense of riskiness and/or a desire to reduce risk (von Wachter & Bender, 2008; Oreopoulos et al., 2012; Shu, 2015; Schwandt & von Wachter, 2019; von

Wachter, 2020). Individuals who select double majors may also have greater unobserved "vertical ability." Despite our attempts to address differences in "vertical ability," such differences may still confound our estimates (other studies of double majors suffer from the same issue). Future studies that address the issue of how unobserved factors impact the protective effect of human capital diversification could complement this study.

In addition to endogeneity threats, another limitation of our work is that we primarily focus on college majors as a proxy for human capital diversification and do not consider other aspects, such as the depth and breadth of college course content, work experience, certifications, or additional training (Light & Schreiner, 2019). Analyses with a richer set of variables could provide a more comprehensive understanding of the protection associated with double majors. Still, we believe that our study provides a valuable foundation for future research exploring the protective effects of these other dimensions of human capital diversification.

Our analysis also only provides insights regarding the earnings shock protection of double majors, not the time, effort, and financial costs required to earn the degree. A comprehensive cost-benefit analysis is required before evaluating the optimality of double majoring. Moreover, it is not clear whether a large increase in human capital diversification would reduce its benefits (e.g., through negative externalities on other double and even single majors).

While further study is warranted for the reasons we have discussed, benefits from human capital diversification have important practical implications. Firstly, double majors might be encouraged by fostering collaboration and interdisciplinary initiatives among different academic departments. Such efforts can create an environment that supports interdisciplinary learning and the development of human capital diversification. Secondly, career counseling services can highlight the potential advantages of human capital diversification, be it through double majors, the choice of minors, or curriculum breadth, and guide students in making informed decisions about their educational paths. Lastly, diversifying skills and knowledge throughout one's career has the potential to reduce earnings volatility and potentially other labor market fluctuations.

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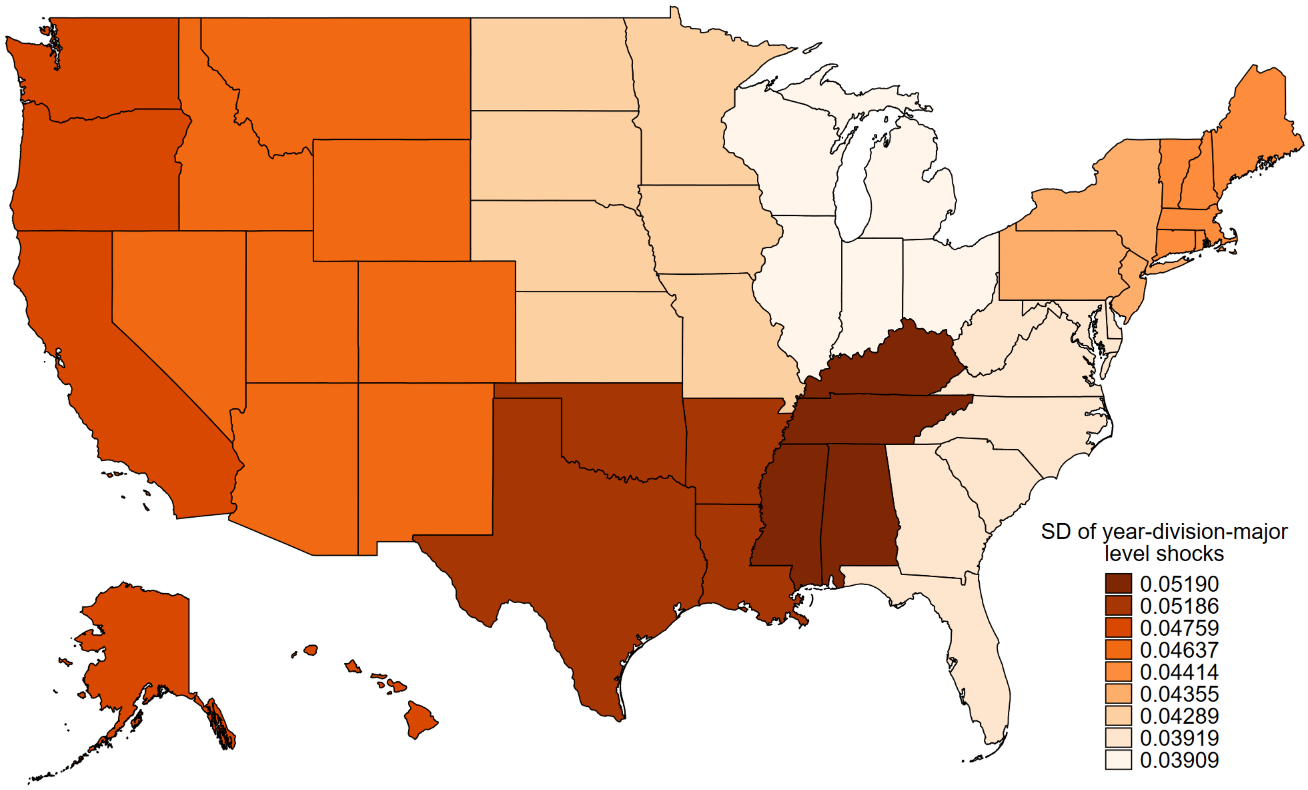
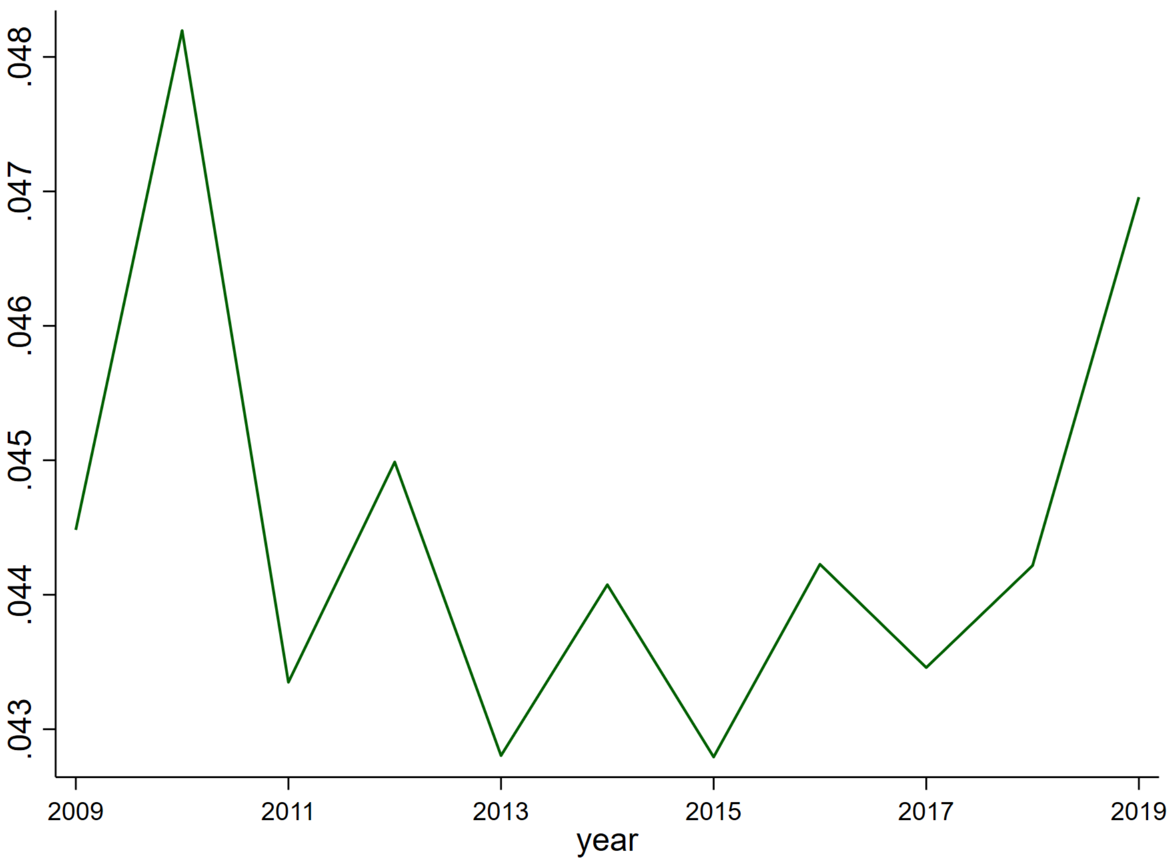
Figure 1: Geographic differences in the variation in earnings shocks



