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Essays on Labor Market Size and Job Match Quality

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Abstract

This dissertation is comprised of two essays that delve into the construction of a major-related labor market and its correlation with college graduates' job match quality. Investigating the job match quality of college graduates for different majors in large cities is crucial, as it provides evidence on which majors tend to yield better job matches. This contributes to the study of the return on major while also shedding light on how city size impacts individuals' ability to find jobs that align with their educational level and major, thereby enriching the study of the benefits of agglomeration.

The first chapter examines whether college graduates work in occupations that match their educational level and the skills acquired through their majors, subsequently assessing the correlation between labor market size and job match outcomes. Although previous theoretical literature posits that larger cities lead to better job matching outcomes, empirical evidence regarding this relationship remains inconclusive. This paper proposes a novel measure of labor market size specific to each college major and investigates its impact on job match quality. The results suggest that the size of a major-specific labor market is a predictor of improved job match quality. However, the size of the overall labor market demonstrates an inconsistent effect on job match quality. Furthermore, the findings reveal that the impact of major-specific labor market size is more pronounced for male and younger workers.

In chapter two, the focus shifts to the correlation between major-specific labor markets and job match quality for married power couples. Power couples, defined as highly educated, dual-career spouses, have been documented to reside predominantly in large cities.

However, literature providing direct evidence supporting the notion that college-educated women experience greater career success by living in larger urban areas remains scarce. Building upon the ideas and results from the first chapter, this section examines whether power couples' job match quality benefits from residing in large urban areas, as defined by various criteria. The findings suggest that both husbands and wives in power couples are more likely to work in occupations that match their educational level and acquired abilities in larger major-related labor markets. Interestingly, the correlation between population and job match outcomes for power couples proves inconsistent across different models, which is in line with the individual-level results presented in the first chapter.

Dedication

To my parents, Shaotong and Yan! Thank you for always supporting me and believing in me.

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Please note that all errors are my own.

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Chapter 1

The Benefits of Major-related Labor Markets for Job Match Quality of College Graduates

1.1 Introduction

College graduates often aspire to work in jobs that are related to their major, but the extent to which they achieve this goal may vary across labor markets. Economic theory suggests that large and dense urban areas may facilitate better job matches by reducing search costs and providing a wider variety of work opportunities (Marshall 1890; Kim 1990, 1991; Duranton and Puga 2004). This hypothesis implies that individuals who reside in large cities are more likely to find jobs that enable them to fully utilize their skills, which may explain why wages are generally higher in larger cities. However, wages may vary across cities for reasons other than job match quality.

To shed more light on the relationship between job match quality and city size, Abel and Deitz (2015) examined job match quality among college graduates. They measured job match quality as having a job that requires a college degree and working in an occupation that uses skills relevant to a college graduate's major field or fields. Their regression evidence suggests that job match quality is superior in larger cities.

However, it is not clear why larger cities should provide better job matches in a world of heterogeneous workers and firms (Brueckner et al. 2002). Job seekers with specific skills are likely to focus on jobs requiring those skills, and greater heterogeneity of workers and firms may lead to lower job match quality (Sato 2001). Hence, the effects of city size on job match quality are not straightforward.

To address these issues, this paper combines the insights of Abel and Deitz (2015) and Dauth et al. (2022) to re-examine the determinants of job match quality of college graduates. The paper uses information on college majors and the occupational distribution of employment in the American Community Surveys (Ruggles et al. 2021) to construct a measure of major-related labor market size for college graduates across U.S. cities. The paper then estimates regressions for job match quality as a function of major-related labor market size and city size.

The results indicate that college-educated workers in cities with larger major-related labor market sizes are more likely to find jobs that match their educational level and degree field. In contrast, the estimated effects of city size on match quality are inconsistent: positive for the probability of finding a job that requires a college degree but negative for the probability of finding a job in an occupation that matches well with their major. Importantly, the effect of major-related labor market size remains positive even after controlling for city size. Additionally, the effect of major-related labor market size interacts negatively with overall city size.

The remainder of this paper is organized as follows. In Section 1.2, the paper reviews the theoretical and empirical contributions of the literature and explains how the analysis builds upon them. Section 1.3 presents the data, including how match quality and market size are measured, and descriptive summary statistics. Section 1.4 describes the empirical model, while Section 1.5 presents the results of the baseline model and interaction model. Finally, Section 1.6 concludes.

1.2 Previous Research

Theoretical research predicting better matching in large cities can be found in several studies, including Helsley and Strange (1990), Sato (2001), and Papageorgiou (2022). Specifically, Helsley and Strange (1990) demonstrate how the matching of heterogeneous workers' skills and firms' labor demands can generate an agglomeration economy. Building on this work, Sato (2001) constructs a model that defines matching between a firm's job demands and workers' skills as a function of city size. This model predicts that larger city size increases job match quality by increasing the probability that a worker finds a job more suitable to their skills, particularly when the search technology exhibits increasing returns to scale. More importantly, the model predicts that more heterogeneous workers and firms lead to lower job match quality.

Sato (2001) defines how suitable a job is for workers' skills as the distance between job requirements and skills. In particular, the model assumes that workers with heterogeneous skills and firms with heterogeneous job requirements are indexed as points uniformly distributed on a circle's circumference. The expected distance between job requirements and skills is reduced with city size, which means a firm is more likely to hire workers whose skills lie closer to their job requirements in larger cities. However, when a new technology is invented, it requires a new skill, which increases the skill space and makes workers and firms more heterogeneous. As a result, job match quality decreases as firms are less likely to hire workers whose skills lie closer to their job requirements. Larger cities offer a greater variety of work opportunities and contain more heterogeneous workers and firms. Thus, Sato (2001) provides micro-foundation testing for match quality dampened in markets with larger skill spaces.

The empirical literature on work-firm matching in local labor markets is still developing. Some studies quantify scale effects in job search by comparing the number of job matches in labor markets of different sizes (Petrongolo and Pissarides 2006). Others find that the probability of changing occupation or industry is positively correlated with city size for young workers and negatively correlated with city size for older workers (Wheeler 2008; Bleakley and Lin 2012). Several studies have found that higher-skilled labor is more likely to match with higher-productive firms in denser or larger areas (Andersson et al. 2007; Yankow 2009; Dauth et al. 2022; Leknes et al. 2022). However, the findings are not always consistent, as some studies have found limited or negative support for better matches in denser or larger areas (Figueiredo et al. 2014; Mion and Naticchioni 2009; Andini et al. 2013).

Due to the lack of available information on the linkage between individuals' skills and skills required by a job, the empirical literature on skill-job matching in local labor markets is also in its early stages. Abel and Deitz (2015) were the first to utilize information on individuals' majors recorded in the American Community Surveys to examine the correlation between city size and job match quality of college graduates. They find that individuals located in large cities are more likely to find a job that matches their educational level and major. Another study by Wright et al. (2016) shows that STEM major graduates are more likely to find a STEM job in STEM occupation clustered areas, while the total population does not have a significant effect on the match.

This paper focuses on college-educated workers and aims to explore whether they work in jobs related to their major and how this propensity varies by labor market size. Additionally, by constructing major-related labor market size, the paper investigates how city size affects job match quality for workers with heterogeneous skills and tests an empirical implication of Sato's model.

1.3 Data

1.3.1 Microdata

The data used in this study are obtained from the pooled 2010-2019 American Community Surveys (ACS), a nationally representative sample of 1% of the US population compiled by Ruggles et al. (2021). The ACS provides rich economic and demographic information for individuals, including their occupation, wage, and level of education. Notably, since 2019, the ACS has included detailed information on an individual's undergraduate degree major. Respondents are asked to provide up to two degree fields, which are then converted into one of 172 detailed college major categories and grouped into 36 broad major categories by the US Census Bureau. Table 1.1 presents the sample compositions of selected primary and secondary degree fields from the 172 detailed categories. Among the sample, graduates majoring in Business account for the largest proportion, with 6.4% of individuals listing it as their primary degree field and 4.1% listing it as their secondary field. In contrast, individuals who report Physical Science, Astronomy and Astrophysics, Social Psychology, Soil Science, Geological and Geophysical Engineering, and Court Reporting as their primary degree field represent less than 0.1% of the sample, although roughly 0.2% of individuals list Astronomy, Astrophysics, and Soil Science as their secondary fields. It is worth noting that the ACS does not record individuals' degree field for advanced degrees. The ACS also includes information on an individual's occupation, sex, race, highest degree completed, annual earnings, marital status, and the number of children in the household.

Given the focus on college graduates, the sample is limited to working-age individuals (i.e., aged 21 to 64) with at least a Bachelor's degree who are in the civilian labor force, earned at least $10,000 in pre-tax income in the prior year, and located in metropolitan areas, as this geography is a good proxy for local labor markets. The full sample contains nearly 360,000 observations representing more than 36 million college graduates.

No dataset, including the cross-sectional ACS, is perfect. Other datasets, such as the National Longitudinal Surveys and the Panel Study of Income Dynamics (PSID), track individuals over time and contain a wider range of information on respondents' behavior and backgrounds. However, the ACS offers important advantages, including the information related to individuals' major and the availability of large sample sizes.

For information on individuals' occupations, I used the Standard Occupational Classification (SOC), a six-digit alphanumeric string variable that reports the person's primary occupation in my analyses.[1] My geographic unit of analysis is the metropolitan statistical areas (MSAs) from the U.S. Office of Management and Budget (OMB). For the purposes of this paper, I will refer to this resulting geographic unit as the "city." The key data for each city is the average 2010 population of the metro/micro areas in each Public Use Microdata Area (PUMA). When a PUMA lies entirely within a single metro area, this "average" is simply the metro area's population. Elsewhere, this key data provides an approximation of the typical population size of the commuting systems where PUMA residents live.

The sample for analysis consists of 290 metropolitan areas, with a mean population of 0.84 million and a median of 0.31 million. Table 1.2 lists the most and least populous cities on average. The largest city, with almost 20 million people, is New York City, which includes residents from Connecticut, New Jersey, and Pennsylvania. This is followed by Los Angeles (12.83 million), Chicago (9.42 million), Dallas (6.39 million), and Houston (5.92 million).

The distribution of college graduates across cities is nearly symmetrical, as shown in Table 1.3, which lists the most and least educated cities, with smaller college towns dominating both lists. Washington DC, Ann Arbor, Bridgeport, and San Jose have over half of their residents holding college degrees, while less than 15% of their residents hold college degrees in Hanford, Lake Havasu City, Madera, Visalia, and El Centro.

Table 1.4 reveals significant variation in the major composition of different cities. Among the five cities listed, New York and Los Angeles, the two largest cities, have Business-related majors and Psychology as the most common majors. The least common majors in these cities include Geological and Geophysical Engineering and Soil Science majors. In contrast, Washington DC, as the most educated city and the political center of the United States, is dominated by Political Science and Government majors, while the least common majors are Soil Engineering and Geological and Geophysical Engineering. Among the smaller cities, Hanford has the lowest education level, and Business-related majors are still the most common. However, the percentage of college-educated workers with such

[1] The SOC system is a federal statistical standard used by federal agencies to classify workers into occupational categories.

majors is relatively high compared to the largest cities. Elementary Education, Nursing, and Liberal Arts are the most common majors in smaller cities. Interestingly, the least common majors in smaller cities include Computer Programming and Music in Hanford and Animal Science in Parkersburg, which differ from the least common majors found in larger cities.

The occupation composition of cities exhibits significant variation, as demonstrated in Table 1.5, which outlines the most and least common occupations in five cities of different sizes. Elementary and middle school teachers are the most common occupations in both large and small cities, and New York and Los Angeles share similar common occupations. However, the composition of the least common occupations differs across cities of various sizes. By plotting the correlation between the variety of occupations and city size, as illustrated in Figure 1.1, we can observe a positive correlation between population and the variety of occupations in cities. Specifically, the variety of occupations undergoes a sharp increase when the population increases from zero to 0.25 million. Although people have varying reasons for choosing to live in different areas, college graduates generally find employment in more diverse occupations in larger cities.

1.3.2 Measuring Job Match Quality

Urban economists and education economists have different perspectives on measuring job match quality. While urban economists focus on labor outcomes, education economists examine whether college graduates can apply their acquired knowledge in the workforce. Combining both approaches could provide valuable insights into the skills possessed by workers and the requirements of their jobs, particularly across urban areas. However, publicly available datasets typically have limited information on workers' skills beyond years of schooling. Since 2009, the American Community Survey (ACS) has included information on individuals' college majors, enabling the examination of the relevance of skills to job requirements. Two studies have used this information to define job match quality for college graduates. Abel and Deitz (2015) constructed two measures of job match quality based on the ACS data: degree match, indicating whether the occupation requires a college degree, and major match, indicating whether the occupation is relevant to the college degree major(s). They found that 62.1% of college graduates work in an occupation that requires a college degree, while 27.3% work in an occupation that is relevant to their major. Similarly, Wright et al. (2016) investigated the match quality of workers with STEM degrees by identifying STEM degree fields in the ACS. In this study, I adopt the same approach as Abel and Deitz (2015) to characterize match quality in two ways.

1.3.2.1 Degree Match

College graduates in ACS have *degree match* if they work in an occupation that requires a college degree. The percentage of college graduates in each occupation determines whether an occupation requires a college degree. For example, using Occupational Information Network (O*NET) SOC occupational information, Abel and Deitz (2015) define an occupation requires a college degree if more than 50% of survey respondents working in that occupation report that they hold at least a college degree.[2]

I attempted to follow Abel and Deitz (2015). However, O*NET reports eight-digit SOC while the ACS reports six-digit SOC. As shown in Table 1.6, for ACS occupation 111021, only one eight-digit O*NET SOC corresponds to it. Then it is straightforward to say that the General and Operation Managers position requires a college degree. However, for ACS occupation 113051, several eight-digit O*NET occupations correspond to it, and half do not require a college degree based on the 50% threshold. Without further information, I cannot determine whether the Industrial Production Managers position requires a college degree. [3]

[2]The O*NET system contains occupation-level data for hundreds of detailed occupations collected via interviews of incumbent workers and input from professional occupational analysts. They use the following question from the O*NET Education and Training Questionnaire to determine whether an occupation requires a college degree: "If someone were being hired to perform this job, indicate that level of education that would be *required*?"

[3]Alternatively, I considered using the U.S. Bureau of Labor Statistics (BLS) information to determine whether an occupation requires a bachelor's degree. The BLS reports typical entry-level education for 832 six-digit SOC occupations. I consider an occupation requires a bachelor's degree if typical entry-level education is a bachelor's degree, master's degree, or doctoral or professional degree. However, due to the

Eventually, I used the pooled 2010-2019 ACS to calculate the percentage of college graduates in each occupation. Table 1.7 presents jobs with the most and least college graduates and around 50% of college graduates among employees in the ACS. Occupations close to the 50% threshold include Tax Preparers, Sales Representatives, Photographers, Financial Clerks, and General Managers. I determine an occupation requiring a bachelor's degree if more than 50% of employees hold at least a bachelor's degree. Overall, I find that 68.89% of college graduates are employed in an occupation requiring a bachelor's degree or higher.

