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Heterogeneity in Labor Market Returns to Master's Degrees: Evidence from Ohio

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Heterogeneity in Labor Market Returns to Master's Degrees: Evidence from Ohio

Abstract

Graduate education is among the fastest growing segments of the U.S. higher educational system. This paper provides up-to-date causal evidence on labor market returns to Master's degrees and examines heterogeneity in the returns by field area, student demographics and initial labor market conditions. We use rich administrative data from Ohio and an individual fixed effects model that compares students' earnings trajectories before and after earning a Master's degree. Findings show that obtaining a Master's degree increased quarterly earnings by about 12% on average, but the returns vary largely across graduate fields. We also find gender and racial disparities in the returns, with higher average returns for women than for men, and for White than for Black graduates. In addition, by comparing returns among students who graduated before and under the Great Recession, we show that economic downturns appear to reduce but not eliminate the positive returns to Master's degrees.

Keywords: Economic impact, educational economics, returns to education, graduate education, the Great Recession

Introduction

Graduate education is among the fastest growing segments of the U.S. higher educational system. While total undergraduate enrollment in degree-granting postsecondary institutions increased by 26 percent between 2000 and 2018, total post-baccalaureate enrollment increased by 41 percent over the same period (Hussar et al., 2020). This rapid growth in enrollment has been accompanied by an even faster increase in graduate school debt, which rose by 51 percent between 2000 and 2018. While the increase in graduate student debt has attracted policy concern (Douglas-Gabriel, 2020; Miller, 2020), less attention has been given to the other side of the equation: what returns students earn from a graduate degree. Most of the existing studies on this question use outdated sources of data, self-reported measures of labor market outcomes, and/or empirical strategies that can control only for selection on observable characteristics (e.g., Arcidiacono et al., 2008; Song et al., 2008; Stevenson, 2016; Tamborini et al., 2015; Titus, 2007). Two recent papers (Altonji & Zhong, 2021; Altonji & Zhu, forthcoming) provide more rigorous causal evidence on labor market returns to a wide range of graduate programs. These recent studies find substantial differences in returns to Master's degrees across fields, but still leave important open questions about the heterogeneity in labor market returns to graduate degrees across demographic groups and labor market contexts.

In this paper, we provide up-to-date causal evidence on labor market returns to Master's degrees, and examine the returns by field area, student demographics and labor market conditions at graduation. We use administrative data tracking graduate students enrolled in Ohio from 2000 to 2009, with quarterly earnings spanning historically for 20 years through the fourth quarter of 2019.

Our study will contribute in two primary ways. First, we examine labor market returns to Master's degrees using an individual fixed effects strategy similar to Altonji and Zhu (forthcoming), but with a sample from a different state (Ohio) spanning over a long time frame including the Great Recession and the steady recovery of the 2010s. Second, we examine heterogeneity in the returns by the labor market conditions at graduation. Increasing evidence has shown that initial macroeconomic conditions matters for both the quality of first job and long-term career development (Altonji, Kahn & Speer, 2016; Kahn, 2010; Schwandt & von Wachter, 2019). Our study not only advances the literature to highly-skilled entrants with graduate degrees, it also informs more rational educational choices under a recession, with possible implications during the current pandemic for policymakers and students. To the best of our knowledge, we are the first to compare labor market outcomes under different economic conditions at graduation for highly skilled graduates.

On average, we find that obtaining a Master's degree increased quarterly earnings by about 12%. Consistent with past empirical evidence, the returns varied across fields. Our results suggest that while Master's degrees in Health increased earnings by approximately 25%, students could have nearly zero earnings gains from completing a Master's degree in Arts and Humanities. The magnitudes of the returns to obtaining a Master's degree in other fields are around 10%. We also find gender and racial disparities in the returns to Master's degrees, with higher average returns for women than for men, and for White graduates relative to their Black peers. In addition, we compare returns among cohorts who graduated with the Master's degree before versus during the Great Recession. The returns remained strongly positive among cohorts who graduated during the recession (8%), but were about 6 percentage points lower than for those who graduated before the recession (14%). While obtaining a Master's degree on average

can boost up earnings, it is important for individuals and policymakers to take into consideration the heterogeneity in returns to Master's degrees depending on field area and labor market conditions.

The paper proceeds as follows. The next section reviews literature on labor market returns to graduate degrees and interactions between graduating under recessions and labor market outcomes. Section 3 describes the data and the analysis sample used in the study. Section 4 discusses the empirical framework to analyze labor market returns to graduate degrees. Section 5 presents empirical results, and the paper concludes with a discussion of the findings and future research in Section 6.

2. Previous Literature

The economic theory of human capital investment suggests that individuals invest in schooling until the marginal benefits in terms of future earnings and other non-monetary benefits are equal to its marginal costs. While costs of graduate education are relatively more straightforward, students have incomplete information about its payoffs. Moreover, Lindley and Machin (2016) warned against examining college graduates as a single group of workers in the labor market due to its increasingly heterogeneous nature between advanced degree holders and college-only workers. Therefore, providing information about returns to graduate degrees is critical to guide students and policymakers about investments in graduate schools.

There is a small but growing literature examining labor market returns to graduate degrees. For example, Titus (2007) employed a propensity score matching model among students who completed a Bachelor's degree in 1993, and found no significant returns to Master's degrees in fields other than Education and Business. Arcidiacono et al. (2008) used an individual fixed effects approach and found positive wage returns to an MBA program among students who

registered to take the GMAT in 1990 and were followed up with surveys through 1998. Song et al. (2008) applied a two-stage regression model among Bachelor's degree recipients between 1963 and 1986, and found an estimated annualized return of 7.3% for Master's degrees, 16.6% for professional degrees, and 12.8% for doctoral degrees. Stevenson (2016) examined returns to quality in graduate education among students who received a Bachelor's degree in 1993, and found no returns to either degree completion or program quality in most graduate programs. Important exceptions include Master's programs in health, where completion substantially increased earnings, as well as MBA and professional degree programs, where program quality had a positive influence on earnings. While these studies shed light on returns to graduate degrees, they all used data from more than two decades ago. As both graduate education and the labor market have been developing and changing, the results may not generalize well to current conditions.

One important recent paper by Altonji and Zhong (2021) used fixed effects for combinations of college major and graduate field with more recent data from the National Survey of College Graduates (NSCG, 1993 to 2015) and the National Survey of Recent College Graduates (NSRCG, 1993 to 2010). The paper found differences across fields of graduate degrees in returns on earnings. One limitation of the study is that the analyses are based on self-reported earnings and oversampled individuals in Science & Engineering fields.

The most similar study to ours is Altonji and Zhu (forthcoming) examining labor market returns to various graduate degrees applying alternative fixed effects models with administrative data from Texas. Results also show variations across fields, with particularly high returns to graduate degrees in health-related fields. In addition, this paper found substantial differences across racial and gender groups, and studied how the returns differ by college GPA and major,

and across graduate institutions. Our paper examines labor market returns to Master's degrees with administrative data from a different state (Ohio) using an individual fixed effects model. We show similar patterns in the returns under a different state context to findings from Altonji and Zhu (forthcoming). In addition, our data span over a long-time frame and allow us to compare labor market returns to Master's degrees among students who graduated before and during the Great Recession.

Our paper also relates to the literature on the effects of entering the labor market during a recession. Prior literature has documented that initial labor market experiences have large and persistent impacts on long-term career progression and success (Oreopoulos, von Wachter, & Heisz, 2012; Kahn, 2010; Liu, Salvanes, & Sorensen, 2016; van den Berge, 2018). For example, both the quality of the first employer and the first job match have been shown to have lasting impacts on students' future employment and earnings. Therefore, how graduates fare during labor market shocks can have critical implications for their earnings trajectories.

