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 how earnings respond to labor market shocks. Our findings show that double majors experience substantial protection against earnings shocks, of 56%. This finding holds across different model specifications and data sets. Furthermore, we find that the protection double major earners 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 less likely to work in occupations that are closely related to their majors and that they are more likely to work in jobs that require a diverse set of skills and knowledge.

Keywords: human capital, diversification, double major, earnings shock
JEL Codes: J24, D81, I23, J30

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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 how to reduce it (Markowitz, 1952; Sharpe, 1964; Wagner & Lau, 1971). While human capital has an important vertical (i.e., quantity) dimension, it also varies widely in terms of its substantive content - the specifics of knowledge and skills - especially at the postsecondary level, an insight that has become more prominent as economists focus more on tasks and skills. It is therefore surprising that, given the large amount of human capital (Christian, 2014), more attention has not been paid to the diversification of human capital. To begin to address this gap, we ask whether a specific form of human capital diversification is associated with protection from labor market shocks. To the best of our knowledge, we are the first to study this phenomenon.

Specifically, we use double majors in college to measure human capital diversification (Del Rossi & Hersch, 2008, 2016) and estimate shocks to earnings at a variety of levels based on time, geography, 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.

We hypothesize that double majors possess a wider range of knowledge and skills than single majors and that this diversified set of human capital helps to buffer them from shocks to earnings. If so, the extent of human capital diversification would likely be related to the amount of protection from labor market shocks, but how does the amount of protection relate to the amount of diversification? In the ACS, majors are categorized into coarse and fine fields, and 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 very well shielded against most of the shocks identified in our data, 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 range of skills possessed by double majors positions 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, mitigating the impact of the adverse shock to their other major on their earnings.

To distinguish these hypotheses, we look for asymmetries in how the earnings of double majors respond to positive and negative shocks. Specifically, if double majors are buffered from shocks, we would expect to see muted earning responses among double majors to both positive and negative shocks. By contrast, if double majors have an option of switching between positions that emphasize their different majors, we would expect asymmetric responses to shocks with earnings responding to positive but not negative shocks. To see this, consider a double major where one of their majors realizes only a very small shock, while the other major experiences either a large positive or large negative shock. If the shock to the major that experiences a large shock is negative, the person has the option to switch to work that uses the human capital of the major that experienced a small shock. On the other hand, if the major experiences a large positive shock, the person has the option of switching to work that uses the human capital of that major. 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). Our estimates indicate that double majors are shielded against both positive and negative shocks, and that there are slight asymmetries in wage responses.

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. Using the occupation data in the ACS, we construct a measure of major-occupation concentration (Altonji et al., 2012; Blom et al., 2021) using 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. In addition, we link skill and knowledge measures from the Occupational Information Network (O*NET) database with 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. In both cases, 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 sets of skills are relatively better protected.

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 initial breadth 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 people who are over 30, for whom anticipating earnings shocks to specific majors is likely to be quite difficult given the time between major choices and when the shocks that we focus on occur. A second possibility is that vertical differences in ability, as opposed to some form of 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). We leverage data from the NSCG to include parental education and college type, which can proxy for skills. Inspired by Murphy & Topel (1990), Altonji et al. (2005), and Oster (2019), we use the relationship between observed skills and the responsiveness to wages shocks to gauge the effect of unobserved skills on the responsiveness of wages to shocks. 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 robust to controls for parental education, as a measure 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 work has proposed measures of intellectual diversity such as the Herfindahl-Hirschman Index (HHI) of occupational concentration for each major (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 offers a new perspective on the relationship between double majors and labor market outcomes. The 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. For instance, Jiang (2019) shows that there are no statistically significant differences in wages between college graduates with a single major and those with two majors and one bachelor's degree. Pfister et al. (2017) find negative returns to being a double major. Our study suggests that a 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 they desire to reduce risk which increases the supply of double majors.

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

2 Methodology

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 of their first ($w_{1st,i}$) and second ($w_{2nd,i}$) majors as well as the earnings of the higher-earning major ($w_{max,i} = max\{w_{1st,i}, w_{2nd,i}\}$). In this way, we account for the extent to which people's earnings depend on the amount of human capital invested in each major and the returns to the majors in a parsimonious way (an alternative approach would be to include a full-set of ordered major-pair fixed effects, but that would add thousands of parameters and be hard to interpret). For convenience, we represent these variables as $W_{it} = \{w_{1st,i},\ w_{2nd,i},\ w_{max,i}\}$.

We build on this logic to estimate how double majors are affected by earnings shocks. Specifically, we allow earnings to depend on shocks to the earnings in both majors. Similar

to the functional form of earnings W_{it}, we define the earnings shock in the first major $s_{1st,i}$, the earnings shock in the second major $s_{2nd,i}$, and the larger shock among the two majors $s_{max,i} = max\{s_{1st,i}, s_{2nd,i}\}$. While we parameterize our models using these 3 measures given their explanatory power, our approach is more general and can allow for more complex functions of earnings shocks. Our goal here is to estimate how the response of individual earnings to earnings shocks ($S_{it} = \{s_{1st,i},\ s_{2nd,i},\ s_{max,i}\}$) depends on whether people are double majors and the degree of similarity between the majors.

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 reported 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 come from double majors. Our treatment of shocks is similar. Namely, we include an analogous set of shocks and set $s_{1st,i}$=$s_{2nd,i}$=$s_{max,i}$, 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[1], occupation fixed effects λ_o, geographical location level fixed effects φ_g (e.g. census division, census region, 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 will be reflected by β_1, β_2, and β_3 and especially how the effects of the shocks interact with being a double major, DM_i, as reflected by β_4, β_5, and β_6. (We note that 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.) If the estimated $\hat{\beta}_4$, $\hat{\beta}_5$, and $\hat{\beta}_6$ are negative, double majors are less affected by earnings shocks than single majors.

2.2 Estimating Earnings and Earnings Shocks by Major

As indicated, we estimates the 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

[1]Note, 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 substantially more than 35 hours per week.

on all of the observed individual characteristics in X_{it}, major fixed effects, hours of work per week, occupation fixed effects λ_o, geographical location level fixed effects φ_g, and year fixed effects θ_t. Formally, our first stage model is:

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

In this model, the μ_m represent 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). Put differently, 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 location, year, and major, as the S_i, ($\hat{s}_{1st,i}$, $\hat{s}_{2nd,i}$, and $\hat{s}_{max,i}$). We generate these shocks using single majors, who are the majority of college graduates. Doing so 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 location, major, and year. We choose the census division of birth as the basic level of geographic location in this study. We take the mean of the residuals in each cell to be our shocks $\hat{s}_{1st,i}$, $\hat{s}_{2nd,i}$, and $\hat{s}_{max,i}$ aggregated to the (birth) division (d), year (t) and major (m) level $\bar{\omega}_{mdt} = \frac{\sum \hat{\omega}_{it(md)}}{N_{mdt}}$ to capture variations by academic major, time, and geography.[2] 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 $\bar{\omega}_{mt} = \frac{\sum \hat{\omega}_{it(md)}}{N_{mt}}$ and (birth) state-year-major level $\bar{\omega}_{mst} = \frac{\sum \hat{\omega}_{it(ms)}}{N_{mst}}$, and (birth) state-year level $\bar{\omega}_{st} = \frac{\sum \hat{\omega}_{it(ms)}}{N_{st}}$.