1.3.2.2 Major Match

College graduates in ACS have *major match* if they work in an occupation that is relevant to their major. I determine those occupations using a crosswalk between college majors, called Classification of Instructional Programs (CIP), and SOC occupations, called the "CIP-SOC Crosswalk." The CIP-SOC Crosswalk is a joint effort by the Bureau of Labor Statistics (BLS) and NCES that matches "post-secondary programs of study that provide graduates with specific skills and knowledge to occupations requiring those skills or knowledge to be successful." The programs typically satisfy the educational requirements for entry and advancement and/or prepare individuals to meet licensure or certification requirements to work in the occupation.

One concern is that the occupations deemed to be a match are most frequently chosen by individuals majoring in a particular field, which could generate a spurious positive relationship between major-related market size and the occurrence of a major match. Fortunately, this does not seem to be the case. The CIP-SOC Crosswalk is constructed based on the "expertise from statisticians" at both BLS and NCES, and, importantly, "is not based on actual empirical data." [4]

However, one problem is that the CIP title differs from an exact duplicate of a

incomplete ACS SOC issue, less than half of the sample can be defined using BLS information.

[4] These words are quoted directly from https://nces.ed.gov/ipeds/cipcode/post3.aspx?y=56. For more information on the CIP-SOC Crosswalk, go to the file " Guidelines for Using the CIP to SOC Crosswalk" using https://nces.ed.gov/ipeds/cipcode/Files/CIPSOCUsersGuideMarch152011.doc.

specific major title used by the ACS. Consequently, I use an additional crosswalk provided by Abel and Deitz (2015) that ties the ACS majors to the CIP majors. Table 1.8 lists selected examples of how ACS majors are crosswalked to CIP (majors) and SOC occupations. For example, the ACS-based major, "General Social Sciences, Economics, and Miscellaneous Social Sciences," corresponds to a single CIP major, "Economics, General." The CIP-SOC Crosswalk, in turn, shows this CIP major to be relevant in four SOC occupations: Managers, Economists, Survey Researchers, and Economics Teachers. Therefore, individuals with this ACS major, for example, Economics, are classified as having a major match if employed as an Economist, a Manager, or a Market Research Analyst. Also as shown in the Table, CIP major "Political Economy" and "Development Economics and International Development" do not have correspondent ACS major, which may cause bias on the major match rate. I would consider occupations in this crosswalk as "perfect match" for ACS majors which could provide a lower bound of the major match rate for college graduates in the ACS.

Although establishing a link between an individual's major and their job is conceptually straightforward, there is a nuanced challenge that arises in practice. Specifically, the American Community Surveys (ACS) and National Center for Education Statistics (NCES) use different codes to identify majors and occupations, respectively. The ACS majors are incomplete six-digit codes, while the NCES majors are complete six-digit codes. This can create bias when using the ACS major to SOC crosswalk to define a major match for each individual. To address this issue, I adjusted the SOC code in the crosswalk to better match the ACS SOC in the sample. One alternative approach is to match with different digit levels, starting with 6-digit SOC and then using 5-digit, 4-digit, and 3-digit codes if necessary. However, I opted for the first method due to its higher accuracy.

Table 1.9 provides examples of how I dealt with this incomplete issue. For instance, the crosswalk records "Computer User Support Specialists" as 151151, which does not have a match with the SOC in ACS. However, ACS has a very similar occupation title, "Computer Support Specialists", which should be a match for the SOC in the crosswalk. Therefore, I changed the code 151151 in the crosswalk to 151150 to create a match with the SOC in ACS. Overall, my analysis finds that 22.56% of college graduates are employed in an occupation that utilizes the skills they acquired during their studies.

Table 1.10 summarizes the job match rates by the broad degree of fields. The major match rates vary a lot across different majors from 1.47% for Nuclear, Industrial Radiology, and Biological Technologies to 51.77% for Education Administration and Teaching. The degree match rate at the same time does not vary as much as the major match rate across different majors. In particular, the degree match rate vary from 16.86% for Cosmetology Services and Culinary Arts to 80% for Medical and Health Sciences and Services. According to table 1.10 we can see on average, 68.89% of college graduates work in an occupation that match their education level while 22.56% of the college graduates work in an occupation that match their college major based on the linkage provided by the NCES. I also consider the intersection and union of degree match and major match. Overall, 19.52% of the sample have both a degree match and a major match, while 71.94% of the sample have either a degree match or a major match. Recall that I define major match and degree match use the same way as the Abel and Deitz (2015), they find on average, 62.1% of college graduates work in occupations that match their education level and 27.3% of college graduates work in occupation that match their major.[5]

1.3.3 Measuring Market Size

Previous literature often utilizes population or population density as a means to measure the size of a city. The study by Abel and Deitz (2015) investigates the impact of population size on job match quality. Additionally, two recent publications provide empirical evidence on the importance of skill-specific labor market measures. Specifically, Wright et al. (2016) initially employs the STEM job count to examine its effect on the probability of STEM degree holders securing a STEM job. However, they did not observe any significant impact from STEM job counts. Consequently, they adopted the STEM job location quotients (LQ) to capture the concentration of STEM jobs in cities, estimating

[5] In Appendix B, I present the full match rate results for 172 detailed degree fields and how Abel and Deitz (2015) construct major match and degree match and their match rate result.

its effect on the likelihood of STEM degree holders working in a STEM job. As described by the BLS, a location quotient reveals the occupation's share of an area's employment in comparison to the national average. For instance, the LQ of STEM jobs in Los Angeles can be calculated as

$$LQ = \frac{\text{STEM jobs in LA/total jobs in LA}}{\text{STEM jobs in US/total jobs in the US}}. \tag{1.1}$$

Then a location quotient of 2.0 indicates that an occupation accounts for twice the share of employment in the area than it does nationally. A location quotient of 0.5 indicates that the area's share of employment in the occupation is half the national share. They found that STEM graduates are more likely to work in STEM occupations in STEM job clusters (San Jose, Seattle, Raleigh-Durham) than in the largest STEM employment markets (New York, Los Angeles, Washington, DC).

Dauth et al. (2022) used the *log* of the number of workers in each city-occupation cell and examined its effect on the strength of assortative matching – measured by the within-city correlation of plant and worker effects. They found that doubling the city-occupation cell size resulted in a 6.4% increase in assortative matching. More importantly, the positive effect of the total employment in the city disappeared after controlling the employment in the city-occupation cell, and it became negatively significant from 2008-2014. Other studies that studies the benefit of the agglomeration tend to use density defined by different physical spaces (Ciccone and Hall 1993; Roca and Puga 2017) or defined by different activities (Bleakley and Lin 2012; Moretti 2004, 2021).

This paper aims to investigate whether college graduates apply their college-acquired skills to jobs requiring those skills and if this varies by city size. To achieve this, the focus is placed on the labor market associated with college graduates' skills, as measured by their college major. The concept of major-related labor market size expands on the STEM job counts presented by Wright et al. (2016), which only considers seven-degree fields. To bridge the gap in match quality among non-STEM graduates, this study broadens the skill-specific labor market size to include all majors recorded in the ACS.

In contrast to location quotients, major-related labor market size is constructed based on its correlation with a specific major, rather than the classification of occupations themselves. Additionally, the study does not use the share of relevant occupations. Given the paper's focus on the impact of city size on job match quality, the average 2010 population of metro/micro areas in each Public Use Microdata Area (PUMA) is used to measure city size, where each individual is located. Major-related labor market size is then utilized to measure city size.

The following sections will introduce the key variable of this study, the major-related labor market size, and explain the method used for its construction.

1.3.3.1 Major-related Market Size

The major-related labor market size is defined as follows. Let O_m represent the set of occupations $\{O_1, ..., O_{N_m}\}$ relevant to college degree major m, as determined using the information from the NCES, as described in Section 1.3.1. I define the major-related labor market size for detailed college major m in area c in year y, $MajMktSize_{cm,y}$, to be the total employment in relevant occupations in that area in the prior year. It can be expressed as:

$$MajMktSize_{cm,y} \equiv \sum_{o \in O_m} Emp_{oc,y-1}, \tag{1.2}$$

where $Emp_{oc,y-1}$ represents employment in occupation o in area c in the previous year. One might be concerned about a mechanical relationship between major-related labor market size and the probability of a good match. However, by relying on the fact that the sample consists of randomly selected individuals each year, using total employment in relevant occupations in the prior year can address this concern. Additionally, note that the ACS allows individuals to report up to two-degree fields, with around 11% of college graduates obtaining a secondary degree. I calculate the major-related labor market size for individuals with two-degree fields without overlapping.

Table 1.11 presents the average major-related labor market size encountered by graduates from various broadly defined degree fields. It is evident that Business and Family and Consumer Science majors have comparatively larger major-related market sizes, while Nuclear, Industrial Radiology, and Biological Technologies majors have relatively smaller ones. Additionally, Table 1.11 displays the average population size faced by graduates in different broadly defined degree fields. For instance, Business major graduates typically reside in cities with an average population of 5.21 million. Interestingly, the average population size where different majors are situated does not fluctuate significantly, while the major-related market size ranges from 12.97 thousand for Nuclear, Industrial Radiology, and Biological Technologies majors to 318.99 thousand for Business majors.

1.3.4 Descriptive Summary Statistics

Table 1.12 provides a comprehensive overview of the sample statistics utilized in this paper's analysis. Furthermore, this section offers additional descriptive summary statistics, examining the relationship between city size, major-related labor market size, and match rate across various majors.

1.3.4.1 Major-related Market and Population

Larger urban areas may potentially provide more extensive labor markets for all majors. However, the variation in labor market size for different majors cannot be exclusively attributed to population fluctuations. Table 1.11 showcases the average major-related labor market size and city size experienced by various broadly defined degree fields, along with the elasticity of major-related labor market size. Notably, majors such as Computer and Information Sciences, Business, and Engineering display a more significant increase in major-related market size, correlating with population movement within a city. In contrast, the major-related market size for Nuclear, Industrial Radiology, and Biological Technologies majors appears relatively inelastic, even when accounting for population movement within a city.

Figure 1.2 depicts the correlation between population size and major-related labor market size for broad degree fields with comparatively larger market sizes and higher match rates. Among the five majors analyzed, the major-related market size corresponds more closely to population increases for Business, Computer and Information Science, Education Administration, and Teaching majors. Conversely, the major-related market size correlates less with population increases for Cosmetology Service, Culinary Arts, and Transportation Science and Technologies majors.

Figure 1.3 demonstrates the correlation between population size and major-related labor market size for broad degree fields facing relatively smaller market sizes and lower match rates. Among these five majors, the major-related market size corresponds more closely to population increases for all but Nuclear, Industrial Radiology, and Biological Technologies majors. While larger city sizes result in more substantial major-related labor market sizes for all majors, the magnitudes differ by major. Consequently, the impact of labor market size on match quality appears to be empirical in nature.

1.3.4.2 Market Size and Match Rate

Larger urban areas may potentially offer more extensive labor markets for all majors. However, does this translate to better matches as defined in this paper? To investigate this, the correlation between average market size and average match rate across broadly defined majors is examined using a simple OLS regression. Figure 1.4 plots the coefficients for both major-related market size and population, along with their respective confidence intervals.

As demonstrated in Figure 1.4, a larger major-related market size is significantly correlated with a higher major match rate across broadly defined majors, though it does not predict a higher degree match rate. Conversely, both major match rate and degree match rate do not exhibit a significant correlation with larger populations. In fact, a larger population predicts a lower major match rate but a higher degree match rate across broadly defined majors.

1.3.4.3 Having a Double Major

Approximately 11% of observations in the sample include a secondary degree field, for which I calculate the major-related labor market size without overlap. By employing a simple OLS regression, it is determined that having a second major, on average, increases the major-related labor market size by roughly 87,000 jobs in a metropolitan area. Specifically, Table 1.13 indicates that possessing a double major expands the major-related market size the most for college graduates with primary fields in Transportation Sciences and Technologies, Electrical and Mechanic Repairs and Technologies, and Cosmetology Services and Culinary Arts. In contrast, a double major leads to the smallest increase in major-related market size for graduates with primary fields in Area, Ethnic, and Civilization Studies, English Language, Literature, and Composition, and Criminal Justice and Fire Protection.

1.4 The empirical model

1.4.1 Baseline Model

This paper next uses the 2010-2019 ACS microdata to examine the effects of labor market size on the job match quality of college-educated workers. Specifically, I first examine the effects of major-related labor market size and overall population size on $MATCH$ of individual i in metropolitan area c and educated in college major m at year y by estimating a linear probability model (LPM) of the following equation

$$MATCH_{icm} = \beta_1 MajMktSize_{cm} + \beta_2 Pop_c + \beta_3 I_i + \gamma_c + \theta_m + \epsilon_i. \tag{1.3}$$

The dependent variable is a dummy equal to one if an individual has a *degree match* or an individual has a *major match*. $MajMktSize_{cm}$ is the major-related labor market size. Pop_c is the average population in each metropolitan area c. I_i is a vector of individual characteristics and year dummies included as control variables. γ_c is a set of metropolitan area fixed effects. θ_m is a set of detailed college major fixed effects, and ϵ_{icm} is a mean zero error term. The LPM is used instead of probit or logit because of the need to include the large number of fixed effects which often prevents probit/logit from being estimable and asymptotically unbiased. LPM estimation facilitates easier interpretation since coefficients can be directly interpreted as marginal effects. Standard errors reported below are clustered by metropolitan area.

The I vector includes age, age-squared, and dummy variables for being male, married, Black, American Indian, or Asian; attainment of a master's, professional or doctoral degree; and having any children. The metropolitan area fixed effects will account for aggregate differences in match propensities across metropolitan areas that affect all college graduates similarly. The college major fixed effects account for aggregate differences in match propensities across college majors. Including metropolitan areas and college major fixed effects mean that the identifying variation comes from across majors within a metropolitan area. The primary regression sample is restricted to college graduates ages 21-64 who live in an identifiable metropolitan area and excludes individuals earning less than ten thousand annual wages and salary in the prior year. Individuals who earn an advanced degree are included in regression on having a degree match but excluded in having a major match because ACS does not record an individual's major in the advanced degree.

One concern is that individuals with a high propensity to find suitable matches may move to cities with larger major-related labor markets. The issue is addressed by including metropolitan area fixed effects in the regressions to account for average differences in match across metropolitan areas. Other control variables help account for this as well. As discussed in Section 1.3.2.2, one may also be concerned that the occupations deemed to be a match are those most frequently chosen by individuals majoring in a particular field, which could generate a spurious positive relationship between major-related market size and the occurrence of a major match. Again, the CIP-SOC Crosswalk is not based on actual empirical data, and I use the sum of relevant jobs from a prior year to eliminate such concerns. Unobserved factors affecting match are included in the error term. The empirical approach assumes that after conditioning on the fixed effects and other control variables in Eq. (1.3), major-related labor market sizes by major and metropolitan areas are not correlated with the error term. If so, coefficient estimates for $MajMktSize_{cm}$ will be unbiased and allow accurate inferences. This is a reasonable assumption but not testable, so some caution is required. Furthermore, the estimated effect of β_1 captures the effects of major-related labor market size on the probability of matching marginal college-educated workers.