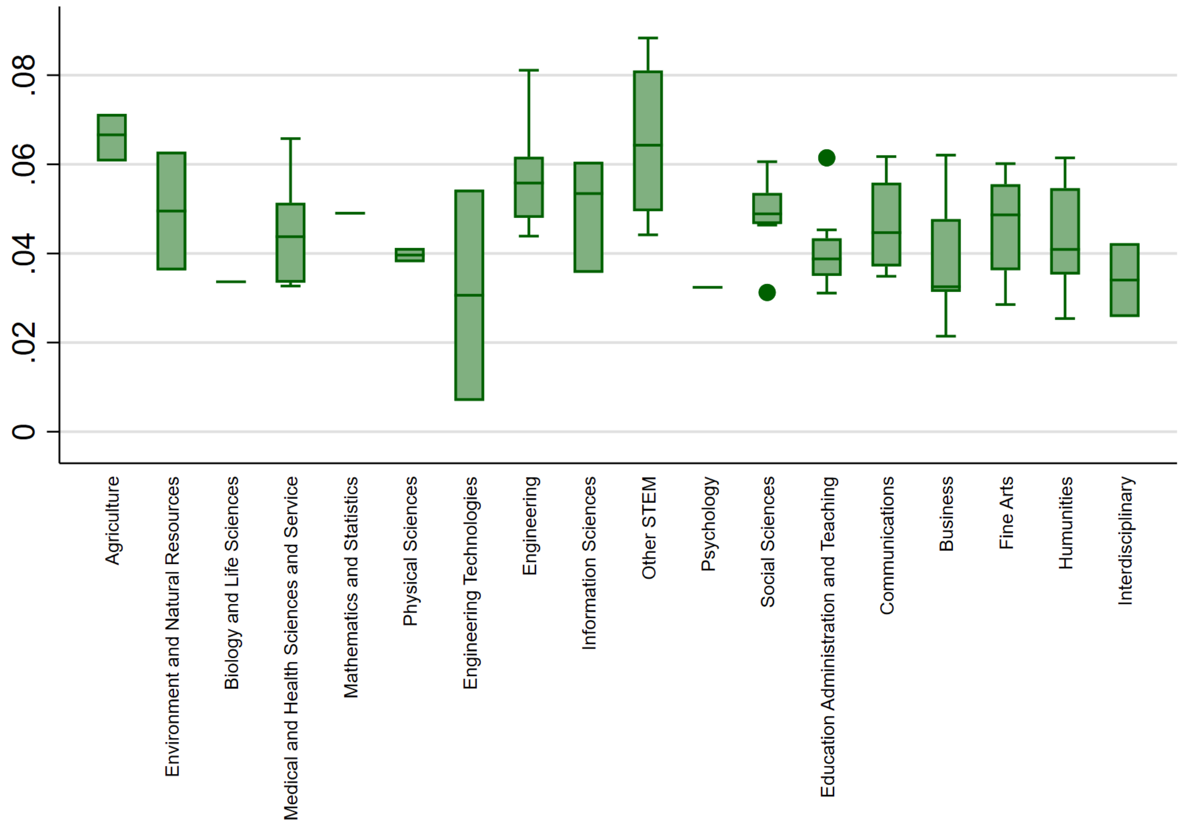
Notes: This figure shows the standard deviation of earnings shocks at the division-year-major level for each census division. Data come from the ACS (2009-2019). When calculating earnings shocks, we exclude division-year-major cells with fewer than 100 single majors.