One issue with these measures is that single majors enter the calculation of the shocks but double majors do not. As consequence, shocks will be more highly correlated with earnings of single majors than double majors. To address this concern, we limit the analysis to division-year-major cells with a minimum number of single majors. We present results below to identify the threshold for inclusion.[3] That analysis of ACS data, suggests that a threshold of 100 per division-year-major produces consistent estimates with the smallest reduction in sample and hence precision.[4]

[2]We sum all the individual residuals $\hat{\omega}_{it}$ in (birth) division (d), year (t) and major (m) and then divide by the total number of single majors from (birth) division (d), year (t) and major (m).

[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]That threshold is at the 25th percentile of the distribution of cell sizes and we apply that 25th

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 is affected by earnings shocks for the main analysis.[5] Furthermore, we probe the role of "ability" and whether it accounts for our diversification estimates below using methods developed by Altonji et al. (2005) and Oster (2019).

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. For our purposes, the ACS records up to two (ordered) fields of study from undergraduate education, which makes it feasible for us to implement our measure of human capital diversification. Our sample period is from 2009, when field of study is first included on the ACS, to 2019. We focus on individuals whose highest degree is a bachelor's degree and further restrict the sample 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 possibility that majors are chosen in response to anticipated earnings shocks. We further remove those who are born in U.S. outlying areas/territories so that we have a well-defined state of birth, We drop those whose annual earnings (CPI deflated to 2009 dollars) are less than 2,000 dollars to eliminate outliers. After removing missing values [6], our final, pooled ACS sample size has 1,423,860 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

percentile when studying the NSCG.

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

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

where respondents received their bachelor's degree. This information is useful for examining whether "vertical ability" drives our estimated effects of double majors.

When constructing our sample from the NCSG, we apply similar rules to those applied to 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 2013 dollars), and those who are born outside of the U.S. After removing observations with missing values for variables, the NSCG sample includes 94,278 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 work in different jobs with a wider range of skill and knowledge requirements than single majors. O*NET data are constructed under the sponsorship of the U.S. Department of Labor/Employment and Training Administration. The O*NET data define basic skills 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.[7] Taken together, there are 35 bottom-level skill components including skills such as reading comprehension, writing, programming, and management of financial resources. Similarly, 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 contains 873 bottom-level Standard Occupational Classification (SOC) codes, which 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 3 digits of the O*NET-SOC occupation classification and match them to the ACS-SOC occupation classification. We then compute the weighted average of the skill and knowledge measures for each 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."

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

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 combines people who have two bachelor's degree and some 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, which is why we define them as double majors in our study. Furthermore, we follow Kniffin & Hanks (2017) and construct "global double major" and "local double major" indicators to proxy for the academic distance between the two major fields. While a "global double major" combines two majors across more disparate field boundaries (e.g. sociology and biology), a "local double major" has two majors in the same top-level area (e.g. economics and political science are both social sciences). Top-level fields of study are presented in Table A.2 along with how we aggregate some of the smaller fields.[8] Our assumption is that a "global double major" has a more diversified human capital portfolio compared to a "local double major".

In our ACS sample, 10% of respondents are double majors. The percentage of double majors found in previous studies varies according to sample representativeness, year of the survey, and 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) uses survey evidence from one 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 140,114 individuals with a double major, the most common ordered pairing is "Business Management and Administration" and "Accounting" with 2,533 people (1.81% of the double majors) in our sample. The most common ordered global double major combination is "History" and "Political Science and Government", accounting for 1088 people or 0.78% 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 of study in the ACS, we further aggregate college majors into 18 categories (Table A.1). Table A.4 reports the share of all college graduates with each major as their first major (for single majors, we treat their major as their "first" major) and the share of double majors with a specific major as the first major and second major. Results show that "Business" is the most popular college major choice, for both the first major and the second major, followed by "Humanities" and "Social Science." For example, 28.8% of our sample choose "Business" as the first major. Among individuals with "Business" as the first major, 27.5% choose a double

[8]In the ACS, fields of study are recorded in two levels: top level and bottom level. There are 38 top level fields of study and 175 bottom level fields of study in our sample.

major. Across all double majors, 26.3% choose "Business" as the second major.

In the NSCG, based on a similar survey question, we define double majors as individuals who have a second major for their highest degree,[9] 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 15.9%. The NSCG sample is different from the ACS sample 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 and not 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 college major earnings shock is generated by region of birth in the NSCG, which is different from the earnings shock generated from the ACS, which is based on the state of birth. Third, the NSCG sample is less than 5% of the size of the ACS sample and has a special focus on science and engineering college graduates. Given the nature of the ACS data, we believe the share of double majors based on the ACS is more representative of double majors as a whole.

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, Hispanic, and are more likely to be women. They are less likely to be married and have fewer years of potential experience.[10] The unconditional earnings difference between single majors and double majors is 1.5%, which is small but statistically significant. Panel B reports summary statistics for our NSCG sample. The NSCG includes data on parental education and measures of the type of tertiary institution people attended, which are not available in the ACS. On average, double majors have lower levels of parental education and are more likely to graduate from comprehensive and liberal arts universities. From these summary statistics, it is not clear that double major have, on average, higher "ability" than single majors. However, it is possible that individuals from families with lower parental education levels may have higher levels of motivation and ambition 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 barriers in double majoring in research and doctorate granting universities (Del Rossi & Hersch, 2016).

(Table 1 here)

[9]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)."

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

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 the division-year, year-major, state-year-major, and state-major levels. To provide a sense of our earnings shocks, we summarize the variation in them in three ways. Figure 1 plots the standard deviations of the earnings shocks in each division. Figure 1 indicates that the shocks are greatest in the South Central (East and West). The East North Central has the smallest shocks with the other regions being intermediate.[11] Figure 2 shows the standard deviation of the shocks over time. The variability of our shocks only ranges between 0.43 and 0.48. It is highest during the 2010 financial crisis and turns up again in 2019.

correlation matrix between the 3 shocks for double majors

(Figure 1 and Figure 2 here)

We also summarize the variation of the shocks both within and between majors. Within each bottom level field, we first generate the standard deviations of shocks. Then, within each top-level field, Figure 3 plots the distribution of the standard deviations of the shocks for each bottom-level field. On average earnings shocks are higher in Agriculture and Other STEM., Biology and Life Sciences, Mathematics and Statistics, Physical Sciences, and Psychology. They are lowest in Business and, tellingly, Interdisciplinary majors.

(Figure 3 here)

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 state, calendar year, and major level. For all the regressions, we include the baseline controls in Equation (1).

[11] The population of the regions can influence the standard deviations. We (1) believe that 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 the that effect.

To illustrate our methods and main findings more clearly, we limit the sample to individuals with single majors in Column (1), and report the coefficients on shocks to earnings in the first major, second major, and major with the higher shock. In this sample of single majors and given that the shocks are generated from log earnings residuals among single majors, the estimated coefficient on the earnings shock in the first major is equal to one by construction. Intuitively, all three major shocks are the same for single majors, so all but one are dropped. 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 of one indicates 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 (by construction).