1.4.2 Interaction Model

This paper second examines how does the effects of major-related labor market size change with the population, based on the consideration that though population size and major-related labor market size are positively correlated, the elasticity of major-related labor market size varies among majors, as shown in Table 1.11. Specifically, I examine major-related labor market size, population size, and the interaction between them on $MATCH$ of individual i in metropolitan area c and educated in college major m by estimating a linear probability model (LPM) of the following equation

$$MATCH_{icm} = \beta_1 MajMktSize_{cm} + \beta_2 Pop_c + \beta_3 MajMktSize_{cm} \times Pop_c + \beta_4 I_i + \gamma_c + \theta_m + \epsilon_i. \tag{1.4}$$

Then the estimated effect of β_1 plus $\beta_3 Pop_c$ captures the effects of major-related labor market size on the probability of matching marginal college-educated workers given a certain population size. Furthermore, this estimated effect captures how the effects of major-related labor market size change with the population size change.

For various reasons, there could be heterogeneous effects by age and sex. The primary analysis focuses on ages 21-64 for both sexes. However, effects for males and females, ages 21-30, 31-40, 41-50, and 51-60, are also examined. Sex differences in responsiveness to major-related labor markets across metropolitan areas and majors may exist, but the direction is not clear a priori. Wright et al. 2016 suggested that women have much poorer matching probabilities than men.

1.5 Results

1.5.1 Baseline Model

Regression results from estimating Eq. (1.3) for college-educated workers ages 21-64 are reported in Table 1.14. Columns (1), (3), and (5) report results without city fixed effects because one may worry that including city dummy variables may make it harder for the population to explain the probability of a match. While Columns (2), (4), and (6) report results with city fixed effects. Overall, larger major-related labor market sizes significantly increase the probability that the individual has a degree match and increase the probability that the individual has a major match with city fixed effects.

The coefficients on having a degree match and a major match are relatively consistent in magnitude suggesting minimal differences in responsiveness to major-related labor market size between different measures of job match quality. The magnitudes of coefficients in Column (2) can be interpreted as one million more jobs in the major-related labor market would increase the probability of having a degree match by roughly 1.5 percentage points and increase the probability of having a major match by roughly 1.3 percentage points. The coefficients in Columns (2) and (6) are consistent in magnitude suggesting minimal differences in responsiveness to major-related labor market size with city fixed effects before and after controlling for the population size.

The coefficients in Column (5) suggest a larger effect on having a degree match while a smaller effect on having a major match without city fixed effects but controlling for the population size. The magnitudes of coefficients can be interpreted as one million more jobs in the major-related labor market leads to a roughly 2.3 percentage points increase in the probability of having a degree match and a roughly 1.5 percentage points increase in the probability of having a major match. The estimated magnitudes are not very large but are undoubtedly trivial.

Columns (3) and (4) report the estimated effects of population size on having a job match. With an exclusion of city dummy variables, one million more population in a city does not have significant effect on the probability of having a degree match. In comparison, it decreases the probability of having a major match by roughly .08 percentage points. With the inclusion of city dummy variables, one million more population in a city significant increases the probability of having a degree match by roughly one percentage point while decreases the probability of having a major match by roughly .3 percentage points. As sources of comparison, Abel and Deitz (2015) find that an individual's probability of working in a job that requires a college degree increases by .2 percentage points as the metropolitan population increases by one million. An individual's probability of working in a job relevant to their college degree major increases by about .2 percentage points as the metropolitan area population increases by one million. Wright et al. (2016) does not find a significant positive effect of STEM occupation counts on STEM degree holders working in a STEM job. Dauth et al. (2022) find a significant negative effect of employment in the city on the strength of assortative matching.

1.5.2 Interaction Model

Regression results from estimating Eq. (1.4) for college-educated workers ages 21-64 are reported in Table 1.15. I used a de-meaned major-related labor market and population size to make the interpretation easier. The effects of major-related labor market size become larger and still consistent compared to baseline model. Columns (1) and (2) report the effect of major-related labor market size on the probability of having a degree match. Columns (3) and (4) report its effect on the probability of having a major match. For all columns, a larger major-related labor market size significantly increases the probability of having a match. However, its effect on having a degree match increases with city fixed effects while its effect on having a major match decreases with city fixed effects. In addition, the effects of major-related labor market size are negatively interact with population size. One possible explanation is that larger cities offer workers more alternative career options outside their major field.

With an exclusion of city dummy variables, the magnitudes of coefficients can be interpreted as one million more jobs in the major-related labor market increase the probability of having a degree match by around 7.4 percentage points and increases the probability of having a major match by around 2.2 percentage points, given average city size(5.12 million). In addition, its effects decrease by around .7 percentage points on having a degree match and around .1 percentage points on having a major match with one million more population in a city. With the inclusion of city dummy variables, one million more jobs in the major-related labor market increase the probability of having a degree match by around 4.6 percentage points and increases the probability of having a major match by around 3.5 percentage points. At the same time, its effects decrease by around .4 percentage points on having a degree match and around .2 percentage points on having a major match with one million more people in a city.

The population size shows consistent negative effect on the probability of having a major match with or without city dummy variables, while it has inconsistent effect on the probability of having a degree match. Possible explanation for negative effects on major match could be larger cities allow more competitors for similar jobs, therefore, one may less likely to find a job that better match their major. In the following sections, I will stay with the interaction model to explore the effect of major-related labor market size on heterogeneous groups.

1.5.3 Effects of Agglomeration by Gender

This paper next examines Eq. (1.4) by males and females using de-meaned variables. Regression results in Table 1.16 suggest that the effects of major-related labor market size on job match quality are positively significant and larger for men. Columns (1) and (2) report the effect of major-related labor market size on the probability of having a degree match. Columns (3) and (4) report its effect on the probability of having a major match. In particular, the magnitudes of coefficients for males can be interpreted as that one million more jobs in the major-related labor market would increase the probability of having a degree match by roughly 9.2 percentage points without city fixed effects, which decreases by roughly .7 percentage points with one million more population in a city. At the same time, one million for more relevant jobs increases the probability of having a major match by roughly 3.7 percentage points which decreases by roughly .2 percentage points with one million more population in a city, without city fixed effects. On the other hand, one million more jobs in the major-related labor market would increase the probability of having a degree match by roughly 3.7 percentage points with city fixed effects, which decreases by roughly 1.1 percentage points with one million more population in a city. One million more jobs in the major-related labor market would increase the probability of having a major match by roughly .3 percentage points which decreases by roughly .2 percentage points with one million more population in a city.

As for females, the magnitudes of coefficients can be interpreted as that one million more jobs in the major-related labor market would increase the probability of having a degree match by roughly 6.1 percentage points without city fixed effects, which decreases by roughly .6 percentage points with one million more population in a city. One million more for more jobs in the major-related labor market increases the probability of having a major match by roughly 1.34 percentage points which decreases by roughly .2 percentage points with one million more population in a city. On the other hand, with city fixed effects, one million more jobs in the major-related labor market would increase the probability of having a degree match by roughly 3.3 percentage points, which decreases by roughly .4 percentage points with one million more population in a city. One million more jobs in the major-related labor market would increase the probability of having a major match by roughly 4.2 percentage points, which decreases by roughly .3 percentage points with one million more population in a city. The effects of population size follow similar patterns but slightly different magnitudes on the probability of having a match for males and females.

Overall, both major-related labor market size and population size have relatively smaller effects on the probability of a match for females than males. Wright et al. (2016)

find that women have much poorer matching probabilities than men among STEM degree holders. If women generally have less attachment to the labor force, it might explain that agglomeration measures have poorer effects on women's job match quality.

1.5.4 Effects of Agglomeration by Age Group

This paper further examines Eq. (1.4) across different age groups. Table 1.17 presents results without city fixed effects, while Table 1.18 displays results with city fixed effects. Specifically, Columns (1) and (2) show regression results for both sexes across various ages, Columns (3) and (4) present results for males of different ages, and Columns (5) and (6) outline findings for females across age groups. A larger major-related labor market size significantly boosts the likelihood of both degree and major matches for workers aged 21-30. However, its effects diminish with age, particularly for females, becoming insignificant for older female workers.

Excluding city dummy variables, an increase of one million in jobs in the major-related labor market raises the probability of a degree match by approximately 10.5 percentage points. This number decreases by around 9.7 percentage points with one million additional people in a city for workers aged 21-30. The effect is 1.2 percentage points larger for males and 2.6 percentage points smaller for females in the same age group. A one million increase in jobs in the major-related labor market heightens the chance of a major match by about 5.6 percentage points, decreasing by nearly .4 percentage points with one million more people in a city. This effect is 1.7 percentage points larger for males and two percentage points smaller for females aged 21-30.

For ages 31-40, a one million increase in jobs in the major-related labor market enhances the likelihood of a degree match by around 8.9 percentage points. This effect is reduced by about 0.8 percentage points with one million more people in a city, and is 1.6 percentage points lower than the effect on workers aged 21-30. Moreover, the impact is 1.5 percentage points greater for males and 1.6 percentage points lesser for females aged 31-40. Simultaneously, a one million increase in jobs in the major-related labor market raises the chance of a major match by approximately 3.8 percentage points, decreasing by nearly .2 percentage points with one million more people in a city. This outcome is 1.8 percentage points lower than its effect on workers aged 21-30. In addition, the influence is 1.2 percentage points larger for males and 1.7 percentage points smaller for females aged 21-30.

The impact of the major-related labor market size on the probability of having a match continues to decline from ages 21 to 50. For ages 41-50, the major-related labor market size exhibits no significant effect on the likelihood of a major match, especially for mixed sex and females, and has a less substantial impact on males compared to those aged 21-40. For workers aged 51-60, the major-related labor market size demonstrates a significant effect on the probability of male workers finding a match. Specifically, one million more jobs in the major-related labor market raises the likelihood of a degree match by roughly 6.7 percentage points and the chance of a major match by about 2.4 percentage points for males. The effect of the major-related labor market size remains less significant or insignificant for females.

In general, population size negatively impacts the likelihood of degree and major matches. Furthermore, the magnitudes are relatively consistent, suggesting that one million more population in a city will decrease the probability of a degree match and major match by approximately .3 percentage points each.

When city dummy variables are included, the impact of major-related labor market size becomes smaller on the probability of having a degree match, while larger on the probability of having a major match. Specifically, for ages 21-30, an increase of one million in jobs in the major-related labor market raises the likelihood of a degree match by about 10.5 percentage points, which declines by approximately .8 percentage points with one million more people in a city. This effect is 1.2 percentage points smaller for males, while 2.6 percentage points smaller for females. A one million increase in jobs in the major-related labor market also enhances the probability of a major match by about 5.5 percentage points, decreasing by nearly .3 percentage points with one million more people in a city. The impact is 1.8 percentage points larger for males and 1.9 percentage points smaller for females.

For ages 31-40, a one million increase in jobs in the major-related labor market boosts the likelihood of a degree match by around 9.1 percentage points, which is 1.4 percentage points lower than its effect on workers aged 21-30. Additionally, the influence of the major-related labor market size diminishes by about .9 percentage points with one million more people in a city. This effect is 1.3 percentage points higher for males while 1.8 percentage points smaller for females. Simultaneously, a one million increase in jobs in the major-related labor market raises the probability of a major match by approximately 3.8 percentage points, which is 1.7 percentage points lower than its effect on workers aged 21-30. The impact declines by around .2 percentage points with one million more people in a city, being 1.3 percentage points larger for males and 1.5 percentage points smaller for females.

For ages 41-50, the major-related labor market size exhibits a less significant effect on the likelihood of a major match, while a larger impact on the probability of a degree match compared to workers aged 31-40. Notably, it shows no significant effect on the probability of a major match for both females and males aged 41-50. However, the influence of the major-related labor market size on the probability of a major match re-emerges for workers aged 51-60. In particular, a one million increase in jobs in the major-related labor market raises the likelihood of a degree match by roughly 2.8 percentage points and the chance of a major match by about 2.4 percentage points. The major-related labor market size has a marginally larger effect on males by approximately .5 points for having a degree match and .8 for having a major match. In addition, its effect is smaller and relatively insignificant effect on females by around 1.4 percentage points on either match.

In general, population size has a positive effect on the probability of having a degree match and a negative impact on the likelihood of having a major match. The magnitudes are comparable to the results examining the entire sample.

Overall, major-related labor market sizes have greater effects on the probability of a match for younger workers than older workers, particularly young men. One possible explanation is that recent college graduates lack on-the-job training for skills beyond their college majors. As a result, the major-related labor market size is more crucial for recent college graduates to find matches for their educational level and major. Furthermore, the major-related labor market size has a relatively larger influence on males than females across different age groups, consistent with the results obtained by estimating Eq. (1.4) with gender differences only.

1.6 Conclusion

This paper delves into the relationship between labor market size and job match quality for college graduates, providing valuable insights into the empirical study of agglomeration. By utilizing data that connects majors to occupations, this research develops and calculates a major-related labor market size for college-educated workers, taking into account their degree fields and places of residence. In alignment with the methodology of previous research, job match quality for college graduates is defined based on whether they work in a job that requires their educational degree and whether their job aligns with the field of their educational degree.

The findings reveal that college-educated workers are more likely to secure occupations that match their educational level and acquired competencies in larger major-related labor markets. Interestingly, these effects continue to hold even after accounting for population size. In contrast, the effects of overall city size—population—on job match quality appear to be inconsistent. Larger cities offer a more extensive array of opportunities, which aligns with Sato (2001)'s concept of skill space. Specifically, a larger skill space negatively impacts match quality in equilibrium. It can be argued that the size of the skill space is more substantial in larger cities, leading to inconsistent population effects. Furthermore, although a positive correlation exists between major-related market and population, the influence of major-related labor market size declines as the population size increases.

Recognizing potential concerns surrounding causality, it is crucial to consider the possibility that individuals with a higher propensity for finding suitable matches might opt to relocate to cities boasting larger major-related labor markets. This issue seems to be a common feature in other studies (Abel and Deitz (2015), Wright et al. (2016), Dauth et al. (2022)).

These findings highlight the potential influence of city size on job match quality through major-related labor markets, contributing to empirical studies that aim to identify the sources of productivity gains in large and dense urban environments. In light of ongoing discussions about the gender gap and age differences in labor force participation and labor behavior, this research also investigates the effect of major-related labor market size on job match quality based on gender and age. The results indicate that women are less responsive to major-related market size compared to men, and the major-related labor market size has a more substantial impact on young workers. This suggests that targeted policies and interventions might be necessary to bridge the gap between different demographic groups and improve overall labor market outcomes.