Figure 2: Time trend in the standard deviation of earnings shocks



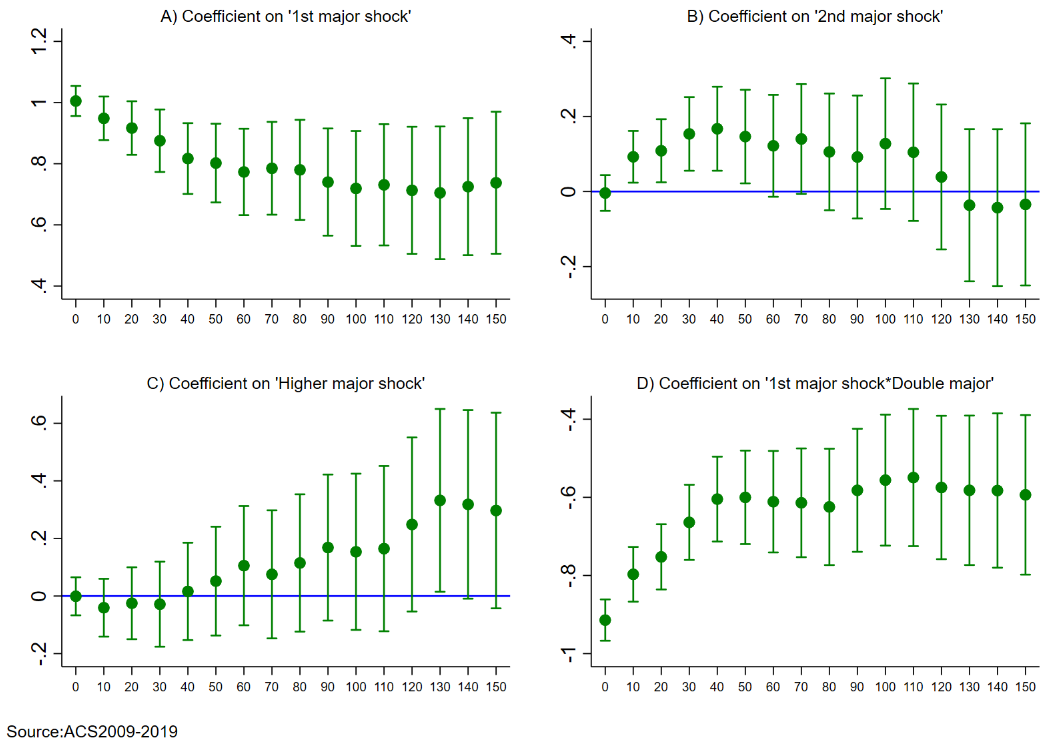
Notes: This figure plots the standard deviation of earnings shocks at the division-year-major level across time. Data come from the ACS (2009-2019). When calculating earnings shocks, we exclude division-year-major cells with fewer than 100 single majors.

Figure 3: Field differences in the variation in earnings shocks



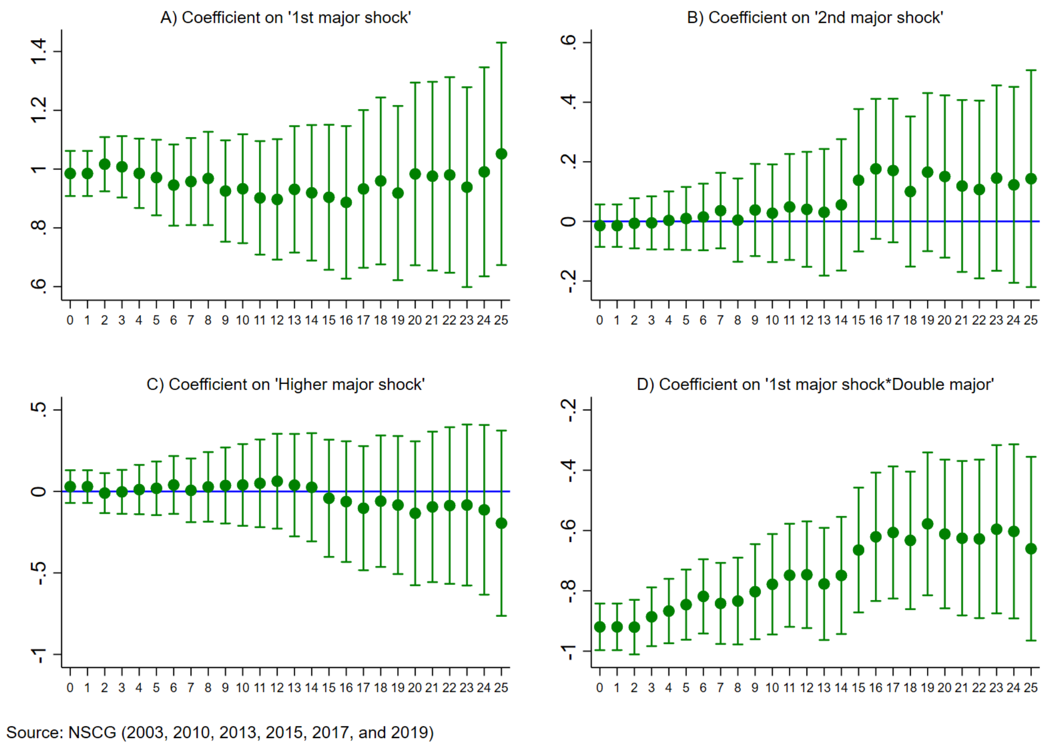
Notes: This figure shows the distribution of the standard deviation of division-year-major level earnings shocks for each fine degree within each aggregated degree category. (For broad fields with only a single major, the figure shows the standard deviation of that major.) When calculating earnings shocks, we exclude division-year-major cells with fewer than 100 single majors. Based on the aggregated degree classification in the ACS, we further group some relatively small top-level degrees with other similar degrees based on the classification in Table A.2.

Figure 4: Coefficients on earnings shocks and double major interactions by minimum cell counts: ACS



Notes: This figure plots the estimated coefficients on shocks to the primary major (β_1), second major (β_2), higher shock major (β_3), and interaction between double major and the primary major (β_4) from Equation (1). Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. Earnings shocks are measured at the division-year-major level. We exclude division-year-major cells with fewer than $N = 0, 10, 20, ..., 150$ single majors. (Double majors who have a major in a cell that is dropped are also excluded from the regressions.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the household level and presented with 95% confidence intervals.