Indeed, there is increasing evidence showing that labor market entrants under a bad economic condition suffer adverse consequences on labor market outcomes. Kahn (2010) showed that graduating under the recession in the early 1980s led to earnings losses persisting up to 15 years among college graduates. Schwandt and von Wachter (2019) studied young workers who entered the labor market in the U.S. from 1976 to 2015, and found that entrants under times of high unemployment experienced substantial and long-lasting employment and wage reductions. These effects were particularly large among nonwhite student groups, partly driven by greater losses in employment. Altonji, Kahn and Speer (2016) examined labor market outcomes of U.S. college graduates from the classes of 1974 to 2011, and also concluded that a large recession at graduation substantially reduced initial earnings. Furthermore, the effects

differed by field of study: the losses were smaller among students in fields predicted with higher earnings.

Yet, less is known about how entering the labor market during a recession interacts with labor market outcomes among highly-educated workers with graduate degrees. Human resources with graduate-level training are scarcer in the labor market. Thus, workers with graduate degrees are potentially less vulnerable to adverse conditions in the labor market than their less educated counterparts. Our paper intends to not only provide the most up-to-date causal evidence on labor market returns to graduate degrees using administrative data from Ohio, we also examine changes in the returns surrounding the Great Recession to better understand the transition from graduate schools to the labor market under economic downturns.

3. Data and Sample

For our empirical analysis, we use two administrative data sources from the state of Ohio. De-identified data were provided by the Ohio Education Research Center (OERC) under a limited-use, restricted data agreement. The OERC assembles data from multiple state agencies, including the Ohio Board of Regents (OBR) and the Ohio Department of Job and Family Services (ODFJS), into a repository known as the Ohio Longitudinal Data Archive (OLDA).[1]

The first dataset includes demographic and term-level academic information for all the students attending any public institutions of higher education in Ohio between the years of 2000

[1] The following acknowledgement is required to be stated on any materials produced using workforce or higher education data accessed from the OLDA: This workforce solution was funded by a grant awarded to the U.S. Department of Labor's Employment and Training Administration. The solution was created by the Center for Human Resource Research on behalf of the Ohio Department of Job and Family Services and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warranties, or assurances of any kind, express or implied, with respect to such information, including any formation on linked sites and including, but not limited to, accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability, or ownership. This solution is copyrighted by the institution that created it. Internal use, by an organization and/or personal use by an individual for non-commercial purposes, is permissible. All other uses require the prior authorization of the copyright owner.

and 2011. We can identify students' demographic characteristics, school enrollment and degree outcomes from the dataset. The second dataset includes quarterly earnings records of all the employees subject to Unemployment Insurance (UI) contributions in Ohio between the years of 1999 and 2019. The earnings records can be linked to the education data through an individual identifier. Thus, we can identify students' quarterly earnings before enrollment at graduate school as well as after the completion of a graduate degree. The data also include the county of the employer, which allows us to link county-level unemployment rates from the Bureau of Labor Statistics (BLS) to each quarter and every worker in the data, serving as a proxy for the labor market conditions that the individual worked under.

For this study, we restrict the analysis sample to Master's degree holders who first enrolled and obtained a Master's degree in Ohio's public college system from Fall 2000 to Fall 2009. This restriction allows us to track and compare each individual's quarterly earnings from six quarters before graduate school enrollment to ten years after completion. Individuals who obtained Master's degrees older than 50 are excluded.

Since our fixed effects approach compares an individual's earnings before and after obtaining the graduate degree, one would ideally like to focus on Bachelor's degree holders who actively participated in the labor market before graduate school enrollment. Yet, a limitation of the data is that we cannot observe Bachelor's degree completion for all individuals in our sample. To address this, we limit the sample to individuals who had at least four quarters of earnings higher than the state minimum wage at an age older than 22 within six quarters before their first graduate enrollment.[2] Furthermore, we limit the sample to individuals who have at

[2] We cannot capture Bachelor's degree completion for everyone, since some may have earned it prior to our data window, or may have done so at an out-of-state or private institution not covered in our data. Earnings above the minimum wage are approximated using information from U.S. Department of Labor, State Minimum Wage Rate for Ohio [STTMINWGOH], retrieved from FRED, Federal Reserve Bank of St. Louis:

least one quarter of earnings higher than the minimum wage within ten years after completion. This ensures that individuals who did not work actively for UI-covered employers in the state after Master's completion are excluded as we are not able to identify their post-Master's degree earnings.

Table 1 displays descriptive statistics of our analysis sample. Approximately 65% are women and 84% are White students.[3] The average student in our sample first enrolled in graduate school at the age of 30 and earned a Master's degree at the age of 32. Degrees in the fields of Education, Business, Social & Behavioral Sciences and Health are the most common. And we can track approximately an average of six quarters of earnings before graduate enrollment and 33 quarters of earnings post Master's degree completion for individuals in the sample.

Table 1 also compares our analysis sample with national samples of Master's students in NPSAS: GR 2004 and NPSAS: GR 2008 who have earned a Bachelor's degree, had a job prior to graduate enrollment and completed the Master's degree program in 2003-2004 and 2007-2008, respectively. Compared to Master's degree holders in the nation, our analysis sample has a slightly higher proportion of women and White students. Master's degree holders in Ohio are more likely to complete a Master's degree in Education and at a relatively younger age. Overall, descriptive statistics of our analysis sample are similar to the rest of the country.

An important limitation of our earnings data is that we are unable to distinguish between quarters when an individual was unemployed, not in the labor force, worked in another state or

https://fred.stlouisfed.org/series/STTMINWGOH. Minimum wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), in the same way as the earnings data.

[3] The racial distribution of our sample corresponds to Ohio's overall demographics - approximately 76% of the state's population are White based on census estimates in 2019.

under non-UI-covered employers in Ohio. We therefore exclude quarters of missing earnings from the analysis. All the earnings are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% are top-coded. Figure 1 shows the earning trajectory of the analysis sample. Specifically, the figure depicts average quarterly earnings of six quarters before graduate enrollment, shown as negative relative quarters, and ten years after graduate degree completion, shown as positive relative quarters. The figure displays a sharp earning jump right after the completion of the Master's degree, and the earnings continued to rise gradually over the next ten years. Also, the figure shows a slight earning dip one and two quarters before the first enrollment term at graduate school, indicating possible existence of the "Ashenfelter dip" before graduate entry.

4. Empirical Methodology

To estimate the labor market returns to Master's degrees, we employ an individual fixed effects approach comparing pre- and post-graduate education earnings within the same individual among Master's degree holders in our analysis sample. For each individual, we use quarters of earnings within six quarters before the first graduate enrollment as pre-earnings, and quarters of earnings within ten years after the completion of the Master's degree as post-earnings. Only earnings higher than state's minimum wage earned at an age older than 22 are used in the estimation. Specifically, we estimate:

$$Lnearn_{it} = \alpha + \beta Madeg_{it} + \theta_1 Age_{it} + \theta_2 Age_{it}^2 + \gamma Prern_{it} + \delta Demog_i * YQ_t + \lambda Field_i * YQ_t + \pi Cohort_i * YQ_t + \varphi Unempr_{it} + \eta_i + \varepsilon_{it} \quad (1)$$

The dependent variable $Lnearn_{it}$ is the log-transformed real quarterly earning for individual *i* at quarter t. $Madeg_{it}$ is a dummy variable indicating if individual *i* has obtained a

Master's degree in quarter *t*. That is, quarters of pre-earnings have a value of zero for this variable and quarters of post-earnings have a value of one.