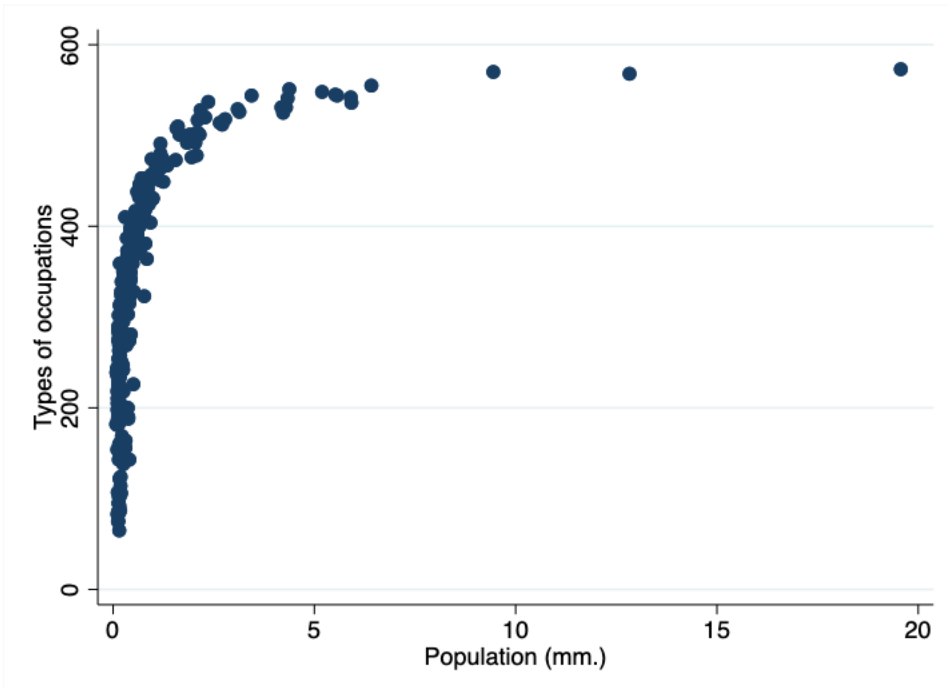
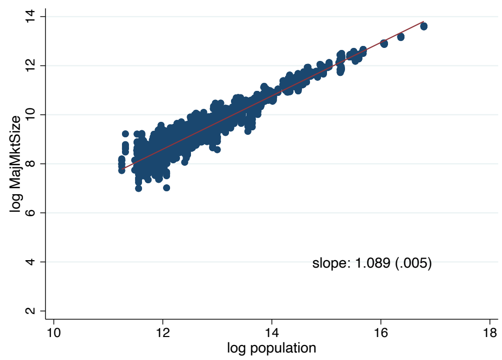
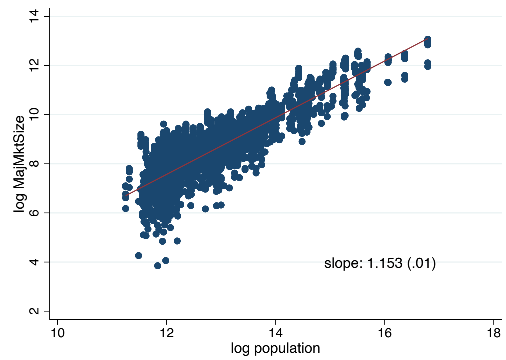


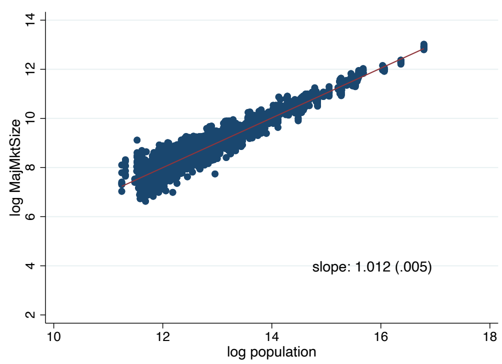
Figure 1.1: The Correlation Between City Size and Types of Occupations



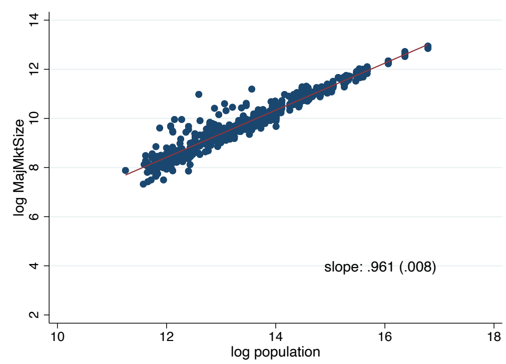
(a) Business



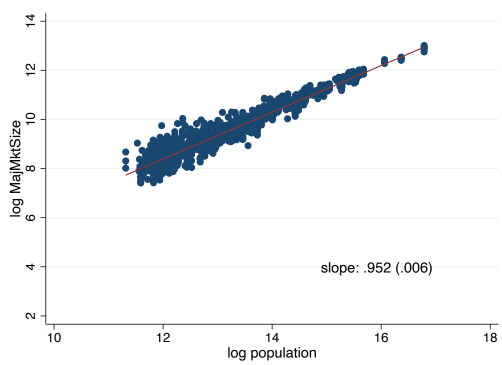
(b) Computer And Information Sciences



(c) Education Administration And Teaching

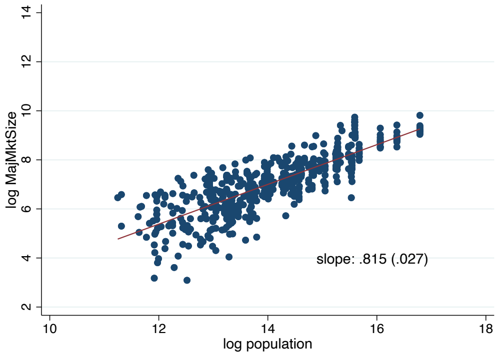


(d) Cosmetology Services And Culinary Arts

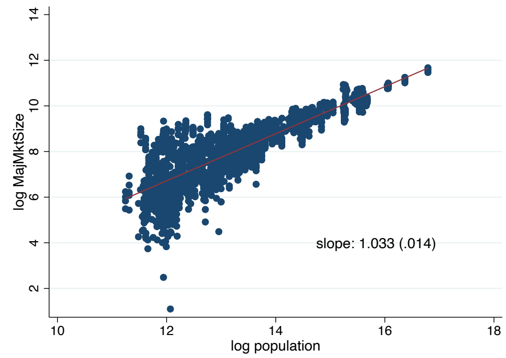


(e) Transportation Sciences and Techologies

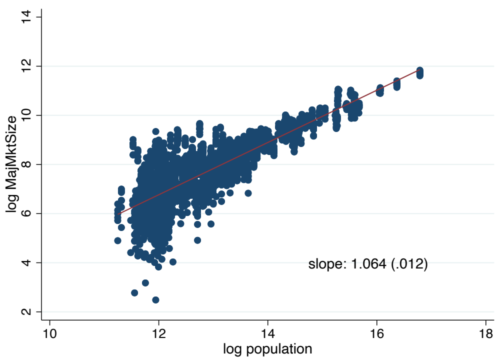
Figure 1.2: Correlation Between Population and Major-Related Market For Majors Have Relatively Large Market and Higher Match Rate



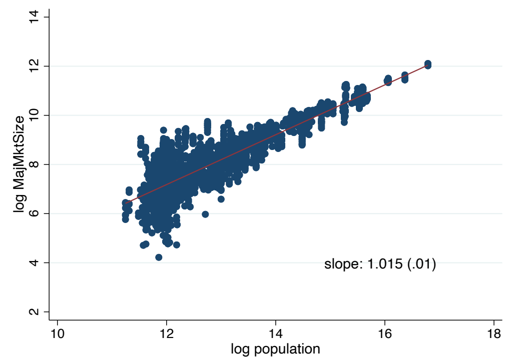
(a) Nuclear, Industrial Radiology, And Biological Technologies



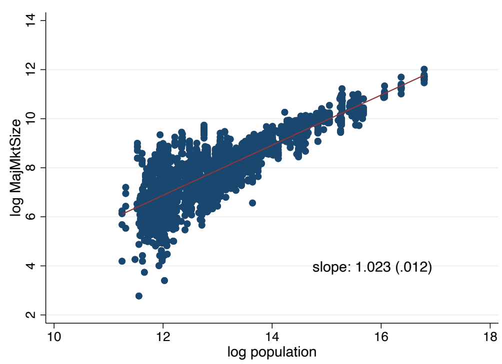
(b) Liberal Arts And Humanities



(c) Social Sciences



(d) Physical Science



(e) Physical Fitness, Parks, Recreation

Figure 1.3: Correlation Between Population and Major-Related Market For Majors Have Relatively Small Market and Lower Match Rate

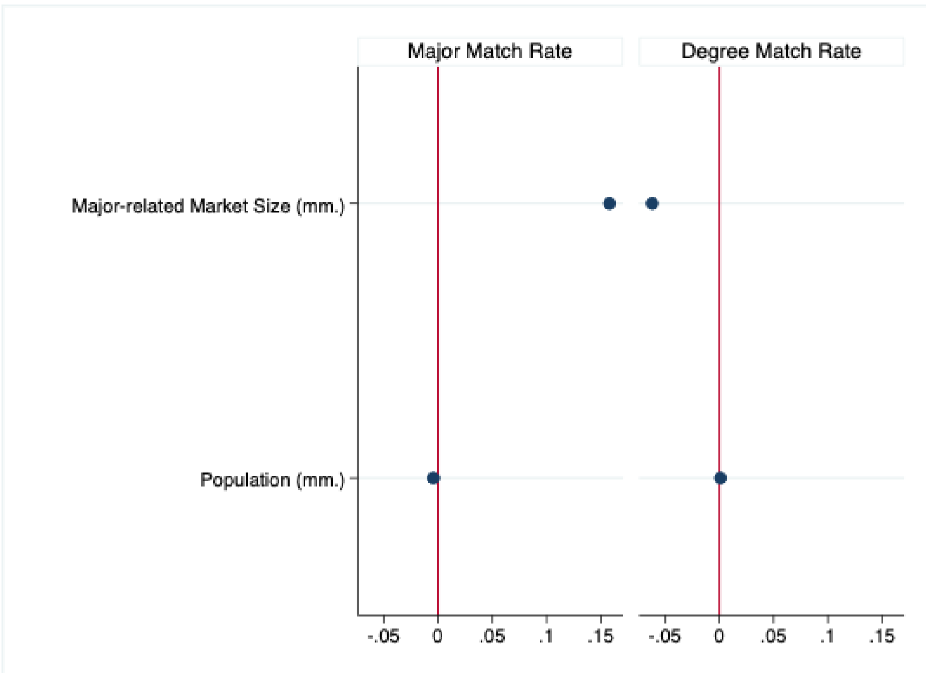


Figure 1.4: The Correlation Between Market Size and Match Rate

The coefficient in this context represents the average correlation between the size of the major-related labor market and the population with a major match rate or degree match rate across various broadly-defined degree fields, without accounting for any additional control factors.

Table 1.1 Detailed Degree Fields, Compositions

Rank	Detailed Degree Fields	Primary (%)	Secondary (%)
1	Business Management And Administration	6.42	4.05
2	General Business	4.64	2.46
3	Psychology	4.46	4.02
4	Nursing	4.20	2.64
5	Accounting	4.00	3.38
6	Biology	3.31	1.63
7	General Education	2.97	1.23
8	English Language And Literature	2.71	2.29
9	Computer Science	2.63	2.05
10	Communications	2.54	2.78
⋮	⋮	⋮	⋮
16	Economics	2.23	0.38
⋮	⋮	⋮	⋮
73	Electrical Engineering Technology	0.24	0.12
74	Microbiology	0.24	0.18
75	General Social Sciences	0.24	0.26
76	Miscellaneous Business And Medical Administration	0.24	0.56
77	Social Science Or History Teacher Education	0.23	0.32
78	Aerospace Engineering	0.22	0.11
79	Art History And Criticism	0.22	0.42
80	Construction Services	0.21	0.16
81	Community And Public Health	0.21	0.25
82	Physiology	0.20	0.26
83	Intercultural And International Studies	0.20	0.54
84	Animal Sciences	0.19	0.07
85	Linguistics And Comparative Language And Literature	0.19	0.41
86	Zoology	0.19	0.18
87	Nutrition Sciences	0.19	0.28
88	Human Services And Community Organization	0.19	0.30
⋮	⋮	⋮	⋮
162	Miscellaneous Fine Arts	0.03	0.12
163	Actuarial Science	0.03	0.04
164	Miscellaneous Agriculture	0.02	0.02
165	Mining And Mineral Engineering	0.02	0.01
166	Pharmacology	0.02	0.02
167	Physical Sciences	0.02	0.04
168	Astronomy And Astrophysics	0.02	0.11
169	Social Psychology	0.02	0.02
170	Soil Science	0.01	0.10
171	Geological And Geophysical Engineering	0.01	0.01
172	Court Reporting	0.01	0.00

Table 1.2 Most and Least Populous Cities

Rank	Metropolitan Areas	Population(mm.)	Pct. of College Graduates
1	New York-Newark-Jersey City, NY-NJ-PA	19.57	42.91
2	Los Angeles-Long Beach-Anaheim, CA	12.83	33.69
3	Chicago-Naperville-Elgin, IL-IN-WI	9.42	40.81
4	Dallas-Fort Worth-Arlington, TX	6.39	36.54
5	Houston-The Woodlands-Sugar Land, TX	5.92	33.18
6	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	5.85	39.62
7	Miami-Fort Lauderdale-West Palm Beach, FL	5.56	34.02
8	Washington-Arlington-Alexandria, DC-VA-MD-WV	5.44	54.29
9	Atlanta-Sandy Springs-Roswell, GA	5.10	40.52
10	Boston-Cambridge-Newton, MA-NH	4.36	51.24
11	San Francisco-Oakland-Hayward, CA	4.34	51.03
12	Detroit-Warren-Dearborn, MI	4.30	33.18
13	Riverside-San Bernardino-Ontario, CA	4.22	21.22
14	Phoenix-Mesa-Scottsdale, AZ	4.15	31.55
15	Seattle-Tacoma-Bellevue, WA	3.44	41.59
16	San Diego-Carlsbad, CA	3.10	36.87
17	Minneapolis-St. Paul-Bloomington, MN-WI	3.00	39.68
18	Tampa-St. Petersburg-Clearwater, FL	2.78	31.50
19	Baltimore-Columbia-Towson, MD	2.71	41.92
20	St. Louis, MO-IL	2.53	34.47
⋮	⋮	⋮	⋮
271	Hammond, LA	0.12	19.42
272	Anniston-Oxford-Jacksonville, AL	0.12	18.02
273	Muncie, IN	0.12	22.32
274	Williamsport, PA	0.12	19.45
275	Sheboygan, WI	0.12	25.53
276	Owensboro, KY	0.11	20.64
277	Kankakee, IL	0.11	19.54
278	Michigan City-La Porte, IN	0.11	18.43
279	Wenatchee, WA	0.11	24.27
280	Lawrence, KS	0.11	47.29
281	Decatur, IL	0.11	22.99
282	San Angelo, TX	0.11	22.90
283	Lewiston-Auburn, ME	0.11	23.25
284	Sumter, SC	0.11	18.31
285	Lima, OH	0.11	18.79
286	Ocean City, NJ	0.11	35.41
287	Gadsden, AL	0.10	16.40
288	Ithaca, NY	0.10	51.56
289	Bismarck, ND	0.08	30.73
290	Parkersburg-Vienna, WV	0.08	23.52

Note: 290 metropolitan areas, and the population are in million.