The sample in column (2) includes both single and double majors. The estimates indicate that shocks to earnings in the first major are more strongly related to earnings than shocks in the second major or the higher earnings major. Specifically, a 1% shock to earnings in the first major increases earnings by roughly 0.52%, a 1% shock to earnings in the second major increases earnings by roughly 0.39% and a 1% shock to earnings in the major with the higher earnings shock raises earnings by 0.02% (not significant). The coefficients on log earnings in the first, second, and higher-paying majors are reported at the bottom, where the first major (0.52) plays a larger role relative to the second major (0.29) and the higher paying major (0.21). The earnings premium associated with a double major (in Column (1)) is small but statistically significant at 0.006%. 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. In addition, the relative sizes of the coefficients of first and second major shocks implicitly indicates that the ordering of major choices reported in the ACS are informative because the coefficients on randomly ordered majors should be very close to each other (See Hanks et al. (2022) for additional evidence that the ordering is informative).

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. (Note that when we include all three earnings shocks, the interaction between only one shock and being a double major is identified due to collinearity.) 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 double major is negative, sizeable, and statistically significant. It implies 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, which 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, interacting the three earnings shock variables with the double major indicator and keeping only the shock to earnings in the first major. (When interactions between all three earnings shocks and the double major indicator are included, we are only able to estimate the effects of one of the main earnings shocks due to collinearity.) In this case, the coefficient on the shock to the first major is identically equal to one and the interactions between double major 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 gives a coefficient of -0.84. When this is added to the interactions for the second and higher major, it reproduces the 0.56 from column (3). Column (5) only includes an interaction between double major and the second major shock. The offset associated with a double major is the same as column (3). Overall, Table 2 shows that, the effect of earnings shocks is substantially smaller for double majors than for single majors. Given that the specifications in the last three columns are isomorphic and that the interaction between double major 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 wage shocks for single majors and then estimating the effects on wages, we exclude small cells where the bias from including own wages 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 successively raise the minimum cell size for inclusion in the regressions. Figure 4 shows that the coefficient on the first major shock declines until a threshold of roughly 100 and then stabilizes. The second major shock is hump-shaped in the cell threshold while the higher major shock is increasing (because 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 major stabilize. Consequently, we drop division-year-major cells with fewer than 100 observations. We also drop double majors with one (or both) majors in a division-major-year cell that has fewer than 100 observations.

(Figure 4 here)

One might expect the amount of protection experienced by double majors to be greater among shocks to majors than broader shocks to labor markets, which are likely harder

to diversify against. 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 (4) of Table 2, measuring shocks at the division-year-major level. In Column (2), we use a division-year shock. We construct these by averaging log earnings residuals at the year and division of birth level. Our results show that double major are insulated from earnings shocks by 54%.[12] In Column (3), we measure shocks at the year-major level. This is a challenging specification 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 quite imprecise. Columns (4) and (5) replicate 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. In column (5) the results 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 double majors 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 global and local double majors in response to the shocks in the previous table, 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, but when shocks are measured at the state-year-major (in 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)

[12]The sample sizes vary across the columns of the table, because we delete cells with fewer than 100 observations, which falls at different points in the distribution of cell sizes for different levels of aggregation.

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 enter different occupations than 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 decreases by 10 percentage points, indicating that the occupation controls improve the fit of the model considerably. The estimated premium associated with being a double major increases from .6% to 3.1% when the occupational dummies are removed, suggesting that part of the premium associated with being a double major is due to differences in occupations between double and single majors. At the same time, the earnings protection associated with double majors is essentially unchanged.

Our main analysis relies on the division of birth to generate earnings shocks because division of current residence is likely to be endogenous. However, division of residence is likely to better capture individuals' current economic environment and 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, major, and year. The results are consistent, showing that double majors are protected against earnings shocks when we measure the shocks using respondents' division of residence. Because we construct division of residence from the state of residence, we can also explore estimates using the of state 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 provide two subgroup analyses, dividing the ACS by gender and by race/ethnicity to explore whether the effects vary by demographic characteristic 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 shock measures.[13] Our estimates show that the protective benefits associated with being a double majors apply to a wide range of demographic groups and are not limited to specific groups.

We also verify 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. First, it shows that our results are robust across datasets. Second, the NSCG defines double majors slightly differently than the ACS. Lastly, the NSCG contains a richer set of control variables than the ACS. Unfortunately, the NSCG sample is considerably smaller than the ACS. Table

[13]Given that a larger share of our sample are men and non-Hispanic, whites, if we used our baseline shocks, they 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 group.

5 estimates buffers against earnings shocks that are generated at the division-year-major level, division-year level, and year-major level respectively in Columns (1) to (3).[14] The estimates for all three measures of shocks indicate substantial and statistically significant protection associated with being a double major. The protection is larger in Column (2), when the earnings shock is measured at the year-major level (i.e., and not for specific divisions).

(Table 5 here)

Again, it is plausible that broader combinations of majors are associated with more protection than more narrow combinations of majors. Table 6 follows Table 4 in dividing double majors into global and local double majors and separately examining the extent to which the earnings of the two types of double major respond to shocks in the NSCG. Given the smaller NSCG sample, 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 difference is only statistically significant (at the 10% level) for division-year shocks..

(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. For instance, individuals who are more motivated might be more likely to choose double majors (e.g., Hemelt (2010) shows that the return to a double major varies by the type of university). To address this concern, we leverage 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. Note that in all NSCG regressions, we control for indicators for a highly-educated father/mother and the Carnegie classification of institutions (research, doctorate granting, comprehensive, liberal arts, and specialized) where an individual receives their bachelor's degree. 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). We define a high-educated parent as a parent who has at least a high school diploma or

[14]Information on state of birth or residence or on the division of birth is not available in the NSCG public use files, so we use information on division of residence, although using divison of birth versus division of residence made little difference in the ACS.

equivalent. Research university and doctorate granting university are classified by the Carnegie Classification of Institutions of Higher Education. Table 7 shows that the proxies for "ability" are strongly and positively related to earnings, but that they provide little protection in their own right. Moreover, the protective effect of a double major remains essentially unchanged after controlling for interactions between earnings shocks and the various proxies for ability, suggesting the weaker effect of shocks on double major is are 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 does not protect against earnings shocks. The coefficients of the interaction terms between earnings shock and a high-educated parent (or school type) are small and insignificant. Therefore, it seems plausible that the protection associated with being a double major is not due to differences in vertical ability.

4.3 Heterogeneous Effects

We examine whether the protective effect of double majors against labor market shocks depends on the direction of earning shocks and labor market experience.

Positive VS Negative Shocks Our previous estimates show that double majors are significantly shielded from earnings shocks, combining positive and negative shocks. While our working hypothesis is that double majors may be more protected against shocks because they have more diversified human capital portfolios, there may be an option value aspect to being a double major, safeguarding individuals against negative impacts while enabling them to reap the benefits of positive shocks. To distinguish this option value view from a pure diversification mechanism, we explore asymmetries in the response of earnings of double majors to shocks. Intuitively, diversification implies a weak response to both positive and negative shocks while an option value view implies a weak response to negative shocks but a strong response to positive shocks. Even if one takes an option value view, it seems plausible that as individuals with double majors progress in their careers and accumulate specific human capital, it becomes harder and less advantageous for them to dramatically switch their work in response to positive earnings shocks to their majors. Thus, the option value associated with double majors may be limited and decline with experience.