The underlying age (experience) - earnings profile is accounted for by Age_{it} and Age_{it}^2. $Prern_{it}$ is a set of two dichotomous variables, which equal to one for the time period one and two quarters before first graduate enrollment, respectively. These two variables control for possible pre-enrollment dips in earnings (Ashenfelter's dip) that we observed shortly before first graduate enrollment in Figure 1. $Demog_i * YQ_t$ is a vector of time-variant person-specific demographics including a time trend interacted with race/ethnicity, gender and age at first enrollment in graduate school. We also control for $Field_i * YQ_t$, a time trend interacted with fields of study declared at first graduate school enrollment, and $Cohort_i * YQ_t$, a time trend interacted with cohorts of entry at graduate school. These interaction terms control for linear time trends specific to individual characteristics, and accounts for the fact that underlying earnings trajectories may be different by these characteristics. $Uempr_{it}$ is the county-level, quarter-specific unemployment rate to control for the macroeconomic condition at graduation for individual *i*. η_i controls for individual fixed effects, and thus eliminates the risk of a bias due to any omitted factors that stay constant across time for each individual. Our estimation includes data from post- Master's degree quarters to account for time-variant factors and underlying earnings trajectories by individual characteristics. However, the time trends may pick up some effect of the Master's degree on earnings growth, especially when returns change with post-graduate school experience.

The coefficient of interest measures the change to earnings within an individual from before graduate school to after graduate degree receipt, compared to the trends we would expect for similar students. Thus, the coefficient can be interpreted as the causal effect of Master's

degrees on log earnings. Since the analysis sample includes individuals who eventually obtained a Master's degree and quarters of earnings higher than the minimum wage only, the estimated return is the treatment on the treated effect conditional on active employment.

The empirical methodology is based on several assumptions. First, since the degree data do not track students beyond the year of 2011 but the earnings data expand to 2019, we could not consistently identify a control group of individuals who never obtained a Master's degree over the entire time frame of the earnings data. As a result, our sample does not include a "pure" control group but includes only those who earned a Master's degree at some point by 2011. We compare graduates' earnings trajectories before versus after degree completion, assuming that the counterfactual earnings in the absence of the graduate degree can be modeled based on the earnings trajectories of similar individuals who eventually completed a Master's degree but hadn't yet enrolled in graduate school. The model controls for any individual-specific variations in the outcome that stay constant over time, important time-variant factors such as the individual's age and county-level unemployment, as well as time trends in earnings by race/ethnicity, gender, field of study, age and cohort of entry in graduate school. For the same reason, quarters from 2011 to 2019 are exclusively post-graduation earnings in our data. We therefore do not control for time fixed effects because it will absorb some of the returns to Master's degrees. Instead, we include controls for flexible time trends, which we allow to vary by age at entry, race/ethnicity, gender, and field area.

Finally, we do not have undergraduate records for students who obtained college degrees outside of Ohio's public college system or beyond the time coverage of the education data. Therefore, we do not control for individual undergraduate variables in the model, such as college major. This is not a concern for our estimation, as any time-invariant effects of college-related

variables are controlled by the individual fixed effects, and our specification also already includes graduate-field-area-specific time trends.

5. Results

Labor Market Returns to Master's Degrees

Table 2 reports estimates of the effects of obtaining a Master's degree on log earnings. Column 1 shows the average return to any Master's degree. Since Master's degree holders in different fields of study enter different labor markets, we categorize Master's degrees into eight areas based on CIP codes: Arts & Humanities, Business, Education, Engineering, Health, Natural Sciences & Math, Services, and Social & Behavioral Sciences.[4] We conduct subgroup analyses by field area and show estimates in Column 2-9.

The coefficient for the estimated return (in logs) to any Master's degree is 0.116. This indicates that on average a Master's degree increased quarterly earnings by about 12%. That is, obtaining a Master's degree increased earnings by approximately $1,400 per quarter from an average baseline quarterly earnings of $11,433.

Although the average return to a Master's degree is positive and statistically significant, Table 2 shows a large variation in returns by graduate fields. Ranked from the highest to the lowest, the estimated returns to a Master's degree are approximately 24% for Health, 13% for Education, 12% for Natural Sciences & Math, 11% for Engineering, 9% for Services, 8% for Business, 7% for Social & Behavioral Sciences, and essentially zero for Arts & Humanities. To allow for comparison across graduate fields, the returns are shown in percentages as baseline earnings also vary across fields. Also, the returns do not take into account direct and indirect

[4] Top majors (CIP codes) within each field area are listed in Appendix Table 1.

costs of completing the Master's degree. These results thus suggest that the net value of a Master's degree in Arts & Humanities could be negative.

Table 3 illustrates heterogeneity in returns to Master's degrees by gender and race/ethnicity. Results for gender disparities indicate that the returns are higher for women than for men. On average, a Master's degree increased quarterly earnings by about 7% for men and 14% for women. Before graduate enrollment, men in our sample had an average baseline earning of $13,380 while women had only $10,511. Obtaining a Master's degree increased quarterly earnings for men by $950 and $1,500 for women. Results demonstrate that women benefit more from obtaining a Master's degree than men, suggesting that the gender wage gap would be narrower but still not fully closed among these highly skilled graduates.

In terms of racial disparities, Table 3 shows that returns are the highest among White degree holders, and relatively lower among Black degree holders. Specifically, obtaining a Master's degree increased quarterly earnings by about 12% for White students and only 8% for Black students. In addition, the estimated returns are about 11% for Hispanic degree holders, and 7% for Asian degree holders. However, results for Hispanic and Asian students are estimated on a small sample and thus should be interpreted with caution.

Heterogeneity in returns by field area may help explain the gender differences in the overall magnitude of estimates returns, because men are substantially underrepresented in health and education fields despite their high returns. As shown in Appendix Table 2, men are relatively more likely to graduate in Business and Engineering, while women are more likely to graduate in Education and Health. Similarly, compared to White degree holders, Blacks are relatively more likely to graduate in fields that have low returns like Social & Behavioral Sciences. Although field choices alone cannot fully explain the heterogeneity in returns across demographic groups,

results suggest that graduate fields serve as a contributing factor to the gender and racial disparities in returns to Master's degrees.

Labor Market Returns to Master's Degrees and the Great Recession

In order to examine heterogeneity in returns to Master's degrees by the labor market conditions at graduation, we compare individuals who graduated with a Master's degree before and under the Great Recession.[5] To ensure the comparability of the two groups, we construct a recession comparison sample by further restricting our analysis sample to individuals who graduated from 2004 to 2009 within three years after they first enrolled in graduate school. Among them, we compare students who graduated from 2004 to 2007 (before the recession) with those who graduated from 2008 to 2009 (under the recession).[6] The majority (84%) of the sample who graduated under the recession started graduate school before the recession (before 2008). Figure 2 shows the wage trajectories of the two graduation cohorts separately. Similar to the full analysis sample shown in Figure 1, students' earnings increased sharply right after completing a Master's degree and further gradually increased over the next ten years for both groups.

Focusing on the recession comparison sample, we examined and compared returns to Master's degrees among students who graduated before and during the Great Recession using the

[5] Note that our only interest here is to examine heterogeneity in returns to credentials depending on initial labor market conditions. We are neither estimating the effect of the Great Recession on earnings per se, nor can we examine how returns to Master's degrees may change after the recession. Furthermore, we note that we cannot causally identify whether the estimated heterogeneity in returns is directly due to the difference in labor market conditions or whether it may reflect heterogeneity in returns along other dimensions (e.g., field areas, gender).