Table 1.3 Most and Least Educated Cities

Rank	Metropolitan Areas	Population(mm.)	Pct. of College Graduates
1	Washington-Arlington-Alexandria, DC-VA-MD-WV	5.44	54.29
2	Ann Arbor, MI	0.34	54.07
3	Bridgeport-Stamford-Norwalk, CT	0.92	52.98
4	San Jose-Sunnyvale-Santa Clara, CA	1.84	52.49
5	Ithaca, NY	0.10	51.56
6	Boston-Cambridge-Newton, MA-NH	4.36	51.24
7	San Francisco-Oakland-Hayward, CA	4.34	51.03
8	Iowa City, IA	0.15	50.28
9	Raleigh, NC	1.07	48.78
10	Charlottesville, VA	0.22	48.73
11	Durham-Chapel Hill, NC	0.50	48.59
12	Fort Collins, CO	0.30	47.92
13	Lawrence, KS	0.11	47.29
14	Columbia, MO	0.16	45.67
15	Denver-Aurora-Lakewood, CO	2.39	45.65
16	Austin-Round Rock, TX	1.61	45.24
17	Trenton, NJ	0.37	44.42
18	Bloomington, IN	0.16	43.61
19	Burlington-South Burlington, VT	0.21	43.41
20	Gainesville, FL	0.26	43.18
⋮	⋮	⋮	⋮
271	Alexandria, LA	0.15	17.45
272	Modesto, CA	0.51	17.34
273	Beaumont-Port Arthur, TX	0.40	17.32
274	Homosassa Springs, FL	0.14	17.22
275	Gadsden, AL	0.10	16.40
276	Jacksonville, NC	0.18	16.37
277	Houma-Thibodaux, LA	0.17	16.21
278	Mansfield, OH	0.12	16.00
279	Yuma, AZ	0.20	15.47
280	Bakersfield, CA	0.84	15.33
281	Yakima, WA	0.24	15.32
282	Odessa, TX	0.14	15.24
283	Farmington, NM	0.13	15.23
284	Vineland-Bridgeton, NJ	0.16	15.11
285	Merced, CA	0.26	14.41
286	El Centro, CA	0.17	13.56
287	Visalia-Porterville, CA	0.44	13.40
288	Madera, CA	0.15	12.66
289	Lake Havasu City-Kingman, AZ	0.16	12.58
290	Hanford-Corcoran, CA	0.15	11.88

Note: 290 metropolitan areas, and the population are in million.

Table 1.4 Major Compositions of Cities

Metropolitan Areas	Population	Majors	Pct. of College Graduates
New York-Newark-Jersey City, NY-NJ-PA	19.57	accounting	5.24
		business management and administration	5.12
		psychology	5.04
		general business	4.02
		english language and literature	3.68
		petroleum engineering/nuclear engineering/agricultural economics	0.01
		geological and geophysical engineering/soil science/miscellaneous agriculture	0.00
Los Angeles-Long Beach-Anaheim, CA	12.83	business management and administration	6.23
		psychology	4.78
		general business	4.52
		accounting	3.51
		nursing	3.48
		nuclear, industrial radiology, and biological technologies/physical sciences/court reporting	0.02
		miscellaneous agriculture/soil science/geological and geophysical engineering	0.01
Washington-Arlington-Alexandria, DC-VA-MD-WV	5.52	political science and government	6.35
		business management and administration	5.63
		psychology	4.14
		economics	3.78
		accounting	3.52
		actuarial science/nuclear, industrial radiology, and biological technologies/petroleum engineering	0.02
		court reporting/soil science/geological and geophysical engineering	0.01
Hanford-Corcoran, CA	0.15	business management and administration	6.45
		liberal arts	5.82
		nursing	5.69
		general education	4.80
		general business	4.55
		computer programming and data processing/geography/theology and religious vocations	0.25
		operations, logistics and e-commerce/music/genetics	0.13
Parkersburg-Vienna, WV	0.08	business management and administration	8.79
		elementary education	8.08
		nursing	6.41
		accounting	6.06
		general education	4.63
		industrial production technologies/animal sciences/area, ethnic, and civilization studies	0.24
		materials science/molecular biology/physical sciences	0.12

Table 1.5 Occupation Compositions of Cities

Metropolitan Areas	Population	Majors	Pct. of College Graduates
		Elementary and Middle School Teachers	6.57
		Accountants and Auditors	3.89
		Miscellaneous Managers, Including Funeral Service Managers and Postmasters and Mail Superintendents	3.57
New York-Newark-Jersey City, NY-NJ-PA	19.57	Lawyers, and judges, magistrates, and other judicial workers	2.83
		Financial Managers	2.15
		Parking Lot Attendants/Aircraft Mechanics and Service Technicians/Transportation Inspectors	0.02
		Agricultural Inspectors/Clinical And Counseling Psychologists/Sheet Metal Workers	0.01
		Elementary and Middle School Teachers	5.52
		Accountants and Auditors	3.89
		Miscellaneous Managers, Including Funeral Service Managers and Postmasters and Mail Superintendents	3.68
Los Angeles-Long Beach-Anaheim, CA	12.83	Lawyers, and judges, magistrates, and other judicial workers	2.53
		Postsecondary Teachers	2.37
		Cargo and Freight Agents/Pharmacy Aides/Surgeons	0.02
		Dancers and ChoreographersNew Account Clerks/Residential Advisors	0.01
		Miscellaneous Managers, Including Funeral Service Managers and Postmasters and Mail Superintendents	6.27
		Elementary and Middle School Teachers	4.57
		Lawyers, and judges, magistrates, and other judicial workers	4.42
Washington-Arlington-Alexandria, DC-VA-MD-WV	5.52	Accountants and Auditors	3.36
		Management Analysts	2.93
		Taxi Drivers/Mental Health Counselors/Biological Technicians	0.02
		Phlebotmists/Bakers/Animal Trainers	0.01
		Elementary and Middle School Teachers	14.66
		Aircraft Pilots and Flight Engineers	4.17
		Secondary School Teachers	3.92
Hanford-Corcoran, CA	0.15	Education And Childcare Administrators	2.53
		Farmers, Ranchers, and Other Agricultural Managers	2.15
		Library Technicians/Physical Therapists/Purchasing Managers	0.25
		Psychologists/Librarians/Urban and Regional Planners	0.13
		Elementary and Middle School Teachers	11.05
		Accountants and Auditors	4.39
		Miscellaneous Managers, Including Funeral Service Managers and Postmasters and Mail Superintendents	3.68
Parkersburg-Vienna, WV	0.08	Secondary School Teachers	2.85
		Physicians and Surgeons	2.49
		Mechanical Engineers/Electricians/Teacher Assistants	0.24
		Marketing Managers/Data Entry Keyers/Physician Assistants	0.12

Table 1.6 O*NET SOC to ACS SOC

ACS SOC Title	ACS SOC	O*NET	O*NET Title	≥Bachelor's Degree (%)
Chief Executives and Legislators	1110XX	111011.00	Chief Executives	89.72
		111011.03	Chief Sustainability Officers	96.16
General and Operations Managers	111021	111021.00	General and Operations Managers	48.04
Industrial Production Managers	113051	113051.00	Industrial Production Managers	44.75
		113051.01	Quality Control Systems Managers	88.07
		113051.02	Geothermal Production Managers	19.60
		113051.03	Biofuels Production Managers	52.04
		113051.04	Biomass Power Plant Managers	61.49
		113051.06	Hydroelectric Production Managers	22.09
Education Administrators	119030	119031.00	Edu. and Childcare Admin, Preschool and Daycare	16.52
		119032.00	Edu. Admin, Kindergarten through Secondary	90.88
		119033.00	Edu. Admin, Postsecondary	100

Table 1.7 Percent College Graduates by Occupations

Rank	Occupations	Percent
1	School Psychologists	100.00
2	Surgeons	100.00
3	Geoscientists And Hydrologists, Except Geographers	100.00
4	Other Psychologists	100.00
5	Clinical And Counseling Psychologists	100.00
6	Physicians	100.00
7	Environmental Scientists And Specialists, Including Health	100.00
8	Dentists	99.80
9	Veterinarians	99.72
10	Optometrists	99.67
⋮	⋮	⋮
183	Athletes And Sports Competitors	52.04
184	Biological Technicians	51.88
185	Musicians, Singers, and Related Workers	51.62
186	Credit Counselors and Loan Officers	51.57
187	Clinical Laboratory Technologists and Technicians	51.38
188	Tax Preparers	50.97
189	Other Life, Physical, And Social Science Technicians	50.86
190	Sales Representatives, Wholesale and Manufacturing	50.39
191	Photographers	50.37
192	Miscellaneous Media and Communication Workers	50.33
193	Sales Representatives, Services, All Other	50.12
194	Financial Clerks, All Other	49.96
195	Real Estate Brokers and Sales Agents	49.80
196	General and Operations Managers	49.72
197	Claims Adjusters, Appraisers, Examiners, and Investigators	49.12
198	Tax Examiners and Collectors, and Revenue Agents	48.96
199	Recreation and Fitness Workers	48.68
⋮	⋮	⋮
598	Welding, Soldering, and Brazing Workers	2.74
599	Cement Masons, Concrete Finishers, and Terrazzo Workers	2.71
600	Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	2.68
601	Drywall Installers, Ceiling Tile Installers, and Tapers	2.40
602	Tool Grinders, Filers, and Sharpeners	2.22
603	Plasterers and Stucco Masons	2.20
604	Surface Mining Machine Operators And Earth Drillers	2.15
605	Manufactured Building and Mobile Home Installers	2.10
606	Paving, Surfacing, and Tamping Equipment Operators	1.56
607	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	1.21

Note: 607 occupations in total and the percentage represent weighted percent of college graduates in each occupation.

Table 1.8 ACS majors to CIP to SOC Occupation

ACS majors	CIP Title	SOC Title
General Agriculture Agricultural Economics Miscellaneous Agriculture	Agricultural Economics	Economists Agricultural Sciences Teachers, Postsecondary
Environment and Natural Resources Environmental Science Forestry	Natural Resource Economics	Fish and Game Wardens
Family and Consumer Sciences	Consumer Economics	Farm and Home Management Advisors
General Social Sciences Economics Miscellaneous Social Sciences	Economics, General	Managers, All Other Economists Survey Researchers Economics Teachers, Postsecondary
General Social Sciences Economics Miscellaneous Social Sciences	Applied Economics	Managers, All Other Market Research Analysts and Marketing Specialists Economists Survey Researchers Economics Teachers, Postsecondary
	Development Economics and International Development	Managers, All Other Economists Economics Teachers, Postsecondary
	Political Economy	Managers, All Other Economists Political Scientists Economics Teachers, Postsecondary
General Agriculture Agriculture Production and Management Soil Science Miscellaneous Agriculture	Agriculture, General	Animal Scientists Food Scientists and Technologists Soil and Plant Scientists Agricultural Sciences Teachers, Postsecondary
Computer and Information Systems Computer Programming and Data Processing	Computer Programming/Programmer, General	Computer Programmers Software Developers, Applications Software Developers, Systems Software Web Developers Computer Network Support Specialists Computer Science Teachers, Postsecondary
Film, Video and Photographic Arts Fine Arts	Art/Art Studies, General	Art, Drama, and Music Teachers, Postsecondary Secondary School Teachers, Except Special and Career/Technical Education Craft Artists Fine Artists, Including Painters, Sculptors, and Illustrators Photographers
General Engineering Miscellaneous Engineering	Engineering, General	Architectural and Engineering Managers Engineers, All Other Engineering Teachers, Postsecondary

Table 1.9 Adjustment on SOC Codes in The Crosswalk

Occupation title in crosswalk	SOC in crosswalk	SOC in ACS	Occupation title in ACS
Computer User Support Specialists	151151	151150	Computer Support Specialists
Animal Scientists	191011		
Food Scientists and Technologists	191012	191010	Agricultural and Food Scientists
Soil and Plant Scientists	191013		
Agricultural Sciences Teachers, Postsecondary	251041		
Forestry and Conservation Science Teachers, Postsecondary	251043		
Environmental Science Teachers, Postsecondary	251053		
Area, Ethnic, and Cultural Studies Teachers, Postsecondary	251062	251000	Postsecondary Teachers
Social Sciences Teachers, Postsecondary, All Other	251069		
Communications Teachers, Postsecondary	251122		
Computer Science Teachers, Postsecondary	251021		
Reporters and Correspondents	273022	273020	Reporters and Correspondents
Audio and Video Equipment Technicians	274011	2740XX	Broadcast and Sound Engineering Technicians and Radio Operators, and Media and Communication Equipment Workers, All Other
Lawyers	231011		
Administrative Law Judges, Adjudicators, and Hearing Officers	231021	2310XX	Lawyers, and judges, magistrates, and other judicial workers
Arbitrators, Mediators, and Conciliators	231022		
Judges, Magistrate Judges, and Magistrates	231023		
Demonstrators and Product Promoters	419011	419010	Models, Demonstrators, and Product Promoters
Models	419012		
Real Estate Brokers	419021	419020	Real Estate Brokers and Sales Agents
Real Estate Sales Agents	419022		
Farm and Home Management Advisors	259021		

Note: Some OCCSOC codes in the crosswalk do not have close match in ACS.

Table 1.10 Job match rates by broad degree fields (%)

Broad Degree Fields	Major	Degree	Intersection	Union
Education Administration And Teaching	51.77	76.49	49.39	78.87
Cosmetology Services And Culinary Arts	47.12	16.86	0.55	63.43
Computer And Information Sciences	39.37	75.88	38.69	76.57
Transportation Sciences And Technologies	35.21	57.22	27.41	65.02
Business	34.10	59.99	24.21	69.88
Law	31.88	46.02	14.59	63.31
Library Science	31.77	73.82	30.60	74.99
Theology And Religious Vocations	31.59	62.98	31.51	63.06
Engineering	21.75	76.52	21.30	76.96
Mathematics And Statistics	21.15	78.24	21.03	78.36
Fine Arts	20.76	59.78	19.59	60.95
Medical And Health Sciences And Services	19.28	80.31	16.40	83.19
Family And Consumer Sciences	17.53	59.73	8.30	68.97
Agriculture	14.54	51.75	6.19	60.10
Physical Sciences	13.58	73.19	13.45	73.32
Architecture	13.21	70.54	11.30	72.45
Linguistics And Foreign Languages	12.72	66.99	12.42	67.29
Biology And Life Sciences	11.75	74.61	11.56	74.80
Public Affairs, Policy, And Social Work	11.58	70.61	11.22	70.98
Communication Technologies	10.79	54.97	9.49	56.27
Criminal Justice And Fire Protection	10.65	41.15	5.03	46.77
English Language, Literature, And Composition	10.18	67.94	10.10	68.02
Communications	10.08	61.13	9.64	61.57
Interdisciplinary And Multi-Disciplinary Studies (General)	9.79	66.65	9.45	66.98
Construction Services	9.08	34.21	0.51	42.78
Philosophy And Religious Studies	8.68	69.33	8.56	69.45
History	8.63	65.75	8.52	65.85
Engineering Technologies	8.07	61.08	4.36	64.79
Environment And Natural Resources	7.59	60.49	7.22	60.86
Psychology	7.08	67.12	6.90	67.29
Area, Ethnic, And Civilization Studies	6.04	68.28	5.95	68.37
Physical Fitness, Parks, Recreation, And Leisure	5.82	54.07	4.76	55.13
Social Sciences	5.22	65.71	5.02	65.91
Electrical And Mechanic Repairs And Technologies	5.13	26.75	1.46	30.42
Liberal Arts And Humanities	2.25	57.59	2.20	57.64
Nuclear, Industrial Radiology, And Biological Technologies	1.47	38.02	0.58	38.91
Total, all majors	22.56	68.89	19.52	71.94