The noisy estimates on the interaction between double majors and the higher major shock in Column (4) of Table 2 suggests that there is unlikely to be a large option value

component to double majors. At the same time, to probe this hypothesis, we estimate models with separate effects of large positive (greater than one standard deviation above the mean) and large negative earnings shocks (greater than one standard deviation below the mean). The estimates in Table 8 show that single majors are more affected (in absolute magnitude) by large positive shocks than large negative shocks. Double majors are essentially completely protected against large negative shocks, but double majors experience some of the upside from large positive shocks. At the same time, the difference in earnings responses between large positive and large negative shocks for double majors is not statistically significant. Thus, it appears that double major may have a small option value, but that double majors are substantially buffered against wide swings in labor market conditions, which is consistent with a diversification mechanism.

(Table 8 here)

Experience As labor market experience accumulates, individuals develop specific skills that related to their work.(Neal, 1995; Weinberg, 2001) For single majors, their specialization in one field would presumably lead to deeper attachment tasks that are closely related to their college major. For double majors, their 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 mindset to keep investing in a diverse set of human capital. Thus, while single majors may be more impacted by shocks as their careers progress, double majors may not show the same increased sensitivity. To examine whether the protection associated with double majors varies over the career, we interact the shocks with experience and include a triple-difference, interacting earning shocks with an indicator of double majors and with labor market experience in Table 9. 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 (a test of the difference between 0.7% and 1.7% has a p-value of 0.15 so we cannot reject the hypothesis that the increase in protection experienced by double majors exactly offsets the increased exposure of single majors). 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 9 here)

4.4 Differences in Occupations between Double and Single Majors

We explore two potential mechanisms why double majors may be buffered against earnings shocks. First, we hypothesize that double majors have access to and enter a

wider range of occupations than single majors and are hence 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. Second, given that double majors receive training in two different fields, they may well possess a wider range of skills than single majors. If so, their wider range of skills provides them with more options and may make them more versatile and valuable to employers even (or especially) in the face of adverse shocks. These mechanisms are, of course, entirely consistent with each other in that a broader skill set is a plausible reason why double majors may be employed in a wider range of occupations.

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: $share_{om} = \frac{Number_SingleMajor_{om}}{Number_SingleMajor_{m}}$. This gives us a measure of the concentration of each major in each occupation. We then attach to each graduate our measure of concentration of that occupation to their major. (For double majors, we get the concentration of each occupation for both the first and second major.) For example, if 90% of nursing majors work as nurses and the remaining 10% work as teachers, then for the nursing majors who become nurses, we attach 0.9 to them and for the nursing majors who become teachers, we attach 0.1 to them.

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, and hours of work per week (above 35), year fixed effects, and birth state fixed effects), fixed effects for first and second majors among double majors, and an indicator for being a double major.[15] 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 among single majors with the same two majors.[16] A finding 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) would indicate that double majors 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 in which 0.7 percentage points fewer (5% of the sample mean of 0.132) single majors are employed in based on their first majors. Column (2) performs

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

[16] An alternative setup might involve estimating the concentration (e.g., using a Herfindahl index) of occupations that single majors and double majors enter. Such an analysis is difficult because one would want to control for the specific major(s) as well as individual characteristics. Moreover, the number of double majors with each combination of two majors is often quite low. Given these challenges, we take the present approach.

the same analysis separating local and global double majors. Here the entire difference turns out to be due 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 in Columns (1) and (2)) or the occupation share of the second major, which we do in Column (3) and (4), or even the mean share across the first and second major, which we do in Columns (5) and (6). Regardless of the major that we use to measure occupation shares, the coefficient on the double major dummy is negative indicating that double majors are less likely to work in an occupation where a large share 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 with their major than single majors.

(Table 10 here)

As indicated, we hypothesize that double majors have a wider range of skills and will enter occupations that use a wider range of skills than single majors. We investigate this hypothesis using skill and knowledge scores from O*NET. We begin by defining a threshold for "high" skill/knowledge using the population distribution of the score among single majors. For example, we classify a person as having a "high" skill/knowledge if that occupational skill/knowledge is scored higher than the median among single majors, the 75^{th}-percentile, and 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.[17] The share of all skill and knowledge categories that each person's occupation exceeds the threshold among single majors is our dependent variable. The larger this share, the wider range of skills and knowledge areas that people in that occupation need strength.

To explore the breadth of skill and knowledge that double majors use on their jobs, Table 11 estimates how the share of O*NET skill and knowledge categories that are "high" differs between double and single majors. Each set of columns reports estimates based on different thresholds to define "high". Column (1) and (2) show that the average share of skills with above-median score 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 0.483) than single majors. When the threshold increases to 75^{th}-percentile in Column (3) and (4), the increased share of "high" skills among double majors is about 1 percentage points higher (4.7% compared to a base

[17] There are 35 O*NET skill categories and 32 O*NET knowledge categories.

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 0.218). Lastly, if the threshold of "high" skill/knowledge increases to 90^{th}-percentile (Column (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 points higher (2.4% compared to a base of 0.081) share of "high" knowledge categories. Both Panel A and Panel B of Table 11 show that double majors, and global double majors in particular, work in occupations where a larger share of skills and knowledge categories are high. We hypothesize that people who are able to perform 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 a smaller set of skill or knowledge areas. These results seem consistent with those in Table 10 and, taken together, they suggest that double majors on average enter distinct occupations that are demanding in terms of their skill requirements compared to single majors with an overlapping major, supporting diversification as a mechanism for our results.

(Table 11 here)

5 Conclusion

We provide a novel analysis of human capital diversification, showing the degree to which the number and relatedness of college majors is associated with more muted responses to labor market conditions. College majors provide a valuable window into human capital diversification in that college graduates acquire specialized skills in fields and, by adding a second major, can obtain a wider set of skills. Our estimates show that double majors are buffered to a large degree against earnings shocks to the majors they hold. This result is robust to a wide range of measures, model specifications, and data sets. Additionally, we show evidence that the protection of a double major is more pronounced when two majors are less related academically. To understand additional associations with skill development and occupational outcomes, we show that double majors are more likely to work in jobs that require a more diverse set of skills/knowledge and 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 results that show how diversified human capital protects individuals against earnings shocks, over a strict option value interpretation.

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 this concern, we focus on labor market shocks that occurs well after graduation, so that the choice of specific majors or to be a double major themselves is likely exogenous to the 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; von Wachter, 2020; Schwandt & von Wachter, 2019; Oreopoulos et al., 2012; Shu, 2015). 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. 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 discussed, benefits from human capital diversification have important practical implications. First, double majors might be encouraged by fostering collaboration and interdisciplinary initiatives between different academic departments, which could create an environment that supports interdisciplinary learning and human capital diversification. Second, 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 careers has the potential to reduce earnings or potentially other labor market volatility.