[6] The National Bureau of Economic Research (NBER) defines a recession as "a period of falling economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales", and estimates that the Great Recession began in December 2007 and ended in June 2009. Since our study focuses on labor market outcomes, and unemployment rates continued to increase through the end of 2009, we include all of 2009 in the recession. Appendix Table 3 compares summary statistics between students who graduated with a Master's degree before and under the Great Recession in the recession comparison sample. There is no significant difference in student compositions across the two cohorts.

same individual fixed effects model. In particular, we add to the estimation an interaction term of a flag for graduating with the Master's degree under the recession and the dummy variable for post-Master's degree quarters. Individuals who graduated in 2008 or 2009 get a value of one for the recession flag, and individuals who graduated before 2008 get a value of zero. The coefficient on the interaction term would estimate the variation in the return to a Master's degree completed under the Great Recession from the return to the degree completed before the recession.

Table 4 shows estimated coefficients on the dummy variable for post-Master's degree quarters and the interaction term of the dummy and the recession flag. The coefficient on the dummy variable indicates returns to Master's degrees completed before the Great Recession, and the sum of the coefficients on the dummy variable and the interaction term indicates returns to degrees completed under the recession. Overall, a Master's degree completed under the recession had a lower return than before the recession. Specifically, a Master's degree increased quarterly earnings by about 14% for students who graduated before the recession, and by only about 8% for those who graduated under the recession. While returns to Master's degrees under the Great Recession were still positive, returns for those graduating during the recession were about 6 percentage points lower.

Table 4 also shows returns to Master's degrees among graduates before and under the Great Recession by graduate field area. This specification breaks the estimations down to smaller samples, resulting in weaker statistical power. None of the coefficients of interaction terms appear positive, indicating that returns to Master's degrees completed under the Great Recession were lower than degrees completed before the recession across fields. Returns completed under the recession were lower than returns completed before the recession by about 12 percentage

points for Master's degrees in Services, and 6 to 7 percentage points for a degree in Business, Social & Behavioral Sciences, and Education. The coefficients of interaction terms are not statistically significant for Arts & Humanities, Engineering, Health, and Natural Sciences & Math. Except for Engineering, the coefficients also have a small magnitude, suggesting that returns to Master's degrees in these fields did not vary significantly with the recession.

Table 5 examines interaction terms between returns to Master's degrees and the Great Recession by gender and race/ethnicity. These interaction terms are mostly negative and significant, suggesting that the relative payoff to Master's degrees decreased during the recession across all gender and racial groups. Returns to Master's degrees decreased by a similar magnitude for both genders in recession years versus prerecession years (6 percentage points). Only for Whites and Hispanics the returns are notably smaller when the economy is in a recession. The distribution of graduate fields by gender and race/ethnicity in recession years versus prerecession years are shown in Appendix Table 4. While the distribution of field areas by gender did not significantly change during the Great Recession, Black degree holders were notably less likely to graduate in Education than their White peers.

Robustness Checks

Appendix Table 5 displays results for a robustness check regarding how we treat missing earnings, which could reflect non-employment but could also indicate migration out of state, self-employment, or employment in a non-UI covered position. As discussed, the main analysis excludes quarters with missing earnings as we could not identify the reason for the missing data. However, our results would overestimate returns to Master's degrees if missing earnings are mostly due to unemployment. To check if the exclusion of missing earnings biases the findings, we conduct a robustness check limiting the analysis sample to individuals with no employment

gaps. We estimate returns for individuals who have earnings data that could be used in the analysis for all the six quarters before graduate enrollment and every quarter throughout the ten years after completion of a Master's degree.

Overall, our findings are robust to missing earnings data. Column 1 of Appendix Table 5 shows that the average labor market return to a Master's degree among individuals with no employment gaps (10%) was slightly lower than but close to the findings using the full analysis sample (12%). Results of how the returns varied with the Great Recession shown in Column 2 are also consistent with our main results.

As discussed above, 16% of the recession comparison sample who graduated with the Master's degree under the recession also entered graduate school under the recession. Their enrollment decisions, such as major choice, may be influenced by the recession, which have implications for their returns to Master's degrees. We therefore test whether the results are sensitive to dropping students who entered graduate school after 2008. Among students who entered graduate school before the recession, we compare students who completed a Master's degree before and under the recession. Appendix Table 6 shows results of this test. These results are consistent with our main results, which reassures that our estimation results on how returns to Master's degrees varied with the Great Recession were not driven by selection bias.

6. Discussion and Conclusion

This paper exploits state administrative data with an individual fixed effects model and provides up to date causal evidence on labor market returns to Master's degrees. On average, obtaining a Master's degree increased earnings by about 12% or $1,400 per quarter. According to data from NPSAS: GR 2008, the average cumulative amount borrowed for graduate school is

$26,263 at Ohio's public institutions.[7] This suggests that graduate debt would be paid off in about 5 years with the estimated average quarterly return to Master's degrees. Although attending graduate school also entails indirect costs such as "forgone earnings," graduate education still seems like a good investment in the long term on average. However, the returns vary largely across graduate fields. While obtaining a Master's degree could be a great investment for students in certain graduate fields (e.g., Health), it may not be for other fields (e.g., Arts & Humanities). These results highlight that students' decisions about attending graduate school and choosing a graduate field are likely to be important in determining labor market outcomes.

Although we use a different approach to categorize Master's degree fields than Altonji and Zhu (forthcoming)'s study, our results are largely similar across several graduate fields such as Engineering, Health and Social & Behavioral Sciences. Yet, our estimates are lower for Master's degrees in Business and higher for Education than Altonji and Zhu (forthcoming)'s estimates.[8] The difference in returns to Business could be due to different labor market conditions at graduation or different quality of MBA programs offered in the two states. And the difference in Education may be explained by differences in teacher's salary schedule between the

[7] Calculated by authors using NCES PowerStats among borrowers who enrolled in and completed a Master's degree in 2007-2008 at a public institution in Ohio.

[8] Specifically, our estimate for a Master's degree in Engineering is 0.109, among which 22% are in Mechanical Engineering; and Altonji and Zhu's individual fixed effects estimate for a graduate degree in Mechanical Engineering is 0.125. We estimate that a Master's degree in Health, mostly in Nursing, has a return of 0.243; and their estimate for a degree in Nursing is 0.26. Also, our estimate for a degree in Social & Behavioral Sciences, represented largely by Social Work, is 0.072; and their estimate for a degree in Social Work is 0.097. While Altonji and Zhu show that an MBA degree has a return of 0.194, our estimate for a Master's degree in Business, among which 66% are in Business Administration and Management, is only 0.079. A Master's degree in Education has a return estimated at 0.128 in our study, represented by 24% in Curriculum & Instruction and 15% in Education Administration and Leadership, but is low for both majors in Altonji and Zhu's results (0.033 for a degree in Education Administration, and -0.005 for a degree in Curriculum & Instruction).

two states.[9] Therefore, returns to graduate degrees could be sensitive to state conditions and regulations, which should be taken into consideration when generalizing our results to a different state.

Our paper also shows that the average labor market return to a Master's degree is higher for women and Black students relative to men and White students. We find that differences in graduate fields may contribute to the gender and the Black-White gaps in returns to Master's degrees. Determining what drives these gaps is beyond the scope of this paper, but should be an important priority for future research.

Finally, we further compare returns to Master's degrees among students who graduated before versus during the Great Recession to examine heterogeneity in the returns by labor market conditions at graduation. Our findings suggest that economic downturns largely reduce but not eliminate the positive returns to Master's degrees.