Table 1.11 Majors, Major Specific Market Size, and Population

Broad Degree Fields	MajMktSize (K)	Population (mm.)	Elasticity	R^2
Business	318.99	5.21	1.09	0.94
Family And Consumer Sciences	232.95	4.53	0.98	0.95
Cosmetology Services And Culinary Arts	138.81	5.42	0.96	0.95
Computer And Information Sciences	130.40	5.37	1.15	0.82
Education Administration And Teaching	113.94	4.43	1.01	0.93
Transportation Sciences And Technologies	105.39	4.22	0.95	0.94
Fine Arts	101.83	6.51	1.04	0.8
Law	83.28	5.59	1.06	0.86
Construction Services	73.13	3.83	0.96	0.93
Agriculture	72.50	3.31	0.93	0.73
Biology And Life Sciences	72.42	4.74	1.09	0.8
Communications	68.40	5.54	1.06	0.75
Mathematics And Statistics	67.86	5.42	0.99	0.78
Engineering Technologies	67.33	4.40	1.05	0.8
History	59.37	5.44	1	0.78
Linguistics And Foreign Languages	59.22	5.56	0.96	0.76
English Language, Literature, and Composition	57.80	5.73	1	0.78
Engineering	57.07	4.92	1.09	0.77
Medical And Health Sciences And Services	54.46	4.66	1.01	0.83
Social Sciences	51.50	5.84	1.06	0.7
Interdisciplinary And Multi-Disciplinary Studies (General)	48.88	4.92	1	0.57
Architecture	48.68	6.19	0.99	0.74
Electrical And Mechanic Repairs And Technologies	45.21	5.10	0.93	0.92
Criminal Justice And Fire Protection	44.53	4.65	1.01	0.79
Public Affairs, Policy, And Social Work	43.25	4.69	1.04	0.77
Area, Ethnic, and Civilization Studies	42.55	6.15	0.92	0.73
Psychology	41.09	5.30	1.06	0.7
Philosophy And Religious Studies	40.72	5.44	0.99	0.69
Library Science	40.48	5.10	0.95	0.83
Communication Technologies	39.38	5.49	1.06	0.88
Theology And Religious Vocations	35.38	4.06	1	0.78
Physical Sciences	35.15	4.94	1.01	0.76
Physical Fitness, Parks, Recreation, And Leisure	34.62	3.88	1.02	0.71
Liberal Arts and Humanities	32.05	5.46	1.03	0.68
Environment And Natural Resources	30.24	3.76	0.98	0.69
Nuclear, Industrial Radiology, And Biological Technologies	12.97	4.29	0.81	0.68

Table 1.12 Summary Statistics

	Mean	SD	Min	Max
Population (mm.)	5.12	5.68	0	20
MajMktSize (mm.)	0.12	0.27	0	6
Degree match(50%)	0.69	0.46	0	1
Major match	0.23	0.42	0	1
Double majors	0.11	0.31	0	1
Graduate degree	0.39	0.49	0	1
Male	0.50	0.50	0	1
Married	0.63	0.48	0	1
Age	42.60	11.51	21	64
Any Children in HH	0.47	0.50	0	1
Black	0.07	0.26	0	1
American Indian	0.00	0.05	0	1
Asian	0.11	0.31	0	1
Annual wage and salary income	85,816.75	83,344.06	10000	736000

Note: Sample contains 3,579,204 individuals who hold at least a college degree. Population gives an average population size where Public Use Microdata Area (PUMA) residents live. Hourly wage was calculated using information on usual hours worked, weeks worked, and annual wage.

Table 1.13 Marginal effect of having a secondary degree

Broad Degree Fields	Double Major	R^2
Agriculture	70.79	0.14
Environment And Natural Resources	47.64	0.06
Architecture	94.24	0.10
Area, Ethnic, and Civilization Studies	40.44	0.06
Communications	77.49	0.07
Communication Technologies	84.01	0.15
Computer And Information Sciences	119.58	0.07
Cosmetology Services And Culinary Arts	139.90	0.10
Education Administration And Teaching	57.56	0.13
Engineering	85.86	0.19
Engineering Technologies	84.77	0.23
Linguistics And Foreign Languages	54.99	0.04
Family And Consumer Sciences	80.12	0.03
Law	114.40	0.07
English Language, Literature, and Composition	42.29	0.04
Liberal Arts and Humanities	58.41	0.07
Library Science	64.87	0.10
Biology And Life Sciences	47.30	0.10
Mathematics And Statistics	88.84	0.13
Interdisciplinary And Multi-Disciplinary Studies (General)	77.48	0.14
Physical Fitness, Parks, Recreation, And Leisure	84.12	0.13
Philosophy And Religious Studies	52.06	0.08
Theology And Religious Vocations	61.20	0.08
Physical Sciences	56.28	0.09
Nuclear, Industrial Radiology, And Biological Technologies	134.07	0.15
Psychology	72.61	0.08
Criminal Justice And Fire Protection	43.80	0.04
Public Affairs, Policy, And Social Work	71.03	0.13
Social Sciences	83.20	0.10
Construction Services	98.41	0.10
Electrical And Mechanic Repairs And Technologies	151.11	0.19
Transportation Sciences And Technologies	177.78	0.09
Fine Arts	102.77	0.09
Medical And Health Sciences And Services	64.49	0.30
Business	136.81	0.27
History	49.29	0.05
Total, all majors	87.37	0.01
Major FE	✓	
Year FE	✓	

Notes: The unit for additional major-related market size is in Thousand. Regressions exclude individuals who face zero major-specific labor market size. Clustered in metropolitan city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.14 Baseline model

	(1)	(2)	(3)	(4)	(5)	(6)
			Degree Match			
MajMktSize (mm.)	0.0118	0.0153^{**}			0.0232^{**}	0.0153^{**}
	(0.0121)	(0.0067)			(0.0109)	(0.0067)
Population (mm.)			−0.0002	0.0100^{***}	-0.0007^{***}	0.0100^{***}
			(0.0004)	(0.0018)	(0.0002)	(0.0018)
N	3579077	3579077	3579077	3579077	3579077	3579077
R^2	0.058	0.061	0.058	0.061	0.058	0.061
			Major Match			
MajMktSize (mm.)	−0.0035	0.0133^{***}			0.0130^{***}	0.0133^{***}
	(0.0035)	(0.0042)			(0.0040)	(0.0042)
Population (mm.)			-0.0008^{***}	-0.0032^{***}	-0.0012^{***}	-0.0032^{***}
			(0.0001)	(0.0009)	(0.0001)	(0.0009)
N	2195255	2195255	2195255	2195255	2195255	2195255
R^2	0.205	0.206	0.205	0.206	0.205	0.206
City FE		✓		✓		✓
Major FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. When estimate effect of market size on major match, I exclude individuals with an advanced degree since ACS do not report degree fields in advanced degree. Columns (1), (3), (5) represent estimate results without city fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.15 Interaction model

	Degree Match		Major Match	
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.1130***	0.0642***	0.0284***	0.0487***
	(0.0271)	(0.0070)	(0.0048)	(0.0071)
Population (mm.)	−0.0014***	0.0101***	−0.0013***	−0.0032***
	(0.0002)	(0.0018)	(0.0001)	(0.0009)
MajMktSize × Population	−0.0067***	−0.0036***	−0.0012***	−0.0026***
	(0.0018)	(0.0004)	(0.0003)	(0.0004)
N	3579077	3579077	2195255	2195255
R^2	0.058	0.061	0.205	0.206
City FE		✓		✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.16 Effects of major-specific labor market size on job match quality by gender

	Degree Match		Major Match	
	(1)	(2)	(3)	(4)
Panel A: Males				
MajMktSize (mm.)	0.1300***	0.0694***	0.0461***	0.0539***
	(0.0270)	(0.0076)	(0.0076)	(0.0116)
Population (mm.)	−0.0010***	0.0149***	−0.0013***	−0.0003
	(0.0004)	(0.0026)	(0.0002)	(0.0014)
MajMktSize × Population	−0.0074***	−0.0034***	−0.0018***	−0.0024***
	(0.0018)	(0.0005)	(0.0004)	(0.0006)
N	1784383	1784383	1108218	1108218
R^2	0.074	0.064	0.171	0.167
Panel B: Females				
MajMktSize (mm.)	0.0923***	0.0509***	0.0217**	0.0389***
	(0.0310)	(0.0082)	(0.0104)	(0.0072)
Population (mm.)	−0.0004	0.0057***	−0.0007***	−0.0057***
	(0.0003)	(0.0018)	(0.0001)	(0.0010)
MajMktSize × Population	−0.0062***	−0.0036***	−0.0016**	−0.0028***
	(0.0021)	(0.0005)	(0.0007)	(0.0004)
N	1794693	1794693	1087036	1087036
R^2	0.070	0.060	0.260	0.257
City FE		✓		✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses, ** $p < 0.05$, *** $p < 0.01$

Table 1.17 Effects on job match quality by age and gender groups without city FE

	All		Males		Females	
	Degree Match	Major Match	Degree Match	Major Match	Degree Match	Major Match
Panel A: Age 21 - 30						
MajMktSize (mm.)	0.1455***	0.0739***	0.1590***	0.0937***	0.1176***	0.0515***
	(0.0387)	(0.0091)	(0.0349)	(0.0149)	(0.0336)	(0.0112)
Population (mm.)	−0.0005	−0.0015***	−0.0005	−0.0021***	−0.0001	−0.0011***
	(0.0004)	(0.0001)	(0.0004)	(0.0002)	(0.0003)	(0.0002)
MajMktSize × Population	−0.0079***	−0.0036***	−0.0083***	−0.0040***	−0.0075***	−0.0031***
	(0.0026)	(0.0005)	(0.0023)	(0.0008)	(0.0023)	(0.0007)
N	681073	516149	303874	237138	1076769	279008
R^2	0.106	0.246	0.113	0.206	0.084	0.289
Panel B: Age 31 - 40						
MajMktSize (mm.)	0.1331***	0.0517***	0.1490***	0.0665***	0.1126***	0.0316**
	(0.0296)	(0.0075)	(0.0286)	(0.0128)	(0.0327)	(0.0140)
Population (mm.)	−0.0000	−0.0006***	−0.0005	−0.0010***	0.0005	−0.0001
	(0.0003)	(0.0002)	(0.0004)	(0.0003)	(0.0003)	(0.0001)
MajMktSize × Population	−0.0083***	−0.0026***	−0.0087***	−0.0030***	−0.0077***	−0.0021**
	(0.0019)	(0.0004)	(0.0019)	(0.0006)	(0.0022)	(0.0009)
N	940244	548353	463185	282646	477058	265703
R^2	0.074	0.224	0.082	0.187	0.067	0.275
Panel C: Age 41 - 50						
MajMktSize (mm.)	0.1172***	0.0130	0.1414***	0.0203*	0.0850***	0.0023
	(0.0263)	(0.0085)	(0.0264)	(0.0114)	(0.0292)	(0.0133)
Population (mm.)	−0.0011***	−0.0009***	−0.0013***	−0.0010***	−0.0009***	−0.0008***
	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0002)
MajMktSize × Population	−0.0072***	−0.0006	−0.0082***	−0.0006	−0.0060***	−0.0005
	(0.0018)	(0.0006)	(0.0018)	(0.0007)	(0.0020)	(0.0009)
N	909692	530229	464670	274347	445019	255881
R^2	0.063	0.211	0.067	0.167	0.062	0.270
Panel D: Age 51 - 60						
MajMktSize (mm.)	0.0791	0.0193**	0.0978***	0.0294***	0.0530*	0.0029
	(.)	(0.0080)	(0.0279)	(0.0102)	(0.0316)	(0.0127)
Population (mm.)	−0.0013	−0.0010***	−0.0015***	−0.0011***	−0.0009***	−0.0008***
	(.)	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0002)
MajMktSize × Population	−0.0053	−0.0011*	−0.0061***	−0.0011*	−0.0042*	−0.0010
	(.)	(0.0006)	(0.0019)	(0.0006)	(0.0022)	(0.0009)
N	823840	480357	427706	247538	396130	232816
R^2	0.059	0.194	0.061	0.158	0.061	0.246
City FE						
Major FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1.18 Effects on job match quality by age and gender groups with city FE

	All		Males		Females	
	Degree Match	Major Match	Degree Match	Major Match	Degree Match	Major Match
Panel A: Age 21 - 30						
MajMktSize (mm.)	0.0848***	0.0886***	0.0884***	0.1045***	0.0672***	0.0691***
	(0.0122)	(0.0116)	(0.0151)	(0.0179)	(0.0093)	(0.0113)
Population (mm.)	0.0231***	−0.0010	0.0324***	0.0010	0.0099***	−0.0028
	(0.0038)	(0.0033)	(0.0054)	(0.0049)	(0.0019)	(0.0030)
MajMktSize × Population	−0.0040***	−0.0047***	−0.0037***	−0.0049***	−0.0043***	−0.0044***
	(0.0008)	(0.0006)	(0.0009)	(0.0009)	(0.0006)	(0.0007)
N	681073	516149	303874	237138	1076769	279008
R^2	0.091	0.245	0.103	0.203	0.066	0.289
Panel B: Age 31 - 40						
MajMktSize (mm.)	0.0674***	0.0550***	0.0713***	0.0631***	0.0563***	0.0422***
	(0.0128)	(0.0098)	(0.0128)	(0.0160)	(0.0154)	(0.0137)
Population (mm.)	0.0121***	−0.0040**	0.0168***	0.0020	0.0087***	−0.0093***
	(0.0028)	(0.0016)	(0.0037)	(0.0026)	(0.0030)	(0.0024)
MajMktSize × Population	−0.0038***	−0.0030***	−0.0034***	−0.0029***	−0.0040***	−0.0029***
	(0.0008)	(0.0005)	(0.0008)	(0.0008)	(0.0009)	(0.0008)
N	940244	548353	463185	282646	477058	265703
R^2	0.066	0.220	0.074	0.181	0.062	0.274
Panel C: Age 41 - 50						
MajMktSize (mm.)	0.0808***	0.0227**	0.0913***	0.0218	0.0606***	0.0192
	(0.0084)	(0.0101)	(0.0096)	(0.0147)	(0.0124)	(0.0123)
Population (mm.)	0.0099***	−0.0032***	0.0147***	−0.0016	0.0055**	−0.0042**
	(0.0024)	(0.0011)	(0.0033)	(0.0020)	(0.0023)	(0.0017)
MajMktSize × Population	−0.0048***	−0.0013**	−0.0048***	−0.0008	−0.0044***	−0.0017**
	(0.0005)	(0.0006)	(0.0006)	(0.0009)	(0.0008)	(0.0007)
N	909692	530229	464670	274347	445019	255881
R^2	0.057	0.209	0.060	0.165	0.057	0.270
Panel D: Age 51 - 60						
MajMktSize (mm.)	0.0415***	0.0356***	0.0462***	0.0430***	0.0251*	0.0234*
	(0.0094)	(0.0115)	(0.0103)	(0.0150)	(0.0130)	(0.0120)
Population (mm.)	0.0052**	−0.0065***	0.0108***	−0.0034*	−0.0007	−0.0078***
	(0.0023)	(0.0017)	(0.0035)	(0.0020)	(0.0038)	(0.0018)
MajMktSize × Population	−0.0027***	−0.0022***	−0.0025***	−0.0021**	−0.0024***	−0.0025***
	(0.0006)	(0.0007)	(0.0006)	(0.0009)	(0.0008)	(0.0007)
N	823840	480357	427706	247538	396130	232816
R^2	0.053	0.192	0.054	0.157	0.057	0.249
City FE	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 2

The Benefits of Major-related Labor Markets for Job Match Quality of Power Couples

2.1 Introduction

Previous literature has documented the tendency of power couples, characterized as dual-career and highly-educated spouses, to reside in large cities. This phenomenon has been attributed to the need to address the unique challenges of co-locating faced by such couples, as highlighted by Costa and Kahn (2000). However, Simon (2019) identified two puzzling aspects regarding this co-location argument.