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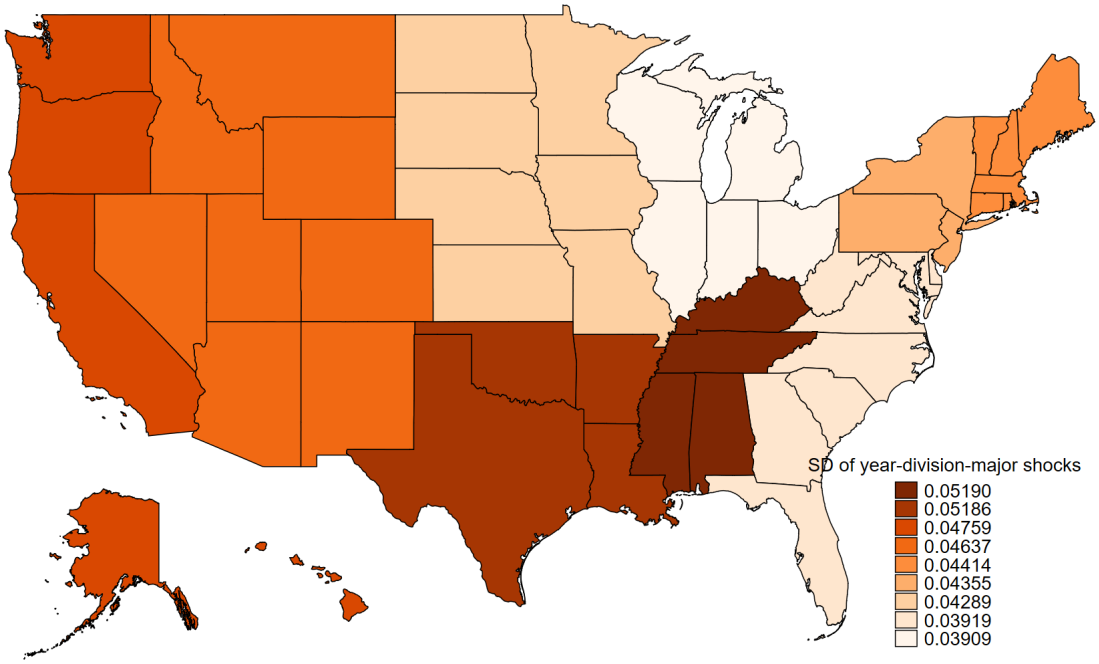
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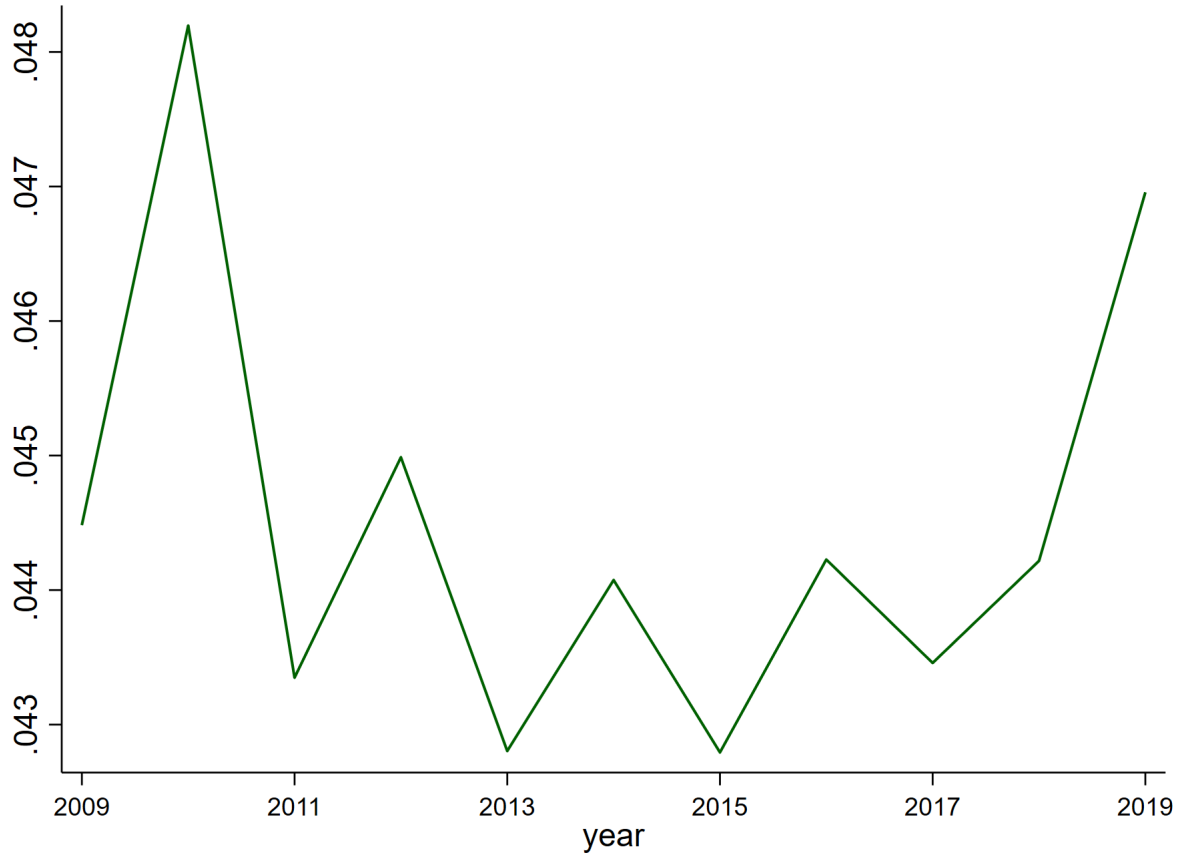
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Figure 1: Geographical difference of the standard deviation of division-year-major level earnings shocks



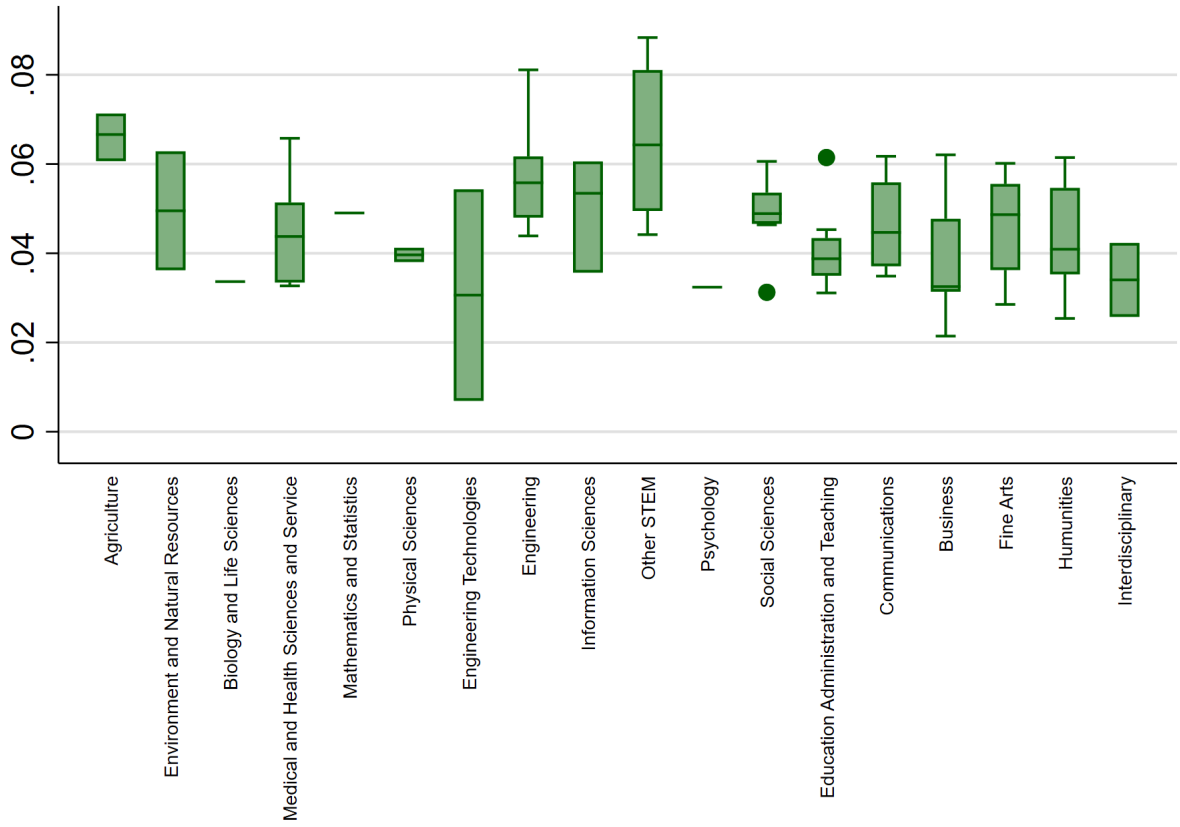
Note: This figure shows the standard deviation of division-year-major level earnings shocks within each census division. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100.