Our findings are subject to challenges that limit their generalizability. Our sample is limited to individuals who work both before and after graduate school. Another limitation of the data is that Master's degree completion and labor market outcomes can only be observed for individuals who attend public institutions and work a UI-covered position in Ohio. Thus, the findings may have limited generalizability to individuals who enroll in graduate school directly after college, completed Master's degrees at private/for-profit colleges, and worked non UI-covered positions or in another state with different labor market conditions. Our study could be extended with different samples/contexts in order to provide a more thorough understanding about returns to graduate school investments.

[9] In Ohio, the minimum teacher salary increases with the highest degree level of the teacher. In Texas, the minimum salary only depends on years of experience, and teachers with an advanced degree may be compensated with a stipend by districts.

Despite these limitations, we believe that our paper has important implications for policies and future research on returns to graduate education. Our paper highlights important variation in the returns to Master's degrees across demographic groups, field areas and initial labor market condition. This contributes to the body of evidence of differential returns and has implications not only for students' making choices, but also for policymakers evaluating changes aimed at affordability and accountability of graduate school. Costs of graduate education and non-monetary returns to graduate degrees are also critical factors in determining optimal investment decisions in graduate education. While our study focuses on examining returns to Master's degrees on earnings, it has important implications for future research with access to data on costs, debt and non-monetary outcomes associated with graduate education.

References

Altonji, J. G., Kahn, L. B., & Speer, J. D. (2016). Cashier or Consultant? Entry Labor Market Conditions, Field of Study and Career Success. *Journal of Labor Economics*, 34(S1), S361-S401.

Altonji, J. G. & Zhong, L. (2021). The Labor Market Returns to Advanced Degrees. *Journal of Labor Economics*. 39(2), 303-360.

Altonji, J. G. & Zhu, Z. (Forthcoming). Returns to Specific Graduate Degrees: Estimates Using Texas Administrative Records. Retrieved from https://www.dropbox.com/s/urgnlpm1a3d68bl/ja_zz_returns_to_graduate_programs_v24.pdf?dl=0.

Arcidiacono, P., Cooley, J., & Hussey, A. (2008). The Economic Returns to an MBA. *International Economic Review*, 49(3), 873-899.

Douglas-Gabriel, D. (2020). This is the student loan problem that no one talks about: Graduate school debt. *The Washington Post*. Retrieved from https://www.washingtonpost.com/education/2020/01/13/this-is-student-loan-problem-that-no-one-talks-about-graduate-school-debt/.

Hussar, B., Zhang, J., Hein, S., Wang, K., Roberts, A., Cui, J., Smith, M., Bullock Mann, F., Barmer, A., & Dilig, R. (2020). The Condition of Education 2020 (NCES 2020-144). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from https://nces.ed.gov/pubsearch/pubsinfo. asp?pubid=2020144.

Kahn, L. B. (2010). The long-term labor market consequences of graduating from college in a bad economy. *Labour Economics*, 17(2), 303-316.

Lindley, J., & Machin, S. (2016). The Rising Postgraduate Wage Premium. *ECONOMICA*, 83(330), 281-306. [1]. https://doi.org/10.1111/ecca.12184

Liu, K., Salvanes, K. G., & Sørensen, E. Ø. (2016). Good skills in bad times: Cyclical skill mismatch and long-term effects of graduating in a recession. *European Economic Review*, 84, 3-17.

Miller, B. (2020). Graduate School Debt – Ideas for Reducing the $37 Billion in Annual Student Loans That No One Is Talking About. *The Center for American Progress*. Retrieved from https://www.americanprogress.org/article/graduate-school-debt/.

Oreopoulos, P., von Wachter, T., & Heisz, A. (2012). The Short- and Long-Term Career Effects of Graduating in a Recession. *American Economic Journal: Applied Economics*, 4(1), 1-29.

Schwandt, H. & von Wachter, T. (2019). Unlucky Cohorts: Estimating the Long-Term Effects of Entering the Labor Market in a Recession in Large Cross-Sectional Data Sets. *Journal of Labor Economics*, 37(S1), S161-S198.

Song, M., Orazem, P. F., & Wohlgemuth, D. (2008). The role of mathematical and verbal skills on the returns to graduate and professional education. *Economics of Education Review*, 27(6), 664–75.

Stevenson, A. (2016). The returns to quality in graduate education. *Education Economics*, 24(5), 445-464.

Tamborini, C. R., Kim, C., & Sakamoto, A. (2015). Education and Lifetime Earnings in the United States. *Demography*, 52:1383-1407.

Titus, M. A. (2007). Detecting selection bias, using propensity score matching, and estimating treatment effects: an application to the private returns to a master's degree. *Research in Higher Education*, 48, 487–521.

van den Berge, W. (2018). Bad start, bad match? The early career effects of graduating in a recession for vocational and academic graduates. *Labour Economics*, 53, 75-96.

Figure 1. Wage Trajectories for Master's Degree Holders in Ohio

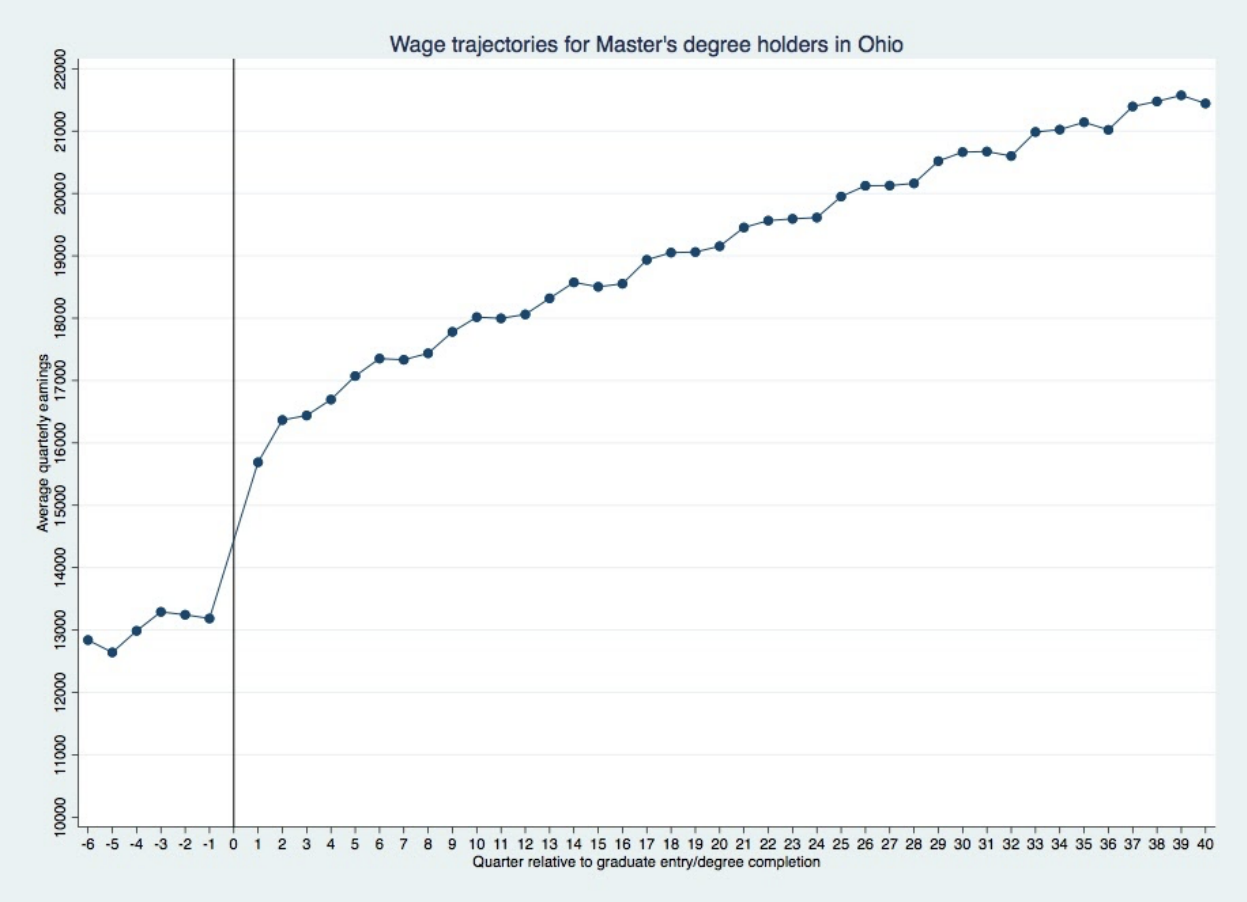

Figure 2. Wage Trajectories for Master's Degree Holders in Ohio, by Graduation Cohort