Firstly, Compton and Pollak (2007) argued that, based on the co-location premise, power couples should be more inclined to migrate to larger cities compared to couples where only one spouse holds a college degree. Contrary to this assumption, their examination of various couples revealed that the wife's college degree had no bearing on the size of the city chosen by migrating couples, regardless of the husband's educational qualifications.

The second enigma pertains to the scarcity of evidence demonstrating the positive impact of living in large cities on women's careers, regardless of their education level. While

Costa and Kahn (2000) supported their co-location argument by demonstrating that power couples were more likely to live in large cities when the wife was employed, neither Costa and Kahn (2000) nor Compton and Pollak (2007) provided direct evidence supporting the notion that college-educated women experienced greater career success by living in larger urban areas. This gap in the literature raises questions about the underlying reasons for power couples' affinity for residing in large cities and calls for further investigation into the potential advantages that such locations may offer to both partners in a power couple.

Indeed, direct evidence highlighting the career benefits of large cities for married women remains scarce. While Frank (1978) found statistically inconclusive evidence suggesting that wives in larger metropolitan areas may be less likely to be overqualified for jobs, McGoldrick and Robst (1996) discovered no such correlation using more recent and arguably superior data.

In addition, McKinnish (2008) reported that occupations with higher migration rates corresponded to a higher probability of migration, although the estimated effect was considerably more prominent for husbands than wives. This study also found that geographic mobility, which often benefited the husband's career, frequently resulted in fewer career opportunities for the wife. Neither McKinnish (2008) nor Compton and Pollak (2007) identified a significant role for city size in enhancing the career outcomes of married women.

However, not all findings have been negative. Ofek and Merrill (1997) observed higher market wage returns to city size for married women compared to their male counterparts. Furthermore, Simon (2019) determined that cities with a better-educated population provided superior joint career outcomes for both wives and husbands holding college degrees, as measured by their occupational attainment.

These mixed results underscore the need for further investigation into the relationship between city size and career benefits for married women. A deeper understanding of this connection could provide valuable insights for policymakers and urban planners seeking to create environments that foster equitable career opportunities for both partners in a marriage.

In the first chapter, I investigate the impact of major-related labor market size on job match quality for college graduates. My analysis reveals that individuals are more likely to secure a job that aligns with their educational degree and college-trained skills when they operate within larger major-related labor markets. Interestingly, I do not observe a significant positive effect on job match quality for college graduates residing in larger cities overall. Considering the scarcity of direct evidence regarding the career benefits of large cities for married women, examining the job match quality of both spouses in a household appears to be a logical extension of the study presented in the first chapter.

Using data from the 2010-2019 American Community Surveys, this paper documents the job match quality of both husbands and wives within a household and examines the job matching quality among power couples through a novel measure of market size. This measure is defined as employment in occupations closely related to individuals' college majors. Specifically, I investigate the following questions: 1) Do the results for power couples align with those observed for individuals? 2) How does the job match quality of power couples change when considering the spouse's match quality? Furthermore, I examine the job match quality of power couples while accounting for selective migration patterns.

By addressing these questions, this study aims to provide a comprehensive understanding of the factors that influence job match quality for power couples. The contribution of this paper lies in offering additional evidence on how college graduates benefit from larger labor markets and how married women, as well as married men, enjoy career advantages in large cities. These findings may present valuable insights for policymakers, urban planners, and employers seeking to create environments that foster equitable career opportunities and support the needs of dual-career households.

2.2 Data

2.2.1 Microdata

The regression analyses in subsequent sections utilize data from the pooled 2010-2019 American Community Surveys (ACS), a nationally representative sample encompassing one percent of the United States population, compiled by Ruggles et al. (2021). As discussed in Chapter 1, the ACS has recently started incorporating detailed information on individuals' undergraduate degree majors, facilitating the construction of a job match quality measure for power couples. Respondents report up to two degree fields, which the US Census Bureau then categorizes into one of 172 detailed college major groups and further consolidates into 36 broad major categories. The ACS also furnishes information on an individual's occupation, sex, race, highest degree completed, annual earnings, marital status, and the number of children in the household. Additionally, since its inception in 2001, ACS has provided data on residential location in the year preceding the survey. Metropolitan-level location data first became available in 2005, while information on an individual's undergraduate degree major was introduced in 2010.

Table 2.1 presents the most and least common combinations of husband's primary degree field and wife's primary degree field, broadly defined. Unsurprisingly, the most common combination is Business and Business. Among the most frequent pairings, we find majors such as Engineering, Education Administration and Teaching, and Medical and Health Sciences and Services. In contrast, the least common combinations include majors like Philosophy and Religious Studies, Communication Technologies, and Cosmetology Services and Culinary Arts.

Considering the focus on college graduates, I restrict the sample to working-age (i.e., aged 21 to 64) heterosexual married couples who live in the same household and reside in an identifiable metropolitan area.[1] In all subsequent analyses, I define "power couples" as

[1]Unmarried heterosexual couples should also be considered. However, since I cannot identify how long unmarried heterosexual couples have lived together using ACS data, I did not include them in the original sample.

those in which both the husband and wife have a bachelor's degree. This definition is crucial to the study, as it establishes the criteria for identifying power couples and allows for the investigation of the impact of larger labor markets on their job match quality.

In this study, the geographic unit of analysis consistently employs the largest of the following three options: Consolidated Metropolitan Statistical Area, Primary Metropolitan Statistical Area, or Metropolitan Statistical Area (MSA). These definitions are provided by the United States Office of Management and Budget (OMB). For the purposes of this paper, the resulting geographic unit will be referred to as the "city." The key data for each city is derived from the average 2010 population of the metro/micro areas within each Public Use Microdata Area (PUMA). When a PUMA is entirely encompassed by a single metro area, this "average" simply corresponds to the metro area's population. In other cases, the key data offers an approximation of the typical population size of the commuting systems where PUMA residents reside.

By considering different levels of metropolitan organization, this analysis allows for a nuanced understanding of the relationship between city size, labor market dynamics, and job match quality for power couples in various urban environments. The approach captures the complex interplay of factors that influence the labor market outcomes of power couples in different cities, providing a more comprehensive perspective on their experiences.

Where do power couples tend to reside? Figure 2.1 shows that, within the power couples sample, approximately 9% of them live in a city with a population of nearly 20 million, such as the New York, Newark, and Jersey City area. In general, larger cities are home to a higher proportion of power couples. However, the correlation between city size and the concentration of power couples varies more significantly among medium and small cities, particularly in smaller urban areas. Figure 2.2 plots the distribution of power couples across medium to small cities, illustrating this variation in more detail. This observation suggests that the factors attracting power couples to large cities may differ from those influencing their choices in medium or smaller urban areas, underscoring the importance of considering different metropolitan scales when examining the labor market outcomes of power couples.

2.2.2 Measuring Job Match Quality

As the same as I discussed in Chapter 1, following the same idea as Abel and Deitz (2015), I characterize match quality in two ways.

2.2.2.1 Degree Match

In the ACS dataset, college graduates are considered to have a *degree match* if they work in an occupation that requires a college degree. The proportion of college graduates within each occupation is used to determine whether a given occupation necessitates a college degree. To calculate the percentage of college graduates in each occupation, I utilized the pooled 2010-2019 ACS data.

Upon examining the data, I found that among married couples, 76.4% of all husbands are employed in occupations requiring a bachelor's degree or higher, while 79.7% of all wives are employed in occupations that call for a bachelor's degree. Moreover, for power couples, where both husband and wife have obtained at least a bachelor's degree, 62.68% of them have a degree match for both husband and wife.

2.2.2.2 Major Match

In the ACS dataset, college graduates are considered to have a *major match* if they work in an occupation that is relevant to their major. To determine the relevant occupations, I use a crosswalk between college majors, known as the Classification of Instructional Programs (CIP), and Standard Occupational Classification (SOC) occupations, referred to as the "CIP-SOC Crosswalk." This crosswalk is a collaborative effort between the Bureau of Labor Statistics (BLS) and the National Center for Education Statistics (NCES) aimed at aligning post-secondary programs of study with occupations requiring specific skills or knowledge for success. These programs typically fulfill the educational requirements for entry and advancement in a field and/or prepare individuals to meet licensure or certification requirements to work in the occupation.

It is important to note that the CIP-SOC Crosswalk is constructed based on the expertise of statisticians from both BLS and NCES, rather than actual empirical data, which emphasizes its exogenous nature[2].

Upon analyzing the data, I found that among married couples, 23.6% of all husbands and 25.5% of all wives are employed in occupations relevant to their majors. Furthermore, 7.85% of power couples have both the husband and wife working in occupations with a major match. These findings highlight the importance of understanding the factors that influence major match and labor market dynamics for power couples. By exploring the relationship between major relevance and occupational outcomes, we can gain insights into the role that higher education plays in shaping career trajectories and the potential challenges faced by dual-career households in finding jobs that align with their fields of study. This knowledge can inform policy decisions and strategies aimed at enhancing career opportunities and supporting the needs of power couples in today's evolving labor market.

In addition, I present the crosstab of degree match rate in Table 2.2, major match rate in Table 2.3, and both match rate in Table 2.4.

2.2.3 Measuring Market Size

Following Chapter 1, I use two measures as labor market size. The first one is city population, and the second one is the major-related labor market size. Recall the definition of major-related labor market size.

The major-related labor market size is defined as follows. Let O_m represent the set of occupations $\{O_1, ..., O_{N_m}\}$ relevant to college degree major m, as determined using the information from the NCES, as described in Section 1.3.1. I define the major-related labor market size for detailed college major m in area c in year y, $MajMktSize_{cm,y}$, to be the total employment in relevant occupations in that area in the prior year. It can be expressed

[2] These words are quoted directly from https://nces.ed.gov/ipeds/cipcode/post3.aspx?y=56. For more information on the CIP-SOC Crosswalk, go to the file " Guidelines for Using the CIP to SOC Crosswalk" using https://nces.ed.gov/ipeds/cipcode/Files/CIPSOCUsersGuideMarch152011.doc.

as:

$$MajMktSize_{cm,y} \equiv \sum_{o \in O_m} Emp_{oc,y-1}, \tag{2.1}$$

where $Emp_{oc,y-1}$ represents employment in occupation o in area c in the previous year. One might be concerned about a mechanical relationship between major-related labor market size and the probability of a good match. However, by relying on the fact that the sample consists of randomly selected individuals each year, using total employment in relevant occupations in the prior year can address this concern. Additionally, note that the ACS allows individuals to report up to two-degree fields, with around 11% of college graduates obtaining a secondary degree. I calculate the major-related labor market size for individuals with two-degree fields without overlapping.

2.3 The empirical model

2.3.1 Baseline Model

This paper next uses the 2010-2019 ACS microdata to examine the effects of labor market size on the job match quality of power couples. Table 2.5 provides summary statistics of the sample that I use for regression analysis. Specifically, I first examine the effects of major-related labor market size and overall population size on $MATCH$ of husband or wife i in metropolitan area c and educated in college major m at year y by estimating a linear probability model (LPM) of the following equation

$$MATCH_{icm} = \beta_1 MajMktSize_{cm} + \beta_2 Pop_c + \beta_3 I_i + \gamma_c + \theta_m + \epsilon_i. \tag{2.2}$$

Where i now represents husband or wife in a household. The dependent variable is a dummy equal to one if an individual has a *degree match* or an individual has a *major match*. $MajMktSize_{cm}$ is the major-related labor market size face by husband or wife. Pop_c is the average population in each metropolitan area c where household locates. I_i is a vector of individual characteristics and year dummies included as control variables. γ_c is a set of metropolitan area fixed effects. θ_m is a set of detailed college major fixed effects, and ϵ_{icm} is a mean zero error term. The LPM is used instead of probit or logit because of the need to include the large number of fixed effects which often prevents probit/logit from being estimable and asymptotically unbiased. LPM estimation facilitates easier interpretation since coefficients can be directly interpreted as marginal effects. Standard errors reported below are clustered by metropolitan area.

The I vector includes age, age-squared, race and whether having any children in the household. The metropolitan area fixed effects will account for aggregate differences in match propensities across metropolitan areas that affect all college graduates similarly. The college major fixed effects account for aggregate differences in match propensities across college majors. Including metropolitan areas and college major fixed effects mean that the identifying variation comes from across majors within a metropolitan area. The primary regression sample is restricted to power couples ages 21-64 live in an identifiable metropolitan area and excludes individuals earning less than ten thousand annual wages and salary in the prior year.

One concern is that individuals with a high propensity to find suitable matches may move to cities with larger major-related labor markets. The issue is addressed by including metropolitan area fixed effects in the regressions to account for average differences in match across metropolitan areas. Other control variables help account for this as well. As discussed in Section 2.2.2.2, one may also be concerned that the occupations deemed to be a match are those most frequently chosen by individuals majoring in a particular field, which could generate a spurious positive relationship between major-related market size and the occurrence of a major match. Again, the CIP-SOC Crosswalk is not based on actual empirical data, and I use the sum of relevant jobs from a prior year to eliminate such concerns. Unobserved factors affecting match are included in the error term. The empirical approach assumes that after conditioning on the fixed effects and other control variables in Eq. (2.2), major-related labor market sizes by major and metropolitan areas are not correlated with the error term. If so, coefficient estimates for $MajMktSize_{cm}$ will be unbiased and allow accurate inferences. This is a reasonable assumption but not testable, so some caution is required. Furthermore, the estimated effect of β_1 captures the correlation between major-related labor market size and the probability of matching.

2.3.2 Interaction Model

This paper second examines how does the effects of major-related labor market size change with the population, based on the consideration that though population size and major-related labor market size are positively correlated, the elasticity of major-related labor market size varies among majors, as discussed in Chapter 1. Specifically, I examine major-related labor market size, population size, and the interaction between them on $MATCH$ of husband or wife i in metropolitan area c and educated in college major m by estimating a linear probability model (LPM) of the following equation

$$MATCH_{icm} = \beta_1 MajMktSize_{cm} + \beta_2 Pop_c + \beta_3 MajMktSize_{cm} \times Pop_c + \beta_4 I_i + \gamma_c + \theta_m + \epsilon_i. \tag{2.3}$$

Then the estimated effect of β_1 plus $\beta_3 Pop_c$ captures the effects of major-related labor market size on the probability of matching marginal college-educated workers given a certain population size. Furthermore, this estimated effect captures how the effects of major-related labor market size change with the population size change.

For various reasons, there could be heterogeneous effects by age and sex. The primary analysis focuses on ages 21-64 for both sexes. However, effects for males and females, ages 21-30, 31-40, 41-50, and 51-60, are also examined. Sex differences in responsiveness to major-related labor markets across metropolitan areas and majors may exist, but the direction is not clear a priori. Wright et al. 2016 suggested that women have much poorer matching probabilities than men.

2.4 Results

2.4.1 Baseline Model

Regression results from estimating Eq. (2.1) for power couples separately ages 21-64 are reported in Table 2.6 and Table 2.7. In order to compare with individual level results, I list the individual level results along with power couple results.