Figure 2: Time trend in the standard deviation of division-year-major level earnings shocks



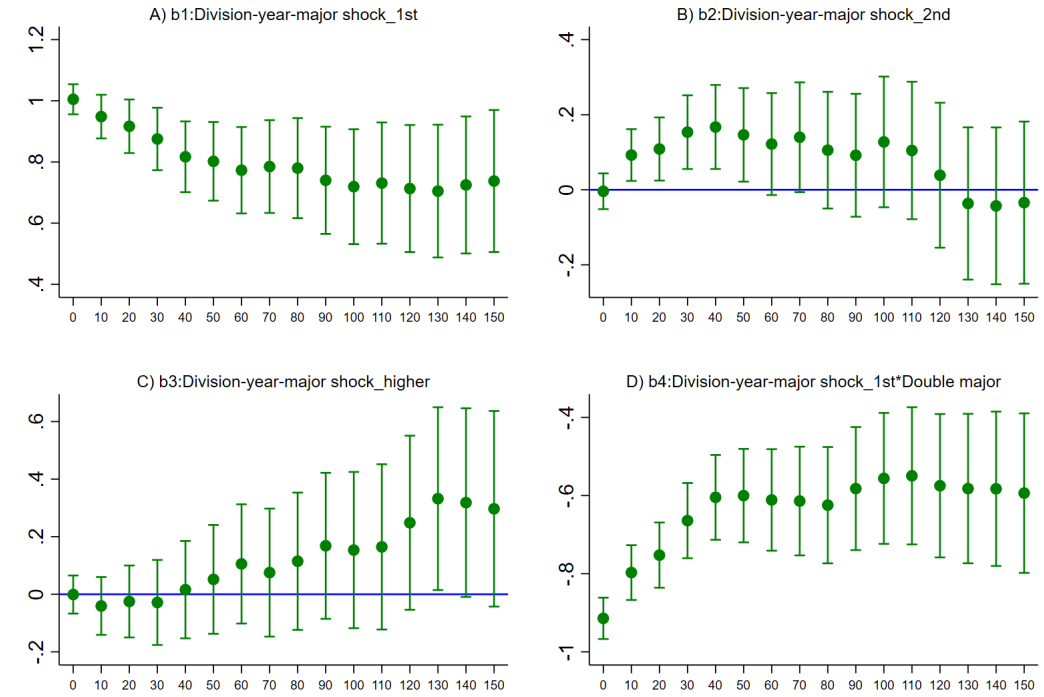
Note: This figure plots the yearly standard deviation of division-year-major level earnings shocks. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100.

Figure 3: Field differences in the standard deviation of division-year-major level earnings shocks



Note: 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. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100. Based on the aggregated degree classification in ACS, we further group some relatively small top level degrees with other similar aggregated level degrees based on the classification in Table A.1.

Figure 4: Estimated coefficients of division-year-major level earning shocks and the interaction with double majors



Note: This figure presents the estimated coefficients: β_1, β_2, β_3, and β_4 using equation (1). β_1, β_2, and β_3 are coefficients of the first, second, and higher major shocks respectively. Meanwhile, β_4 denotes the coefficient corresponding to the interaction between the first major shock and an indicator signifying double majors. In the last panel, we also calculate the absolute value of the ration between β_4 and β_1, which is the percentage rate of buffering for the first major shock as double majors. 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 that are smaller than a certain size $N, N = 0, 10, 20, ..., 150$. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 presented with the 95% confidence intervals.

Table 1: Summary Statistics

(a) ACS sample (2009-2019)

	All (N=1,423,860)		Single majors (N=1,283,746)		Double majors (N=140,114)	
Variables	Mean	SD	Mean	SD	Mean	SD
Log annual earnings	11.003	0.673	11.001	0.672	11.016	0.686
1 if black	0.070	0.254	0.071	0.257	0.053	0.225
1 if Hispanic	0.051	0.219	0.051	0.220	0.047	0.211
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	7.870	44.681	7.852	45.023	8.023
Labor market experience	21.797	9.111	21.864	9.093	21.177	9.254
1 if double major	0.098	0.298				
1 if global double major	0.069	0.253				
1 if local double major	0.030	0.169				

(b) NSCG sample (2003-2019)

	All (N=94,278)		Single majors (N=79,291)		Double majors (N=14,987)	
Variables	Mean	SD	Mean	SD	Mean	SD
Log annual earnings	11.206	0.541	11.213	0.534	11.168	0.574
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	0.364	0.481	0.351	0.477	0.434	0.496
1 if married	0.720	0.449	0.723	0.447	0.703	0.457
Hours of work	44.699	7.053	44.565	6.929	45.405	7.637
Labor market experience	22.809	9.906	22.508	9.870	24.402	9.944
1 if west	0.238	0.426	0.240	0.427	0.225	0.418
1 if south	0.319	0.466	0.318	0.466	0.324	0.468
1 if northcentral	0.264	0.441	0.264	0.441	0.264	0.441
Father's level of education	3.100	1.464	3.118	1.456	3.003	1.505
Mother's level of education	2.864	1.208	2.878	1.203	2.787	1.230
1 if research university	0.365	0.481	0.378	0.485	0.294	0.455
1 if doctorate granting university	0.137	0.344	0.139	0.346	0.125	0.331
1 if comprehensive university	0.317	0.465	0.308	0.461	0.365	0.482
1 if liberal arts college	0.114	0.317	0.105	0.306	0.160	0.366
1 if specialized college	0.035	0.184	0.036	0.187	0.028	0.164
1 if double major	0.159	0.366				
1 if global double major	0.122	0.327				
1 if local double major	0.037	0.188				

Note: "Labor market experience" is calculated as age-22 and "double major" indicates that an individual holds a bachelor's degree in two fields. Bold variables 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 earning 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

Note: Data come from the 2009-2019 ACS. 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 that are smaller than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 earning 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***	0.820***	0.998***	0.682***	1.000***
	(0.096)	(0.109)	(0.099)	(0.128)	(0.041)
2^{nd} major shock	0.127	0.058		0.276**	
	(0.089)	(0.104)		(0.124)	
Higher major shock	0.154	0.122		0.042	
	(0.138)	(0.156)		(0.191)	
1^{st} major * double major	-0.556***	-0.536***	-0.174	-0.504***	-0.655***
	(0.086)	(0.102)	(0.313)	(0.119)	(0.127)
Occupation F.E.	yes	yes	yes	yes	yes
Observations	1,032,943	1,393,951	1,429,573	549,516	1,429,573
R-squared	0.312	0.316	0.312	0.300	0.316