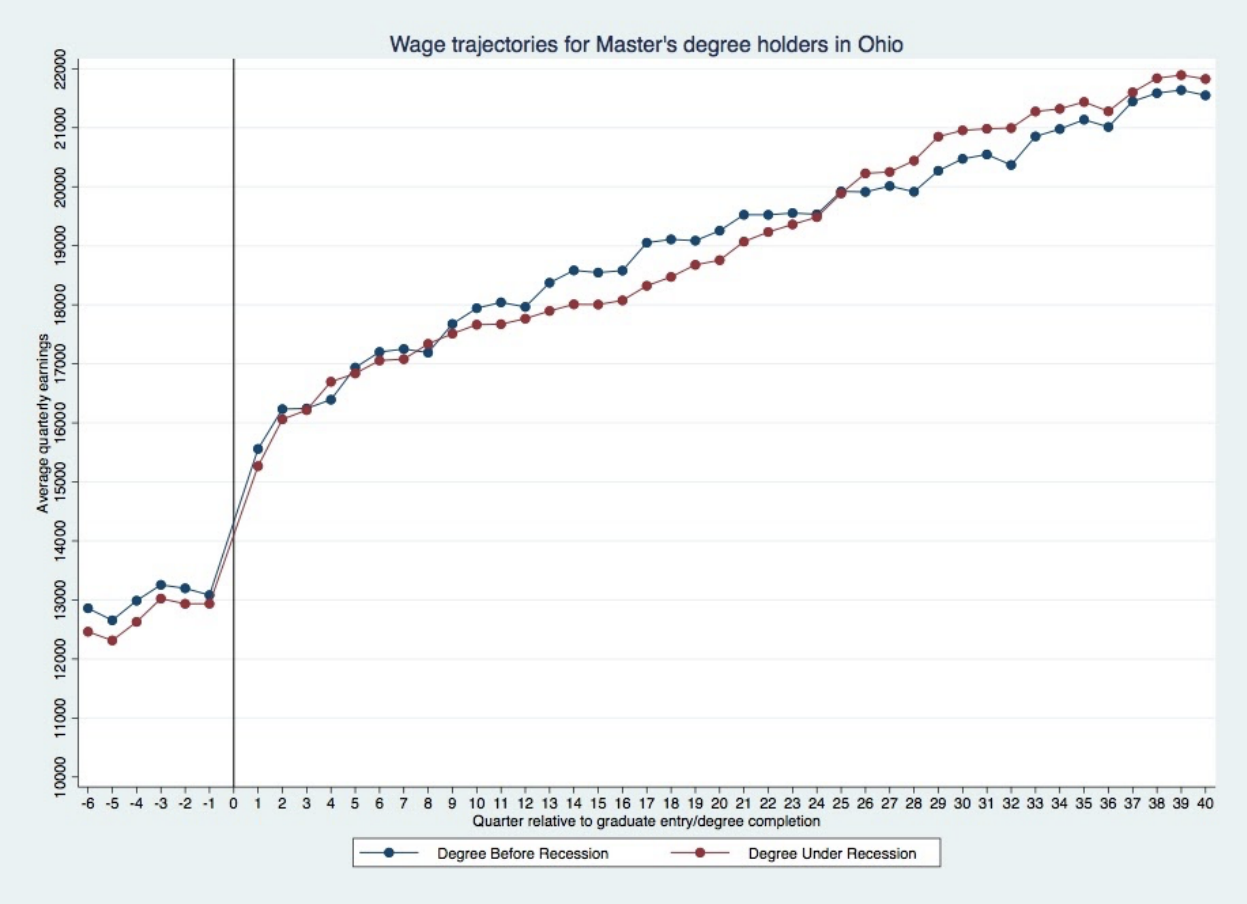

Table 1. Descriptive Statistics

	Analysis Sample	**National Comparison Samples**			
	Master's Degree Holders in Ohio	NPSAS: GR 2004	NPSAS: GR 2008	NPSAS: GR 2004 Public Schools	NPSAS: GR 2008 Public Schools
Gender					
Male	34.6%	42.8%	34.3%	35.1%	37.0%
Female	65.3%	57.2%	65.7%	64.9%	63.0%
Race/Ethnicity					
White Non-Hispanic	84.1%	74.6%	68.1%	73.3%	71.6%
Black Non-Hispanic	8.0%	12.4%	16.3%	13.1%	11.9%
Hispanic	1.2%	6.1%	8.8%	5.9%	8.3%
Asian or Pacific Islander	1.5%	5.2%	5.3%	7.1%	6.3%
Other	5.2%	1.7%	1.5%	0.6%	1.9%
Age					
Graduate School Enrollment	30			-	
Master's Degree Completion	32	35	35	34	34
Master's Degree Field					
Arts & Humanities	3.9%	6.0%	3.8%	5.5%	3.6%
Business	20.2%	30.3%	25.9%	22.6%	17.2%
Education	46.8%	33.1%	38.9%	38.7%	37.9%
Engineering	3.3%	Math/Engineering/CS: 11.2%	Math/Engineering/CS: 5.5%	Math/Engineering/CS: 7.6%	Math/Engineering/CS: 9.5%
Health	9.4%	4.6%	9.0%	4.9%	9.0%
Natural Science & Mathematics	2.8%	Life sciences: 1.9%	Life sciences: 1.8%	Life sciences: 3.7%	Life sciences: 2.8%
Services	1.9%	-	-	-	-
Social & Behavioral Sciences	11.6%	3.4%	4.3%	3.8%	3.7%
Other	-	9.6%	10.9%	13.1%	14.6%
School Type					
Public School	100%	41.6%	44.6%	100%	100%
Private Not-For-Profit	0%	49.4%	42.0%	0%	0%
Private For-Profit	0%	9.0%	13.4%	0%	0%
Sample Size (N)	29,247	-	-	-	-

Notes: (1) Master's degree holders in Ohio include individuals who first enrolled in graduate school and obtained a Master's degree from Fall 2000 to Fall 2009 in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. (2) National comparison samples include master's degree students in NPSAS: GR 2004 and NPSAS: GR 2008 who have earned Bachelor's degree, had job prior to enrollment, and completed the master's degree program in 2003-2004 and 2007-2008 respectively. Summary statistics among students attending public schools in the samples are shown separately. Age at Master's degree completion was calculated as of 12/31/03 for students in NPSAS: GR 2004 and 12/31/07 for students in NPSAS: GR 2008. The statistics were downloaded using NCES PowerStats.