Figure 5: Coefficients on earnings shocks and double major interactions by minimum cell counts: NSCG



Notes: This figure plots the estimated coefficients on shocks to the primary major (β_1), second major (β_2), higher shock major (β_3), and interaction between double major and the primary major (β_4) from Equation (1). Data come from the NSCG (2003, 2010, 2013, 2015, 2017, and 2019). The outcome variable is the natural log of earnings. Earnings shocks are measured at the division-year-major level. We exclude division-year-major cells with fewer than $N = 0, 1, 2, ..., 20$ single majors. (Double majors who have a major in a cell that is dropped are also excluded from the regressions.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), Carnegie classification of universities (research, doctorate-granting, comprehensive, liberal arts, and specialized), parents' education levels, labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, a dummy variable for having a double major, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the individual level and presented with 95% confidence intervals.

Table 1: Summary statistics

(a) 2009-2019 ACS

	All (N=1,429,573)		Single majors (N=1,283,747)		Double majors (N=145,826)	
Variables	Mean	SD	Mean	SD	Mean	SD
Log annual earnings	11.002	0.673	11.001	0.672	11.013	0.684
1 if black	0.070	0.254	0.071	0.257	0.053	0.224
1 if Hispanic	0.050	0.219	0.051	0.220	0.046	0.210
1 if female	0.456	0.498	0.453	0.498	0.480	0.500
1 if married	0.689	0.463	0.693	0.461	0.657	0.475
Hours of work	44.715	7.871	44.681	7.852	45.018	8.034
Labor market experience	21.789	9.110	21.864	9.093	21.127	9.235
1 if double major	0.102	0.303				
1 if global double major	0.071	0.257				
1 if local double major	0.031	0.172				

(b) 2003-2019 NSCG

	All (N=95,413)		Single majors (N=79,871)		Double majors (N=15,542)	
Variables	Mean	SD	Mean	SD	Mean	SD
Log annual earnings	11.124	0.540	11.132	0.533	11.086	0.573
1 if black	0.081	0.273	0.078	0.268	0.097	0.296
1 if Hispanic	0.084	0.277	0.081	0.273	0.097	0.295
1 if female	0.635	0.481	0.649	0.477	0.565	0.496
1 if married	0.720	0.449	0.723	0.447	0.702	0.457
Hours of work	44.774	7.278	44.627	7.139	45.526	7.912
Labor market experience	22.821	9.912	22.514	9.870	24.396	9.974
1 if West	0.238	0.426	0.240	0.427	0.225	0.418
1 if South	0.320	0.467	0.319	0.466	0.327	0.469
1 if Northcentral	0.263	0.440	0.263	0.440	0.261	0.439
Father's level of education	3.101	1.465	3.118	1.456	3.011	1.508
Mother's level of education	2.865	1.208	2.879	1.203	2.794	1.233
1 if research university	0.365	0.481	0.378	0.485	0.295	0.456
1 if doctorate-granting university	0.137	0.344	0.139	0.346	0.125	0.331
1 if comprehensive university	0.316	0.465	0.307	0.461	0.364	0.481
1 if liberal arts college	0.114	0.317	0.105	0.306	0.159	0.366
1 if specialized college	0.035	0.184	0.037	0.188	0.028	0.164
1 if double major	0.163	0.369				
1 if global double major	0.126	0.331				
1 if local double major	0.037	0.190				

Notes: "Labor market experience" is calculated as age minus 22. "Double major" indicates that an individual holds a bachelor's degree in two fields. Parents's education coded as: less than high school (1), high school diploma or equivalent (2), some college (3), Bachelor's degree (4), Master's degree (5), Professional degree (6), and Doctorate degree (7). Variables in bold are those for which the difference in means between single and double majors is statistically significant at the 1% level.

Table 2: Response of double majors' earnings to earnings shocks

	(1)	(2)	(3)	(4)	(5)
1^{st} major shock	1.000***	0.410***	0.719***	1.000***	0.163*
	(0.015)	(0.083)	(0.096)	(0.015)	(0.091)
2^{nd} major shock		0.350***	0.127		0.684***
		(0.081)	(0.089)		(0.095)
Higher major shock		0.220	0.154		0.154
		(0.138)	(0.138)		(0.138)
1^{st} major shock*double major			-0.556***	-0.837***	
			(0.086)	(0.093)	
2^{nd} major shock*double major				0.127	-0.556***
				(0.089)	(0.086)
Higher major shock*double major				0.154	
				(0.138)	
1^{st} major earning	0.999***	0.495***	0.492***	0.492***	0.492***
	(0.008)	(0.045)	(0.045)	(0.045)	(0.045)
2^{nd} major earning		0.256***	0.251***	0.251***	0.251***
		(0.046)	(0.046)	(0.046)	(0.046)
Higher paying major earning		0.268***	0.277***	0.277***	0.277***
		(0.078)	(0.078)	(0.078)	(0.078)
Double major		0.005	0.006	0.006	0.006
		(0.005)	(0.005)	(0.005)	(0.005)
Sample	Single majors	All	All	All	All
Occupation F.E.	Yes	Yes	Yes	Yes	Yes
Observations	964,273	1,032,943	1,032,943	1,032,943	1,032,943
R-squared	0.313	0.312	0.312	0.312	0.312

Notes: Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. Earnings shocks are generated at the division of birth, year, and college major level. We exclude cells with fewer than 100 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, occupation fixed effects, and birth division fixed effects. Due to collinearity, only one interaction between major level shocks and the double major indicator is identified when controlling for all three major level shocks. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 3: Response of double majors' earnings to various earnings shocks

	(1) Division-year-major shock	(2) Year-major shock	(3) Division-year shock	(4) State-year-major shock	(5) State-year shock
1^{st} major shock	0.719***	0.677***	0.998***	0.682***	1.000***
	(0.096)	(0.134)	(0.099)	(0.128)	(0.041)
2^{nd} major shock	0.127	0.116		0.276**	
	(0.089)	(0.126)		(0.124)	
Higher major shock	0.154	0.207		0.042	
	(0.138)	(0.195)		(0.191)	
1^{st} major shock * double major	-0.556***	-0.319***	-0.174	-0.504***	-0.655***
	(0.086)	(0.121)	(0.313)	(0.119)	(0.127)
Occupation F.E.	Yes	Yes	Yes	Yes	Yes
Observations	1,032,943	1,349,168	1,429,573	549,516	1,429,573
R-squared	0.312	0.313	0.312	0.300	0.316