Note: 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 year, division of birth, 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, year-major, and state-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 state 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's earnings to various earning 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***	0.522***	0.998***	0.690***	1.000***
	(0.096)	(0.030)	(0.099)	(0.129)	(0.041)
2^{nd} major shock	0.128	0.300***		0.271**	
	(0.089)	(0.031)		(0.124)	
Higher major shock	0.145	0.204***		0.040	
	(0.139)	(0.051)		(0.191)	
Global double major	0.007	0.004	0.006**	0.021**	0.007***
	(0.005)	(0.003)	(0.003)	(0.009)	(0.003)
Local double major	0.004	0.010***	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***	-0.628***	0.016	-0.655***	-0.869***
	(0.093)	(0.113)	(0.363)	(0.138)	(0.147)
1^{st} major shock * local double major	-0.361***	-0.319**	-0.621	-0.286***	-0.156
	(0.134)	(0.157)	(0.570)	(0.159)	(0.233)
F-test P-value	0.0465	0.0655	0.3355	0.0362	0.0082
Occupation F.E.	yes	yes	yes	yes	yes
Observations	1,032,943	1,393,951	1,429,573	549,516	1,429,573
R-squared	0.312	0.316	0.312	0.300	0.316

Note: 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 year, division of birth, 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 year and division of birth level. The "state-year-major shock" is generated at the year, state of birth, and college major level. The "State-year shock" is generated at the year and state of birth level. When calculating the division-year-major, year-major, and state-year-major level earnings shocks, we exclude single major observations from cells with the number of observations that is less than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 birth state fixed effects. Standard errors are clustered at the household level. We also report the P-value for whether the protection 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 earning shocks, using the NSCG

	(1)	(2)	(3)
	Division-year-major shock	Year-major shock	Division-year shock
1^{st} major shock	0.894***	1.151***	1.003***
	(0.105)	(0.286)	(0.134)
2^{nd} major shock	0.028	-0.004	
	(0.099)	(0.278)	
Higher major shock	0.076	-0.148	
	(0.149)	(0.418)	
1^{st} major shock * double major	-0.745***	-0.990***	-0.716**
	(0.091)	(0.249)	(0.327)
Occupation F.E.	yes	yes	yes
Minimum cell size	12	87	533
Observations	68,032	67,730	95,413
R-squared	0.391	0.373	0.377

Note: 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, year-major, and division-year level earnings shocks, we exclude single major observations from cells with the number of observations that is less than the lowest 25% threshold. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. The "division-year shock" is generated at the division of birth and year level. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 earning shocks, using the NSCG

	(1)	(2)	(3)
	Division-year-major shock	Year-major shock	Division-year shock
1^{st} major shock	0.919***	1.221***	1.003***
	(0.104)	(0.292)	(0.134)
2^{nd} major shock	0.028	0.016	
	(0.100)	(0.288)	
Higher major shock	0.051	-0.238	
	(0.150)	(0.431)	
Global double major	0.027**	0.030**	0.000
	(0.013)	(0.013)	(0.008)
Local double major	0.015	0.017	0.002
	(0.012)	(0.012)	(0.009)
1^{st} major shock* global double major	-0.796***	-1.086***	-0.978***
	(0.099)	(0.290)	(0.366)
1^{st} major shock* local double major	-0.645***	-0.775**	0.126
	(0.149)	(0.374)	(0.622)
F-test P-value	0.3455	0.4721	0.1123
Occupation F.E.	yes	yes	yes
Minimum cell size	12	87	533
Observations	68,032	67,730	95,413
R-squared	0.391	0.373	0.377

Note: 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 year, birth division, 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, year-major, and division-year level earnings shocks, we exclude single major observations from cells with the number of observations that is less than the lowest 25% threshold. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. The "division-year shock" is generated at the year and birth division. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 protection 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 earning shocks controlling for parental education and university type, using the NSCG

	(1)	(2)	(3)	(4)	(5)
High-edu father (high school and above)	0.029***	0.029***	0.029***	0.029***	0.029***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
High-edu mother (high school and above)	0.015***	0.015***	0.015***	0.015***	0.015***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research university	0.140***	0.140***	0.140***	0.140***	0.140***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Doctorate granting university	0.081***	0.081***	0.081***	0.081***	0.081***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
1^{st} major shock	0.892***	0.919***	0.927***	0.866***	0.900***
	(0.105)	(0.110)	(0.108)	(0.106)	(0.105)
2^{nd} major shock	0.026	0.025	0.025	0.028	0.026
	(0.099)	(0.099)	(0.099)	(0.099)	(0.099)
Higher major shock	0.081	0.083	0.083	0.079	0.082
	(0.149)	(0.149)	(0.149)	(0.149)	(0.149)
1^{st} major shock*double major	-0.749***	-0.752***	-0.752***	-0.744***	-0.749***
	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)
1^{st} major shock*high-edu father		-0.048			
		(0.051)			
1^{st} major shock*high-edu mother			-0.067		
			(0.050)		
1^{st} major shock*research				0.073	
				(0.052)	
1^{st} major shock*doctorate					-0.064
					(0.076)
Observations	68,032	68,032	68,032	68,032	68,032
R-squared	0.390	0.390	0.390	0.390	0.390

Note: 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, and college major level. When calculating the division-year-major level earnings shocks, we exclude single major observations from cells with the number of observations that is less than the lowest 25% threshold. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 region 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 large negative and positive earning shocks

	(1)	(2)
Large negative 1^{st} major shock	-0.056***	
	(0.016)	
Large negative 1^{st} major shock*double major	0.054***	
	(0.015)	
Large positive 1^{st} major shock	0.048***	
	(0.007)	
Large positive 1^{st} major shock*double major	-0.032**	
	(0.015)	
Negative 1^{st} major shock		-0.043***
		(0.006)
Negative 1^{st} major shock*double major		0.019***
		(0.006)
F-test1 P-value	0.3073	
F-test2 P-value	0.4213	
F-test3 P-value		0.0002
Occupation F.E.	yes	yes
Observations	1,032,943	1,032,943
R-squared	0.311	0.311

Note: 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. "Large negative shock" is a dummy variable indicating whether the shock is more than one standard deviation beneath the mean. "Large positive shock" is a dummy variable indicating whether the shock is greater than one standard deviation above the mean. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and marital status (married), labor market experience and its squared term, hours of work per week, indicators of whether the second major and higher paying major earnings shocks are (large) positive/negative, 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 state fixed effects. Standard errors are clustered at the household level. We also report P-values for whether protective effects of a large negative shock and large positive shock have the same absolute magnitudes (F-test1), P-values for whether the total effect of large negative and large positive shocks have the same absolute magnitudes (F-test2), and P-values for whether the total effect of negative shocks are zero (F-test3). Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 9: Response of double majors' earnings to earning shocks by experience

	(1)
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)
F test	
Occupation F.E.	yes
Observations	1,032,943
R-squared	0.312