Table 2. Individual Fixed Effects Estimates of Labor Market Returns to Master's Degrees

OUTCOME: Log Real Quarterly Earnings	**Any Master's Degree**	**Master's Degree Field**							
		Arts & Humanities	Business	Education	Engineering	Health	Natural Sciences & Math	Services	Social & Behavioral Sciences
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Master's Degree	0.116	0.002	0.079	0.128	0.109	0.243	0.118	0.085	0.072
	(0.004)***	(0.021)	(0.009)***	(0.004)***	(0.021)***	(0.016)***	(0.024)***	(0.030)***	(0.012)***
Number of Observations	1,058,874	36,811	198,369	533,655	31,387	99,245	28,102	18,923	112,376
Number of Students	29,144	1,148	5,884	13,656	952	2,745	827	553	3,378
Baseline Quarterly Earning	$11,433	$9,463	$15,535	$10,364	$13,566	$12,199	$11,068	$10,133	$9,797

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The analysis sample includes Master's degree holders in Ohio who first enrolled in graduate school and obtained a Master's degree from Fall 2000 to Fall 2009 in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is further limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.

Table 3. Gender and Racial Disparities in Return to Master's Degrees

OUTCOME: Log Real Quarterly Earnings	**Gender**		**Race/Ethnicity**			
	Male	Female	White	Black	Hispanic	Asian
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Master's Degree	0.073	0.137	0.124	0.080	0.109	0.073
	(0.006)***	(0.004)***	(0.004)***	(0.012)***	(0.030)***	(0.032)**
Number of Observations	359,065	698,744	905,289	79,331	12,622	13,917
Number of Students	10,082	19,034	24,518	2,331	360	443
Baseline Quarterly Earning	$13,380	$10,511	$11,260	$11,246	$11,775	$15,778

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The analysis sample includes Master's degree holders in Ohio who first enrolled in graduate school and obtained a Master's degree from Fall 2000 to Fall 2009 in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is further limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.

Table 4. Interactions Between Return to Master's Degrees and the Great Recession

OUTCOME: Log Real Quarterly Earnings	**Any Master's Degree**	**Master's Degree Field**							
		Arts & Humanities	Business	Education	Engineering	Health	Natural Sciences & Math	Services	Social & Behavioral Sciences
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Master's Degree	0.137	0.015	0.114	0.155	0.094	0.242	0.137	0.110	0.089
	(0.005)***	(0.029)	(0.011)***	(0.006)***	(0.030)***	(0.021)***	(0.034)***	(0.043)**	(0.016)***
Master's Degree * Degree under the Great Recession	-0.060	-0.015	-0.067	-0.061	-0.062	-0.027	-0.012	-0.118	-0.064
	(0.006)***	(0.035)	(0.014)***	(0.008)***	(0.039)	(0.027)	(0.043)	(0.057)**	(0.021)***
Number of Observations	673,238	22,952	134,863	328,952	19,123	66,949	16,053	12,512	71,834
Number of Students	18,371	711	3,935	8,340	570	1,846	478	366	2,125
Baseline Quarterly Earning	$11,239	$8,991	$15,376	$10,152	$12,870	$11,951	$10,285	$10,004	$9,505

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The analysis sample includes individuals who obtained a master's degree from 2004 to 2009 within three years after they first enrolled in graduate school in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. Individuals who obtained the master's degree from 2004 to 2007 are master's degree holders before the Great Recession, and individuals who obtained the master's degree from 2008 to 2009 are master's degree holders under the Great Recession. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.

Table 5. Interactions Between Return to Master's Degrees and the Great Recession by Gender and Race/Ethnicity

OUTCOME: Log Real Quarterly Earnings	**Gender**		**Race/Ethnicity**			
	Male	Female	White	Black	Hispanic	Asian
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Master's Degree	0.095	0.157	0.146	0.094	0.144	0.096
	(0.008)***	(0.006)***	(0.005)***	(0.017)***	(0.045)***	(0.048)**
Master's Degree * Degree under the Great Recession	-0.057	-0.057	-0.059	-0.036	-0.096	-0.026
	(0.011)***	(0.008)***	(0.007)***	(0.023)	(0.051)*	(0.050)
Number of Observations	227,666	444,859	576,765	48,804	7,925	9,930
Number of Students	6,355	11,998	15,471	1,420	220	313
Baseline Quarterly Earning	$13,210	$10,312	$11,036	$11,076	$11,931	$16,112

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The analysis sample includes individuals who obtained a master's degree from 2004 to 2009 within three years after they first enrolled in graduate school in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. Individuals who obtained the master's degree from 2004 to 2007 are master's degree holders before the Great Recession, and individuals who obtained the master's degree from 2008 to 2009 are master's degree holders under the Great Recession. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.

Appendix Table 1. List of Top Majors by Master's Degree Field Area

Arts & Humanities (N=1,152)			
CIP Code		CIP Description	%
	230101	English Language and Literature, General	37.07
	500901	Music, General	7.64
	90101	Speech Communication and Rhetoric	6.77
	500903	Music Performance, General	5.9
	160905	Spanish Language and Literature	5.12
Business (N=5,919)			
CIP Code		CIP Description	%
	520201	Business Administration and Management, General	66.21
	520301	Accounting	5.96
	520801	Finance, General	4.73
	520101	Business/Commerce, General	4.6
	521401	Marketing/Marketing Management, General	3.73
Education (N=13,673)			
CIP Code		CIP Description	%
	130301	Curriculum and Instruction	24.22
	130401	Educational Leadership and Administration, General	15.13
	130101	Education, General	9.62
	131001	Special Education and Teaching, General	6.74
	250101	Library and Information Science	5.79
Engineering (N=965)			
CIP Code		CIP Description	%
	141901	Mechanical Engineering	21.66
	143501	Industrial Engineering	9.64
	140801	Civil Engineering, General	9.43
	141001	Electrical and Electronics Engineering	9.33
	40201	Architecture	9.12
Health (N=2,756)			
CIP Code		CIP Description	%
	511601	Nursing/Registered Nurse	30.88
	511699	Nursing, Other	7.51
	512201	Public Health, General	6.57
	511603	Adult Health Nurse/Nursing	4.46
	511599	Mental and Social Health Services and Allied Professions, Other	4.35
	512308	Physical Therapy/Therapist	4.35
Natural Science & Mathematics (N=831)			
CIP Code		CIP Description	%
	270101	Mathematics, General	14.92
	110101	Computer and Information Sciences, General	13.72
	260101	Biology/Biological Sciences, General	9.27
	400601	Geology/Earth Science, General	7.46
	400501	Chemistry, General	6.38
Services (N=557)			
CIP Code		CIP Description	%
	430104	Criminal Justice/Safety Studies	49.91
	310501	Sports, Kinesiology, and Physical Education/Fitness, General	17.59
	310504	Sports and Fitness Administration/Management	13.11
	310599	Sports, Kinesiology, and Physical Education/Fitness, Other	7.9
	310505	Exercise Science and Kinesiology	7.36
Social & Behavioral Sciences (N=3,393)			
CIP Code		CIP Description	%
	440701	Social Work	40.73
	440401	Public Administration	18.6
	540101	History, General	3.57
	420401	Community Psychology	3.54
	309999	Multi-/Interdisciplinary Studies, Other	3.07

Appendix Table 2. Distributions of Graduate Fields by Gender and Race/Ethnicity

	Gender		Race	
Master's Degree Field:	Male	Female	White	Black
Arts & Humanities	4%	4%	4%	2%
Business	36%	12%	19%	13%
Education	32%	54%	49%	44%
Engineering	7%	1%	3%	2%
Health	4%	12%	10%	9%
Natural Science & Mathematics	5%	2%	3%	1%
Services	2%	2%	2%	3%
Social & Behavioral Sciences	9%	13%	10%	26%
N	10,132	19,087	24,592	2,342

Note: The analysis sample includes individuals who first enrolled in graduate school and obtained a Master's degree from Fall 2000 to Fall 2009 in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree.