Notes: Data come from the ACS (2009-2019). The outcome variable is log earnings. The "division-year-major shock" is generated at the division of birth, year, and college major level. The "year-major shock" is generated at the year and college major level. The "division-year shock" is generated at the division of birth and year level. The "state-year-major shock" is generated at the state of birth, year, and college major level. The "state-year shock" is generated at the state of birth and year level. When calculating the division-year-major and state-year-major level earnings shocks, we exclude cells with fewer than 100 single majors. For year-major level earnings shocks, we exclude cells with fewer than 180 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, a dummy variable for having a double major, year fixed effects, occupation fixed effects, and regional fixed effects. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 4: Response of global and local double majors' earnings to various earnings shocks

	(1) Division-year-major shock	(2) Year-major shock	(3) Division-year shock	(4) State-year-major shock	(5) State-year shock
1^{st} major shock	0.727***	0.680***	0.998***	0.690***	1.000***
	(0.096)	(0.134)	(0.099)	(0.129)	(0.041)
2^{nd} major shock	0.128	0.114		0.271**	
	(0.089)	(0.126)		(0.124)	
Higher major shock	0.145	0.207		0.040	
	(0.139)	(0.195)		(0.191)	
Global double major	0.007	0.002	0.006**	0.021**	0.007***
	(0.005)	(0.003)	(0.003)	(0.009)	(0.003)
Local double major	0.004	0.006	0.009***	-0.003	0.010***
	(0.006)	(0.004)	(0.003)	(0.009)	(0.003)
1^{st} major shock * global double major	-0.641***	-0.476***	0.016	-0.655***	-0.869***
	(0.093)	(0.134)	(0.363)	(0.138)	(0.147)
1^{st} major shock * local double major	-0.361***	0.053	-0.621	-0.286*	-0.156
	(0.134)	(0.187)	(0.570)	(0.159)	(0.233)
F-test P-value	0.0465	0.0081	0.3355	0.0362	0.0082
Occupation F.E.	Yes	Yes	Yes	Yes	Yes
Observations	1,032,943	1,349,168	1,429,573	549,516	1,429,573
R-squared	0.312	0.313	0.312	0.300	0.316

Notes: Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. The "division-year-major shock" is generated at the division of birth, year, and college major level. The "Year-major shock" is generated at the year and college major level. The "division-year shock" is generated at the division of birth and year level. The "state-year-major shock" is generated at the state of birth, year, and college major level. The "state-year shock" is generated at the state of birth and year level. When calculating the division-year-major and state-year-major level earnings shocks, we exclude cells with fewer than 100 single majors. For year-major level earnings shocks, we exclude cells with fewer than 180 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, year fixed effects, occupation fixed effects, and regional fixed effects. Standard errors are clustered at the household level. We also report the P-value for whether the protections associated with a global double major and a local double major are statistically different. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 5: Response of double majors' earnings to various earnings shocks, using the NSCG

	(1) Division-year-major shock	(2) Year-major shock	(3) Division-year shock
1^{st} major shock	0.919***	0.922***	1.003***
	(0.126)	(0.174)	(0.134)
2^{nd} major shock	0.140	-0.027	
	(0.122)	(0.157)	
Higher major shock	-0.061	0.099	
	(0.184)	(0.244)	
1^{st} major shock * double major	-0.669***	-0.824***	-0.716**
	(0.106)	(0.159)	(0.327)
Occupation F.E.	Yes	Yes	Yes
Minimum cell size	15	35	533
Observations	62,334	86,687	95,413
R-squared	0.386	0.379	0.377

Notes: Data come from the NSCG (2003, 2010, 2013, 2015, 2017, and 2019). The outcome variable is the natural log of earnings. The "division-year-major shock" is generated at the division of birth, year, and college major level. The "year-major shock" is generated at the year and college major level. The "division-year shock" is generated at the division of birth and year level. When calculating the division-year-major and year-major earnings shocks, we exclude cells with fewer than 15 and 35 single majors respectively (all the cells for the division-year shocks are large and are included in the analysis). (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), Carnegie classification of universities (research, doctorate-granting, comprehensive, liberal arts, and specialized), parents' education levels, labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, a dummy variable for having a double major, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the individual level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 6: Response of global and local double majors' earnings to various earnings shocks, using the NSCG

	(1) Division-year-major shock	(2) Year-major shock	(3) Division-year shock
1^{st} major shock	0.964***	0.930***	1.003***
	(0.126)	(0.177)	(0.134)
2^{nd} major shock	0.140	-0.043	
	(0.124)	(0.160)	
Higher major shock	-0.106	0.107	
	(0.187)	(0.247)	
Global double major	0.041***	-0.004	0.000
	(0.013)	(0.009)	(0.008)
Local double major	0.021	-0.002	0.002
	(0.013)	(0.010)	(0.009)
1^{st} major shock * global double major	-0.752***	-0.885***	-0.978***
	(0.115)	(0.182)	(0.366)
1^{st} major shock * local double major	-0.511***	-0.668***	0.126
	(0.175)	(0.245)	(0.622)
F-test P-value	0.1994	0.4326	0.1123
Occupation F.E.	Yes	Yes	Yes
Minimum cell size	15	35	533
Observations	62,334	86,687	95,413
R-squared	0.386	0.379	0.377

Notes: Data come from the NSCG (2003, 2010, 2013, 2015, 2017, and 2019). The outcome variable is the natural log of earnings. The "division-year-major shock" is generated at the birth division, year, and college major level. The "year-major shock" is generated at the year and college major level. The "division-year shock" is generated at the birth division and year level. When calculating the division-year-major and year-major earnings shocks, we exclude cells with fewer than 15 and 35 single majors respectively (all the cells for the division-year shocks are large and are included in the analysis). (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), Carnegie classification of universities (research, doctorate-granting, comprehensive, liberal arts, and specialized), parents' education levels, labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, year fixed effects, occupation fixed effects, and birth division fixed effects. We also report the P-value for whether the protections associated with a global double major and a local double major are statistically different. Standard errors are clustered at the individual level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 7: Response of double majors' earnings to earnings shocks controlling for "ability" proxies