Note: 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. When calculating the division-year-major level earnings shocks, we exclude single major observations from the division-year-major cells that are smaller than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 state fixed effects. Standard errors are clustered at the household level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 10: Relation between having a double major 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		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

Note: Data come from the ACS (2009-2019). The major-specific occupational share is measured as the share of people working in each occupation within a major using single majors. 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 is the occupational share in the first major (Columns (1) and (2)), the occupational in the second major (Column (3) and (4)), and the average share between two majors (Column (5) and (6)). First major fixed effects and second major fixed effects are controlled. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, and birth state fixed effects. Standard errors are clustered at major level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Table 11: Relationship between having a double major and the breadth of high O*NET skill/knowledge categories

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Number of high skills/35 O*NET skills					
	Above median		Above top 75%		Above top 90%	
	Sample Mean: 0.478		Sample Mean: 0.214		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/32 O*NET knowledge categories					
	Above median		Above top 75%		Above top 90%	
	Sample Mean: 0.483		Sample Mean: 0.218		Sample Mean: 0.081	
Double major	0.006**		0.006***		0.002	
	(0.003)		(0.002)		(0.001)	
Global double major		0.009***		0.008***		0.003*
		(0.002)		(0.002)		(0.002)
Local double major		0.002		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

Note: Data come from the ACS (2009-2019). The outcome variable in Panel A is the number of skills out of the 35 O*NET skills (in percent) that are high. In Panel B, the outcome is the number of knowledge categories out of the 32 O*NET knowledge categories that are high (in percent). The threshold of "high" skill/knowledge is defined using the population median, top 25%, and top 10% O*NET scores among single majors. First major fixed effects and second major fixed effects are controlled. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, and birth state fixed effects. Standard errors are clustered at major level. Significant level at ***p<0.01, **p<0.05, *p<0.1.

Appendix

Table A.1: Skill and knowledge measures in the Occupational Information Network (O*NET) database

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

Note: The ACS groups fields of study into 38 top level fields (left column), we rely on whether an individual chooses two majors in the same top level field to define global and local double majors. The right panel gives the aggregate grouping that we use to present summary statistics and in our analysis.

Table A.3: Most common double major pairs in 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	1.81%	0	1
Accounting	Finance	2417	1.73%	0	1
Business Management and Administration	Marketing and Marketing Research	1693	1.21%	0	1
Marketing and Marketing Research	Business Management and Administration	1593	1.14%	0	1
General Business	Accounting	1490	1.06%	0	1
Accounting	Business Management and Administration	1430	1.02%	0	1
History	Political Science and Government	1088	0.78%	1	0
Psychology	Sociology	1070	0.76%	1	0
Finance	Accounting	1053	0.75%	0	1
Business Management and Administration	Finance	1013	0.72%	0	1
Computer Science	Mathematics	981	0.70%	1	0
Elementary Education	Special Needs Education	973	0.69%	0	1
Mathematics	Computer Science	961	0.69%	1	0
Finance	Economics	867	0.62%	1	0
Marketing and Marketing Research	General Business	724	0.52%	0	1
Finance	Marketing and Marketing Research	724	0.52%	0	1
Communications	Advertising and Public Relations	698	0.50%	0	1
Journalism	Mass Media	665	0.47%	0	1
Biology	Nursing	651	0.46%	1	0
English Language and Literature	Communications	647	0.46%	1	0

Notes: Data come from the ACS (2009-2019). Sample size is 140,114 and only double majors are included. There are 9,594 different double major pairs in total at the fine degree level.

Table A.4: Percentages of individuals choosing a certain major as the first major and second major in ACS

Aggregated major	(1) Pct. choosing this major as the first major	(2) Pct. choosing a double major with this first major	(3) Pct. choosing this major as the second major among double majors
Business	28.80%	27.50%	26.34%
Humanities	10.44%	12.00%	12.34%
Social Sciences	8.49%	11.77%	11.98%
Education Administration and Teaching	8.28%	5.24%	6.45%
Engineering	7.13%	3.57%	3.10%
Medical and Health Sciences and Service	6.47%	3.15%	5.53%
Communications	5.56%	7.86%	7.54%
Information Sciences	4.46%	4.13%	5.30%
Fine Arts	4.13%	4.92%	5.07%
Psychology	3.61%	4.45%	3.75%
Biology and Life Sciences	2.71%	4.13%	2.15%
Other STEM	2.67%	2.20%	1.95%
Physical Sciences	2.01%	2.40%	2.28%
Agriculture	1.51%	1.55%	0.90%
Engineering Technologies	1.12%	0.82%	1.05%
Mathematics and Statistics	1.00%	2.21%	1.95%
Environment and Natural Resources	0.92%	1.23%	1.35%
Interdisciplinary and Multi-Disciplinary	0.70%	0.87%	0.96%

Notes: Data come from the ACS (2009-2019). Column (1): percentage of individuals choosing the listed major as the first major among all individuals. Column (2): among individuals with this major as the first major, the percentage of individuals that choose a double major. Column (3): percentage of double majors who choose the listed major as the second major. Global and local double majors are defined using the top level degree classification in ACS. We summarize the statistics from Column (1) to Column (3) under a wider field grouping based on the crosswalk in Table A.1

Table A.5: Response of double majors' earnings to various earning shocks: alternative 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 single major observations from the cells that are smaller than 100. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and marital status (married), labor market experience and its squared term, hours of work per week, year fixed effect, and birth state fixed effect in each column. We also control for occupation fixed effects in Columns (1) and (3). 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 shocks, by gender and race/ethnicity

	(1)	(2)	(3)	(4)
	Men	Women	Non-Hispanic white	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

Note: Data come from the ACS (2009-2019). The outcome variable is the natural log of earnings. Shocks are generated at the year, division of birth, and college major level. When calculating earnings shocks, we exclude single majors from division-year-major cells with less than the lowest 25 percentiles observations in each sample. Therefore, double majors who are matched to the dropped cells are also excluded in the regressions. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and marital status (married), labor market experience and its squared term, hours of work per week, year fixed effects, occupation fixed effects, and birth state fixed effect. 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 by parental education or university type, using NSCG single majors

	(1)	(2)	(3)	(4)	(5)
High-edu 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-edu mother (high school and above)	0.015***	0.015***	0.015***	0.015***	0.015***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Research university	0.132***	0.132***	0.132***	0.132***	0.132***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Doctorate granting university	0.076***	0.076***	0.076***	0.076***	0.076***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
major shock	1.000***	1.021***	1.035***	0.967***	1.005***
	(0.027)	(0.042)	(0.045)	(0.034)	(0.029)
major shock*high-edu father		-0.036			
		(0.054)			
major shock*high-edu mother			-0.050		
			(0.059)		
major shock*research				0.093*	
				(0.056)	
major shock*doctorate					-0.036
					(0.082)
Sample	Single majors	Single majors	Single majors	Single majors	Single majors
Observations	60,251	60,251	60,251	60,251	60,251
R-squared	0.394	0.394	0.394	0.394	0.394

Note: 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 year, birth region, and college major level. When calculating earnings shocks, we exclude single major observations from cells with the number of observations that is less than the lowest 25% threshold. Additional controls include indicators for race (black), ethnicity (Hispanic), gender (female), and 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 effect. Standard errors are clustered at the individual level. Significant level at ***p<0.01, **p<0.05, *p<0.1.