Appendix Table 3. Summary Statistics by Graduation Cohort

	Master's Degree Holders in Ohio	
	Degree Before Recession	Degree Under Recession
Gender		
Male	34.8%	34.3%
Female	65.2%	65.6%
Race/Ethnicity		
White Non-Hispanic	84.3%	83.9%
Black Non-Hispanic	7.8%	7.5%
Hispanic	1.2%	1.3%
Asian or Pacific Islander	1.5%	2.2%
Other	5.2%	5.2%
Age		
Graduate School Enrollment	30	30
Master's Degree Completion	32	32
Master's Degree Field		
Arts & Humanities	3.9%	3.7%
Business	21.8%	20.8%
Education	46.7%	42.5%
Engineering	2.8%	3.8%
Health	9.5%	11.3%
Natural Science & Mathematics	2.6%	2.6%
Services	1.9%	2.3%
Social & Behavioral Sciences	10.9%	13.0%
Sample Size (N)	12,498	5,911

Note: The analysis sample includes individuals who obtained a master's degree from 2004 to 2009 within three years after they first enrolled in graduate school in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. Individuals who obtained the master's degree from 2004 to 2007 are master's degree holders before the Great Recession, and individuals who obtained the master's degree from 2008 to 2009 are master's degree holders under the Great Recession.

Appendix Table 4. Distribution of Degree Fields by Graduation Cohort, Gender & Race/Ethnicity

	Gender				Race			
	Degree Before Recession		Degree Under Recession		Degree Before Recession		Degree Under Recession	
	Male	Female	Male	Female	White	Black	White	Black
Master's Degree Field:								
Arts & Humanities	4%	4%	3%	4%	4%	2%	4%	-
Business	39%	13%	37%	12%	21%	14%	19%	17%
Education	32%	54%	29%	50%	49%	46%	45%	32%
Engineering	6%	1%	9%	1%	3%	-	4%	4%
Health	5%	12%	4%	15%	10%	8%	12%	9%
Natural Science & Mathematics	4%	2%	5%	2%	3%	-	2%	-
Services	2%	2%	2%	2%	2%	3%	2%	4%
Social & Behavioral Sciences	8%	12%	11%	14%	10%	24%	11%	29%
N	4,348	8,142	2,025	3,876	10,537	979	4,957	445

Note: Cells with a sample size smaller than 10 students are suppressed to protect data privacy. The analysis sample includes individuals who obtained a master's degree from 2004 to 2009 within three years after they first enrolled in graduate school in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. Individuals who obtained the master's degree from 2004 to 2007 are master's degree holders before the Great Recession, and individuals who obtained the master's degree from 2008 to 2009 are master's degree holders under the Great Recession.

Appendix Table 5. Labor Market Returns to Master's Degrees Among Individuals with No Employment Gaps

OUTCOME: Log Real Quarterly Earnings	Full Sample with No Employment Gaps	Recession Comparison Sample with No Employment Gaps
VARIABLES	(1)	(2)
Master's Degree	0.102	0.123
	(0.005)***	(0.007)***
Master's Degree * Degree under the Great Recession	-	-0.058
	-	(0.009)***
Number of Observations	383,559	239,130
Number of Students	8,732	5,362
Baseline Quarterly Earning	$12,906	$12,847

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The full sample includes Master's degree holders in Ohio who first enrolled in graduate school and obtained a Master's degree from Fall 2000 to Fall 2009 in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. The recession comparison sample is further restricted to individuals who obtained the master's degree from 2004 to 2009 within three years after they first enrolled in graduate school. And only individuals with no earnings that are missing/lower than minimum wage/younger than 22 for the six quarters before graduate enrollment and the 10 years after obtaining Master's degree are included in the estimations. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.

Appendix Table 6. Interactions Between Return to Master's Degrees and the Great Recession Among Students Enrolled Before the Recession

OUTCOME: Log Real Quarterly Earnings	**Any Master's Degree**	**Master's Degree Field**							
		Arts & Humanities	Business	Education	Engineering	Health	Natural Sciences & Math	Services	Social & Behavioral Sciences
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Master's Degree	0.141	0.016	0.125	0.156	0.101	0.244	0.133	0.132	0.094
	(0.005)***	-0.029	(0.012)***	(0.006)***	(0.030)***	(0.021)***	(0.035)***	(0.041)***	(0.016)***
Master's Degree * Degree under the Great Recession	-0.051	0.002	-0.056	-0.055	-0.06	-0.023	-0.021	-0.123	-0.064
	(0.007)***	-0.036	(0.015)***	(0.009)***	-0.04	-0.027	-0.044	(0.059)**	(0.022)***
Number of Observations	637,194	22,390	126,449	308,438	18,388	66,006	15,522	11,786	68,215
Number of Students	17,419	696	3,688	7,835	550	1,821	462	344	2,023
Baseline Quarterly Earning	$11,200	$8,913	$15,333	$10,114	$12,854	$11,948	$10,294	$9,912	$9,486

OUTCOME: Log Real Quarterly Earnings	**Gender**		**Race/Ethnicity**			
	Male	Female	White	Black	Hispanic	Asian
VARIABLES	(10)	(11)	(12)	(13)	(14)	(15)
Master's Degree	0.099	0.161	0.149	0.098	0.139	0.122
	(0.008)***	(0.006)***	(0.005)***	(0.017)***	(0.046)***	(0.049)**
Master's Degree * Degree under the Great Recession	-0.049	-0.049	-0.05	-0.027	-0.112	-0.023
	(0.012)***	(0.009)***	(0.008)***	-0.025	(0.051)**	-0.052
Number of Observations	214,924	421,557	545,868	46,114	7,521	9,265
Number of Students	6,005	11,396	14,675	1,341	210	293
Baseline Quarterly Earning	$13,172	$10,278	$11,001	$11,006	$11,861	$15,893

Robust standard errors clustered at individual level in parentheses
***p<.01, **p<.05, *p<.1

Note: Each column represents a separate regression showing individual fixed effects estimates. The analysis sample includes individuals who enrolled before 2008 and obtained a master's degree from 2004 to 2009 within three years after they first enrolled in graduate school in the Ohio data. Individuals who obtained the master's degree older than 50 are excluded. The sample is also limited to individuals who have at least 4 quarters of earnings higher than the state minimum wage at an age older than 22 within 6 quarters before graduate enrollment, and at least 1 quarter of earnings higher than minimum wage within 10 years after obtaining the master's degree. Individuals who obtained the master's degree from 2004 to 2007 are master's degree holders before the Great Recession, and individuals who obtained the master's degree from 2008 to 2009 are master's degree holders under the Great Recession. All the wages are converted to 2019Q4 dollars using the Consumer Price Index for All Urban Consumers, U.S. City Average (CPI-U), and the highest 1% wages are top-coded. Wages that are missing/below minimum wage/earned before age 22 are excluded. All the regressions are also controlled for: (i) individual's age at each quarter; (ii) a dummy that is equal to one for the time period one quarter before first enrollment at graduate school, and another dummy that is equal to one for the time period two quarters before first enrollment at graduate school; (iii) a set of demographic and personal characteristics, including race/ethnicity, gender, age at first graduate school enrollment, graduate school entry cohort, and major declared at first graduate school enrollment, all interacted with time trends; (iv) county unemployment rate. Baseline quarterly earnings show geometric mean of earnings before graduate enrollment.