	(1)	(2)	(3)	(4)	(5)
High-educated father (high school and above)	0.028***	0.028***	0.028***	0.028***	0.028***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
High-educated mother (high school and above)	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research university	0.143***	0.143***	0.143***	0.143***	0.143***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Doctorate-granting university	0.084***	0.084***	0.084***	0.084***	0.084***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
1^{st} major shock	0.917***	0.955***	0.987***	0.894***	0.926***
	(0.126)	(0.132)	(0.130)	(0.128)	(0.127)
2^{nd} major shock	0.138	0.138	0.138	0.140	0.138
	(0.122)	(0.122)	(0.122)	(0.122)	(0.122)
Higher major shock	-0.056	-0.055	-0.057	-0.058	-0.055
	(0.184)	(0.184)	(0.184)	(0.184)	(0.184)
1^{st} major shock*double major	-0.674***	-0.678***	-0.678***	-0.669***	-0.674***
	(0.106)	(0.106)	(0.106)	(0.106)	(0.106)
1^{st} major shock*high-educated father		-0.066			
		(0.056)			
1^{st} major shock*high-educated mother			-0.129**		
			(0.056)		
1^{st} major shock*research university				0.066	
				(0.058)	
1^{st} major shock*doctorate-granting university					-0.072
					(0.080)
Observations	62,334	62,334	62,334	62,334	62,334
R-squared	0.385	0.385	0.385	0.385	0.385

Notes: Data come from the NSCG (2003, 2010, 2013, 2015, 2017, and 2019). The outcome variable is the natural log of earnings. Earnings shocks are generated at the division of birth-year-major level. When calculating earnings shocks, we exclude cells with fewer than 15 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), Carnegie classification of universities (comprehensive, liberal arts, and specialized), labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, a dummy variable for having a double major, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the individual level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 8: Response of double majors' earnings to earnings shocks by experience

	(1)
Double major	0.026***
	(0.007)
Experience	0.034***
	(0.000)
1^{st} major shock	0.568***
	(0.102)
2^{nd} major shock	0.136
	(0.089)
Higher major shock	0.137
	(0.138)
1^{st} major shock*double major	-0.192
	(0.163)
1^{st} major shock*experience	0.007***
	(0.002)
Double major*experience	-0.001***
	(0.000)
1^{st} major shock*double major*experience	-0.017**
	(0.007)
Occupation F.E.	Yes
Observations	1,032,943
R-squared	0.312

Notes: Data come from the ACS (2009-2019) and O*NET. The outcome variable is the natural log of earnings. Earnings shocks are generated at the division of birth, year, and college major level. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells with fewer than 100 observations. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, first major earnings, second major earnings, higher paying major earnings, a dummy variable for having a double major, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 9: Double majors and the breadth of high levels of skills and knowledge

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Number of high skills/35 O*NET skills					
	Above median Sample Mean: 0.478		Above top 75% Sample Mean: 0.214		Above top 90% Sample Mean: 0.083	
Double major	0.015***		0.010***		0.002***	
	(0.004)		(0.003)		(0.001)	
Global double major		0.019***		0.013***		0.003***
		(0.005)		(0.004)		(0.001)
Local double major		0.007*		0.003		-0.000
		(0.004)		(0.002)		(0.001)
First major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Second major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573
R-squared	0.134	0.134	0.149	0.149	0.102	0.102
	Panel B: Number of high knowledge categories/33 O*NET knowledge categories					
	Above median Sample Mean: 0.468		Above top 75% Sample Mean: 0.212		Above top 90% Sample Mean: 0.078	
Double major	0.006**		0.006***		0.002	
	(0.002)		(0.002)		(0.001)	
Global double major		0.008***		0.008***		0.003*
		(0.002)		(0.002)		(0.002)
Local double major		0.001		0.001		-0.000
		(0.005)		(0.002)		(0.001)
First major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Second major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573
R-squared	0.075	0.075	0.110	0.110	0.096	0.096

Notes: Data from the ACS (2009-2019) and O*NET. The outcome variable in Panel A is the percentage of high skills out of 35 O*NET skills. In Panel B, the outcome is the percentage of high knowledge out of 33 O*NET knowledge categories. The threshold of "high" skill/knowledge is defined using the population median, top 25%, and top 10% O*NET scores among single majors. The model controls for first and second major fixed effects. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, and birth division fixed effects. Standard errors are clustered at the major level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 10: Double majors and occupational concentration

	(1)	(2)	(3)	(4)	(5)	(6)
	% single majors working in each occupation within a given major					
	Based on 1st major if double majors Sample Mean: 0.132		Based on 2nd major if double majors Sample Mean: 0.134		Based on average of two majors if double majors Sample Mean: 0.133	
Double major	-0.007***		-0.006***		-0.006***	
	(0.001)		(0.001)		(0.001)	
Global double major		-0.011***		-0.008***		-0.009***
		(0.002)		(0.001)		(0.002)
Local double major		0.003		-0.000		0.001
		(0.002)		(0.002)		(0.004)
First major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Second major F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573	1,429,573
R-squared	0.500	0.500	0.504	0.504	0.501	0.501

Notes: Data from the ACS (2009-2019). The major-specific occupational share is the share of single majors working in each occupation within the focal major. The larger the share, the more common the occupational choice is among single majors with the focal major. For the double major samples, the outcome variables include the occupational share in the first major (columns (1) and (2)), the occupational share in the second major (columns (3) and (4)), and the average share between the two majors (columns (5) and (6)). The model controls for first major fixed effects and second major fixed effects. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, and birth division fixed effects. Standard errors are clustered at the major level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Appendix

Table A.1: O*NET skill and knowledge categories

Left Panel: Skill	***Right Panel: Knowledge***
Reading Comprehension	Administration and Management
Active Listening	Administrative
Writing	Economics and Accounting
Speaking	Sales and Marketing
Mathematics	Customer and Personal Service
Science	Personnel and Human Resources
Critical Thinking	Production and Processing
Active Learning	Food Production
Learning Strategies	Computers and Electronics
Monitoring	Engineering and Technology
Social Perceptiveness	Design
Coordination	Building and Construction
Persuasion	Mechanical
Negotiation	Mathematics
Instructing	Physics
Service Orientation	Chemistry
Complex Problem Solving	Biology
Operations Analysis	Psychology
Technology Design	Sociology and Anthropology
Equipment Selection	Geography
Installation	Medicine and Dentistry
Programming	Therapy and Counseling
Operations Monitoring	Education and Training
Operation and Control	English Language
Equipment Maintenance	Foreign Language
Troubleshooting	Fine Arts
Repairing	History and Archeology
Quality Control Analysis	Philosophy and Theology
Judgment and Decision Making	Public Safety and Security
Systems Analysis	Law and Government
Systems Evaluation	Telecommunications
Time Management	Communications and Media
Management of Financial Resources	Transportation
Management of Material Resources	
Management of Personnel Resources	

Note: The skill and knowledge measures are based on the 27.2 version of the O*NET Database.

Table A.2: Top-level field classification in ACS and aggregation of small fields

ACS top-level field	Aggregated grouping
Agriculture	Agriculture
Environment and Natural Resources	Environment and Natural Resources
Biology and Life Sciences	Biology and Life Sciences
Medical and Health Sciences and Service	Medical and Health Sciences and Service
Mathematics and Statistics	Mathematics and Statistics
Physical Sciences	Physical Sciences
Nuclear, Industrial Radiology, and Biological Technologie	Physical Sciences
Engineering Technologies	Engineering Technologies
Engineering	Engineering
Communication Technologies	Information Sciences
Computer and Information Sciences	Information Sciences
Architecture	Other STEM
Military Technologies	Other STEM
Physical Fitness, Parks, Recreation, and Leisure	Other STEM
Construction Services	Other STEM
Electrical and Mechanic Repairs and Technologies	Other STEM
Precision Production and Industrial Art	Other STEM
Transportation Sciences and Technologies	Other STEM
Psychology	Psychology
Family and Consumer Sciences	Social Sciences
Public Affairs, Policy, and Social Work	Social Sciences
Social Sciences	Social Sciences
Education Administration and Teaching	Education Administration and Teaching
Communications	Communications
Library Science	Communications
Business	Business
Fine Arts	Fine Arts
Area, Ethnic, and Civilization Studies	Humanities
Cosmetology Services and Culinary Arts	Humanities
Linguistics and Foreign Languages	Humanities
Law	Humanities
English Language, Literature, and Composition	Humanities
Liberal Arts and Humanities	Humanities
Philosophy and Religious Studies	Humanities
Theology and Religious Vocations	Humanities
Criminal Justice and Fire Protection	Humanities
History	Humanities
Interdisciplinary and Multi-Disciplinary	Interdisciplinary and Multi-Disciplinary

Notes: In the ACS, fields of study are categorized into 38 top-level fields (left column). We define global and local double majors based on whether an individual chooses two majors in the same top-level field. The right panel gives the aggregated grouping that we use for presenting summary statistics and conducting our analyses.

Table A.3: Most common double major pairs in the ACS

First major	Second major	(1) No. of observations	(2) Percentage	(3) Global double major	(4) Local double major
Business Management and Administration	Accounting	2533	1.74%	0	1
Accounting	Finance	2417	1.66%	0	1
Business Management and Administration	Marketing and Marketing Research	1693	1.16%	0	1
Marketing and Marketing Research	Business Management and Administration	1593	1.09%	0	1
General Business	Accounting	1490	1.02%	0	1
Accounting	Business Management and Administration	1430	0.98%	0	1
History	Political Science and Government	1091	0.75%	1	0
Psychology	Sociology	1071	0.73%	1	0
Finance	Accounting	1053	0.72%	0	1
Business Management and Administration	Finance	1013	0.69%	0	1
Elementary Education	Special Needs Education	1003	0.69%	0	1
Computer Science	Mathematics	984	0.67%	1	0
Mathematics	Computer Science	963	0.66%	1	0
Finance	Economics	869	0.60%	1	0
Marketing and Marketing Research	General Business	724	0.50%	0	1
Finance	Marketing and Marketing Research	724	0.50%	0	1
Communications	Advertising and Public Relations	705	0.48%	0	1
Journalism	Mass Media	673	0.46%	0	1
Biology	Nursing	652	0.45%	1	0
English Language and Literature	Communications	647	0.44%	1	0

Notes: Data come from the ACS (2009-2019). There are 145,826 double majors in 10,282 unique fine double major pairs included.

Table A.4: Percent of individuals with a particular major as the first and second major, ACS

Aggregated major	(1) % of single majors with this major	(2) % of people with this major who are double majors	(3) % of double majors listing this major as first major	(4) % of double majors listing this major as second major
Business	28.94%	36.00%	26.79%	25.64%
Humanities	10.27%	21.05%	11.98%	12.34%
Education Administration and Teaching	8.61%	9.08%	5.26%	6.44%
Social Sciences	8.13%	21.06%	11.73%	11.89%
Engineering	7.52%	5.34%	3.67%	3.19%
Medical and Health Sciences and Service	6.83%	8.32%	3.24%	2.42%
Communications	5.31%	12.29%	7.69%	7.36%
Information Sciences	4.50%	8.87%	4.13%	3.78%
Fine Arts	4.04%	8.76%	4.92%	5.59%
Psychology	3.52%	8.13%	4.39%	5.25%
Other STEM	2.72%	4.08%	2.21%	1.97%
Biology and Life Sciences	2.56%	6.08%	4.34%	5.08%
Physical Sciences	1.96%	4.65%	2.51%	2.36%
Agriculture	1.50%	2.32%	1.85%	1.39%
Engineering Technologies	1.16%	1.80%	0.85%	1.06%
Environment and Natural Resources	0.89%	2.40%	1.25%	1.14%
Mathematics and Statistics	0.87%	4.14%	2.24%	2.00%
Interdisciplinary and Multi-Disciplinary	0.68%	2.01%	0.96%	1.11%

Notes: Data come from the ACS (2009-2019). Column (1): Percent of single majors with this major. Column (2): Percent of people with this major (as their first or second major) who are double majors. Column (3): Percent of double majors listing this major as their first major. Column (4): Percent of double majors listing this major as their second major. Global and local double majors are defined using the top-level degree classification in the ACS. We summarize the statistics from column (1) to column (4) using the crosswalk in Table A.2

Table A.5: Response of double majors' earnings to various earnings shocks: Alternative model specifications

	(1) Baseline	(2) Birth division -year-major shock	(3) Residential division -year-major shock	(4) Birth state -year-major shock	(5) Residential state -year-major shock
1^{st} major shock	0.719***	0.722***	0.601***	0.741***	0.717***
	(0.096)	(0.102)	(0.087)	(0.137)	(0.126)
2^{nd} major shock	0.127	0.134	0.147*	0.292**	0.017
	(0.089)	(0.094)	(0.083)	(0.130)	(0.124)
Higher major shock	0.154	0.165	0.253*	-0.022	0.267
	(0.138)	(0.147)	(0.129)	(0.201)	(0.191)
1^{st} major shock*double major	-0.556***	-0.531***	-0.385***	-0.481***	-0.516***
	(0.086)	(0.091)	(0.078)	(0.126)	(0.112)
1^{st} major earning	0.492***	0.529***	0.507***	0.507***	0.388***
	(0.045)	(0.028)	(0.045)	(0.053)	(0.082)
2^{nd} major earning	0.251***	0.450***	0.216***	0.436***	0.096
	(0.046)	(0.029)	(0.046)	(0.056)	(0.089)
Higher paying major earning	0.277***	0.037	0.295***	0.068	0.529***
	(0.078)	(0.049)	(0.078)	(0.095)	(0.149)
Double major	0.006	0.031***	0.006	0.044***	0.002
	(0.005)	(0.005)	(0.004)	(0.009)	(0.008)
Occupation F.E.	Yes	No	Yes	No	Yes
Observations	1,032,943	1,032,943	1,032,734	549,516	555,031
R-squared	0.312	0.211	0.319	0.200	0.313

Notes: Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. When calculating earnings shocks, we exclude cells with fewer than 100 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), labor market experience and its squared term, hours of work per week, year fixed effect, and regional fixed effect in each column. We also control for occupation fixed effects in columns (1), (3), and (5). Column (1) is our baseline specification, and is repeated from column (3) in Table 2. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table A.6: Response of double majors' earnings to earnings shocks, by gender and race/ethnicity

	(1) Men	(2) Women	(3) Non-Hispanic whites	(4) Minorities
1^{st} major shock	0.820***	0.847***	0.861***	0.924***
	(0.104)	(0.108)	(0.096)	(0.126)
2^{nd} major shock	0.099	0.136	0.124	0.163
	(0.098)	(0.103)	(0.090)	(0.131)
Higher major shock	0.081	0.018	0.015	-0.086
	(0.150)	(0.155)	(0.139)	(0.196)
1^{st} major shock*double major	-0.702***	-0.733***	-0.676***	-0.825***
	(0.095)	(0.100)	(0.087)	(0.122)
1^{st} major earning	0.590***	0.339***	0.520***	0.307**
	(0.060)	(0.065)	(0.046)	(0.143)
2^{nd} major earning	0.227***	0.233***	0.301***	-0.055
	(0.061)	(0.071)	(0.048)	(0.143)
Higher paying major earning	0.205**	0.439***	0.197**	0.768***
	(0.103)	(0.118)	(0.080)	(0.244)
Double major	0.014**	-0.001	0.010**	0.012
	(0.007)	(0.006)	(0.005)	(0.012)
Occupation F.E.	Yes	Yes	Yes	Yes
Minimum cell size	58	54	85	19
Observations	564,552	469,080	875,587	159,690
R-squared	0.266	0.276	0.312	0.291

Notes: Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. Shocks are generated at the division of birth, year, and college major level. For our main analysis, we exclude cells with fewer than 100 single majors, which falls at the 25 percentile of the distribution of cell sizes for single majors. Here we exclude cells beneath the 25 percentile of cell sizes among single majors for each group. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black) and ethnicity (Hispanic) in the first two columns, and gender (female) in the last two columns. Also included are marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, occupation fixed effects, and birth division fixed effects. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table A.7: Response of earnings to earnings shocks with ability proxies, using NSCG single majors

	(1)	(2)	(3)	(4)	(5)
High-educated father (high school and above)	0.026***	0.026***	0.026***	0.026***	0.026***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
High-educated mother (high school and above)	0.017***	0.017***	0.017***	0.017***	0.017***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research university	0.138***	0.138***	0.138***	0.138***	0.138***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Doctorate-granting university	0.081***	0.081***	0.081***	0.081***	0.080***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Major shock	1.000***	1.033***	1.063***	0.968***	1.012***
	(0.029)	(0.046)	(0.050)	(0.037)	(0.032)
Major shock*high-educated father		-0.055			
		(0.060)			
Major shock*high-educated mother			-0.118*		
			(0.066)		
Major shock*research university				0.092	
				(0.062)	
Major shock*doctorate-granting university					-0.090
					(0.085)
Sample	Single majors	Single majors	Single majors	Single majors	Single majors
Observations	55,681	55,681	55,681	55,681	55,681
R-squared	0.387	0.387	0.387	0.387	0.387

Notes: Data come from the NSCG (2003, 2010, 2013, 2015, 2017, and 2019). The outcome variable is the natural log of earnings. Shocks are generated at the birth region, year, and college major level. When calculating earnings shocks, we exclude cells with fewer than 15 single majors. (Double majors who have a major in a cell that is dropped are also excluded.) Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), marital status (married), Carnegie classification of universities (comprehensive, liberal arts, and specialized), labor market experience and its squared term, hours of work per week, year fixed effects, occupation fixed effects, and birth region fixed effects. Standard errors are clustered at the individual level. Significant level at ***p<0.01, **p<0.05, *p<0.1.