Table 2.6 presents regression results for the individual level and household level analysis, where the dependent variable is the degree match for individuals, husbands and wives separately. The table is divided into nine columns, with columns 1-3 for individual level analysis and columns 4-9 for household level analysis. Columns 5-6 and 8-9 show the results for husbands and wives, respectively.

For the individual level, we can observe that in the first column, a one million-unit increase in major-related market size is associated with a 1.5 percentage point increase in the probability of having a degree match for college graduates, significant at the 5% level ($p<0.05$). In the third column, the coefficient is consistent with the first column. In the second column, a one million-unit increase in population is associated with a one percentage point increase in the dependent variable, significant at the 1% level ($p<0.01$). The results indicate that the major-related market size and population positively impact the probability of having a degree match at the individual level.

For the household level, focusing on husbands in the fourth, fifth, and sixth columns, we can see that a one million-unit increase in major-related market size is associated with a 1.2 percentage point increase in the probability of having a degree match for husband, significant at the 10% level ($p<0.10$). In the sixth column, the coefficient remains the same as in the fourth column. In the fifth column, a one million-unit increase in population is associated with a two percentage point increase in the probability of having a degree match for husband, significant at the 1% level ($p<0.01$). These results indicate that both market size and population positively impact the probability of having a degree match for husbands.

For the household level, focusing on wives in the seventh, eighth, and ninth columns, the coefficient for major-related market size is not statistically significant. This implies that major-related market size does not have a significant impact on the probability of having a degree match for wives. However, in the eighth column, a one million-unit increase in population is associated with a .7 percentage point increase in the probability of having a degree match, significant at the 1% level ($p<0.01$). In the ninth column, the coefficient remains the same as in the eighth column. The results indicate that population positively impacts the probability of having a degree match for wives, but major-related market size does not have a significant effect.

It is important to note that all columns control for city, major, and year fixed effects, which accounts for unobserved heterogeneity across cities, majors, and years. The sample sizes and R-squared values are consistent across columns for each group (individual level, husbands, and wives).

Table 2.7 presents regression results for the individual level and household level analysis, where the dependent variable is the major match for individuals, husbands and wives separately. The table is also divided into nine columns, with columns 1-3 for individual level analysis and columns 4-9 for household level analysis. Columns 5-6 and 8-9 show the results for husbands and wives, respectively.

At the individual level, a one million unit increase in the major-related market size is associated with a 1.3 percentage point increase in the probability of having a major match (significant at the 1% level) and this relationship is consistent after controlling for the population. On the other hand, a one million unit increase in population size is associated with a .3 percentage point decrease in the probability of having a major match (significant at the 1% level).

At the household level, for husbands, a one million increase in the major-related market size is associated with a 3.9 percentage point increase in the probability of having a major match (significant at the 1% level). For wives, the same increase in market size is associated with a 2.9 percentage point increase in the probability of having a major match (significant at the 1% level). These relationships are consistent across all three husband-level columns (4-6) and wife-level columns (7-9).

As for the population, At the household level, for husbands, a one million unit increase in population size is associated with a .4 percentage point decrease in the probability of having a major match (significant at the 5% level). For wives, the same increase in population size is associated with a .5 percentage point decrease in the probability of having a major match (significant at the 10% level). These relationships are consistent across both husband-level columns 5 and 6, as well as wife-level columns 8 and 9. And these results are consistent to individual level results.

In summary, the results suggest that an increase in major-related market size is positively associated with the probability of having a major match in terms of percentage points, while an increase in population size is negatively associated with the probability of having a major match in terms of percentage points, at both individual and household levels.

2.4.2 Interaction Model

Regression results from estimating Eq. (2.3) for power couples ages 21-64 are reported in Table 2.8. I used a de-meaned major-related labor market and population size to make the interpretation easier. Results are consistent with individual level.

To summarize the results, A one million increase in major-related market size is associated with a 6.4 percentage point increase in the probability of having a degree match at the individual level, a 5.5 percentage point increase for husbands, and a 5.1 percentage point increase for wives (all significant at the 0.01 level). A one million increase in population is associated with a one percentage point increase in the probability of having a degree match at the individual level, a 1.6 percentage point increase for husbands, and a .7 percentage point increase for wives (all significant at the 0.01 level). The interaction term between major market size and population has a negative effect on the probability of having a degree match all groups. The negative intersection term means given average population, increasing one million jobs that are related to one's major associated with a -.4 percentage point change at the individual level, a -.3 percentage point change for husbands, and a -.3 percentage point change for wives (all significant at the 0.01 level).

As for the correlation between the major-related labor market and job match quality. A one million increase in major market size is associated with a 4.9 percentage point increase in the probability of having a major match at the individual level, a 13.5 percentage point increase for husbands, and a 10.7 percentage point increase for wives (all significant at the 0.01 level).

A one million increase in population is associated with a -.3 percentage point change in the probability of having a major match at the individual level (significant at the 0.01 level), a -.3 percentage point change for husbands (significant at the 0.10 level), and a -.4 percentage point change for wives (significant at the 0.10 level).

The interaction term between major market size and population has a negative effect on the probability of having a major match for all groups. A one-unit increase in the interaction term is associated with a -.3 percentage point change at the individual level, a -.6 percentage point change for husbands, and a -.5 percentage point change for wives (all significant at the 0.01 level).

The results from examining power couples are consistent with examining individual level data. Major market size has a positive impact on both degree and major matches across all groups, with larger effects observed for husbands and wives in the household level models. Population has a mixed effect: it positively impacts degree matches for all groups, but negatively impacts major matches, particularly for wives. The interaction between major market size and population negatively affects both degree and major matches across all groups, indicating that the positive effects of major market size may be offset by larger populations.

2.5 Extensions

2.5.1 Compare With Different Genders

Based on the observation that the correlation between major-related market size and job math quality of husband and wife are similar, I present the comparison between results for husbands and wives with results for male and female in individual level.

Table 2.9 presents regression results for degree match and major match outcomes at both the individual level (columns 1-4) and the household level (columns 5-8), separately for males, females, husbands, and wives.

The table presents regression results for degree match and major match outcomes at both the individual level (columns 1-4) and the household level (columns 5-8), separately for males, females, husbands, and wives.

At the individual level, an increase in major-related market size is positively associated with both degree match and major match outcomes for both males and females. For example, a one million increase in major-related market size is associated with a 6.9 percentage point increase in the probability of degree match for males (column 1) and a 5.4 percentage point increase in the probability of major match for males (column 2), both significant at the 1% level. Similarly, a one million increase in major-related market size is associated with a 5.1 percentage point increase in the probability of degree match for females (column 3) and a 3.9 percentage point increase in the probability of major match for females (column 4), both significant at the 1% level.

At the household level, the results are similar only that the major-related market has relatively large effect on the major match for husbands and wives. An increase in major market size is positively associated with both degree match and major match outcomes for both husbands and wives. For example, a one million increase in major market size is associated with a 5.5 percentage point increase in the probability of degree match for husbands (column 5) and a 13.5 percentage point increase in the probability of major match for husbands (column 6), both significant at the 1% level. Similarly, a one million increase in major market size is associated with a 5.1 percentage point increase in the probability of degree match for wives (column 7) and a 10.7 percentage point increase in the probability of major match for wives (column 8), both significant at the 1% level.

We still see positive correlation between population and degree match outcome while negative correlation between population and major match outcome. For males, a one million increase in population is associated with a 1.5 percentage point increase in the probability of degree match (column 1), significant at the 1% level, and a .03 percentage point decrease in the probability of major match (column 2). For females, a one million increase in population is associated with a .6 percentage point increase in the probability of degree match (column 3) and a .6 percentage point decrease in the probability of major match (column 4), both significant at the 1% level.

At the household level, a one million increase in population is associated with a 1.6 percentage point increase in the probability of degree match for husbands (column 5) and a .3 percentage point decrease in the probability of major match for husbands (column 6), both significant at the 1% and 10% levels, respectively. For wives, a one million increase in population is associated with a .7 percentage point increase in the probability of degree match (column 7) and a .4 percentage point decrease in the probability of major match (column 8), both significant at the 1% and 10% levels.

Finally, the interaction between major market size and population is negative and significant across all outcomes, suggesting that the positive effect of major market size on degree match and major match outcomes decreases with increasing population size.

All models include city, major, and year fixed effects.

2.5.2 Results Conditional on Spouse's Job Match Quality

This paper then examining the job match quality of husbands and wives as a function of labor market size conditional on the spouse's job match quality, which are described as following,

$$Prob(Degree/MajorMatch)_{husb.} = F(MajMktSize_{husb.}|(Degree/MajorMatch)_{wife} = 1),$$

$$Prob(Degree/MajorMatch)_{wife} = F(MajMktSize_{wife}|(Degree/MajorMatch)_{husb.} = 1).$$

Table 2.10 presents regression results for husbands' quality conditional on wives' quality (columns 1 and 2) and wives' quality conditional on husbands' quality (columns 3 and 4). Degree match is used in columns 1 and 3, while major match is used in columns 2 and 4.

Major-related market is positively and significantly associated with both husbands' and wives' quality if spouse also has a match, regardless of whether degree or major match is considered. For example, one million more jobs related to one's major is associated with a 5.3 percentage point increase in husbands' quality in the degree match case (column 1) and a thirteen percentage point increase in the major match case (column 2). Similarly, one million more jobs in major-related market is associated with a 5.2 percentage point increase in wives' quality in the degree match case (column 3) and a 13.7 percentage point increase in the major match case (column 4).

Population is positively and significantly associated with the quality of husbands in degree match (columns 1) while is not significantly associated with the quality in major match (columns 2). However, its effect on wives' quality is different, but consistent with previous results, with a positive and significant association in the degree match case (column 3) and a negative and significant association in the major match case (column 4). Specifically, one million increase in population is associated with a 1.9 percentage point increase in husbands' quality in the degree match case and no significant effect in the major match case. For wives, one million increase in population is associated with a .8 percentage point increase in quality in the degree match case and a .7 percentage point decrease in the major match case.

The interaction term between major-related market size and population again has a negative and significant effect on both husbands' and wives' quality in all cases. The results indicate that major-related market size has a positive impact on the quality of both husbands and wives in percentage point terms, while the effect of population varies depending on the gender and the match criterion used. The interaction term between major-related market size and population has a negative effect on quality, suggesting that the positive effect of major-related market size is somewhat offset when considering the population size.

2.5.3 Results on Joint Match

This paper also examines the correlation between major-related market size and the joint match outcome of husband and wife. In order to examine the joint match outcomes, I control for individual characteristics for both husband and wife. Table 2.11 shows the correlation between several variables when both husband and wife have a degree match (columns 1-3) and when both husband and wife have a major match (columns 4-6).

A one-million increase in the husband's major-related market size is associated with a 4.6 percentage point increase in the probability of both having a degree match in columns (1) and (3), respectively. Similarly, the same increase is associated with a 2.5 and 2.3 percentage point increase in the probability of both having a major match in columns (4) and (6), respectively. At the same time, a one-million increase in the wife's major-related market size is associated with a 6.8 and six percentage point increase in the probability of both having a degree match in columns (2) and (3), respectively. For both having a major match, the same increase is associated with a 3.4 and 3.1 percentage point increase in the probability in columns (5) and (6), respectively. Correlations are slightly higher than husband's major-related market size.

A one-million increase in population is associated with a 1.6, 2, and 1.7 percentage point increase in the probability of both having a degree match in columns (1), (2), and (3), respectively. On the other hand, the same increase in population is associated with a .6, .4, and .3 percentage point decrease in the probability of both having a major match in columns (4), (5), and (6), respectively. The negative correlation between population and job match outcome is relatively consistent across different models. The negative correlation between interaction term and job match quality is also consistent across different models, suggesting that the correlation between major-related market size and job match outcomes decreases with larger population. All coefficients are statistically significant at the 1% level, except for the husband's major-related market size and its interaction with population in columns (4) and (6), which are significant at the 5% level, and the population in column (6), which is significant at the 10% level.

2.5.4 Household Fixed Effects Formulation

This paper then examining what is the correlation between the difference of major-related labor market size and the difference of job match quality between husband and wife, and an intersection term between the difference of major-related market size between husband and wife and population.

$$\begin{aligned} MATCH_{cm,husb.} &- MATCH_{cm,wife} \\ &= \beta_1(MajMktSize_{cm,husb.} - MajMktSize_{cm,wife}) \\ &+ \beta_2 Pop_c \\ &+ \beta_3(MajMktSize_{cm,husb.} - MajMktSize_{cm,wife}) \times Pop_c \\ &+ \beta_4 I_i + \gamma_c + \theta_m + \epsilon_i, \end{aligned} \tag{2.4}$$

Table 2.12 shows the relationship between the difference in major-related market size for husbands and wives and the likelihood of husbands having a better degree match or major match.

In columns (1) to (4), the dependent variable is whether the husband has a better degree match. The coefficient for the difference in major-related market size between the husband and wife is positive and statistically significant at the 1% level in columns (3) and (4). This suggests that a one million increase in the difference between the husband's and wife's major-related market size is associated with a four (in both column 3 and 4) percentage point increase in the likelihood of the husband having a better degree match, with or without controlling for the population.

In columns (5) to (8), the dependent variable is whether the husband has a better major match. The coefficient for the difference in major-related market size between the husband and wife is positive and statistically significant at the 1% level in all columns. This indicates that a one million increase increase in the difference between the husband's and wife's major-related market size is associated with a 3.1 (in columns 5 and 6) and 12.3 (in columns 7 and 8) percentage point increase in the likelihood of the husband having a better major match, with or without controlling for the population.

The population variable is significant at the 5% level in columns (2) and (3), suggesting that a one million increase in the population is associated with a 0.8 percentage point increase in the likelihood of the husband having a better degree match.

The interaction term between the difference in major-related market size and population is negative and statistically significant at the 1% level in columns (3), (4), (7), and (8). This indicates that the positive effect of the difference in major-related market size on the likelihood of the husband having a better degree or major match decreases as the population increases.

2.6 Conclusion

This paper investigates the relationship between labor market size and job match quality for power couples, contributing to the empirical study of career benefits of large cities for married couples. Utilizing data relating majors to occupations, this paper uses a major-related labor market size for college-educated workers based on their degree fields and residences. Following the methodology of previous research, this paper defines the job match quality for college graduates as whether or not they work in a job that requires their educational degree and whether or not they work in a job that fits the field of their educational degree.

Results suggest that both the husband and wife in power couples are more likely to work in occupations that match their educational level and acquired abilities in larger major-related labor markets. While the correlation between population and job match outcomes for power couples is inconsistent across different models, the results indicate that an increase in the absolute difference of major-related market size between the husband and wife is positively associated with the likelihood of the husband having a better degree and major match. Moreover, the interaction terms between the absolute difference in major-related market size and population suggest that the effect of major-related market size on the educational outcomes is moderated by the population of the city. Results are consistent with individual level results, indicating that the correlation between major-related market size and job match outcomes is positive and significant.

These findings contribute to the existing literature on educational and labor market outcomes for couples by providing direct evidence supporting the notion that college-educated women experience greater career success by living in larger urban areas, highlighting the importance of considering both individual characteristics and the local labor market context when analyzing the determinants of better educational matches. Furthermore, our study underscores the need to account for narrow city-level factors such as major-related market size, which can influence the educational outcomes.

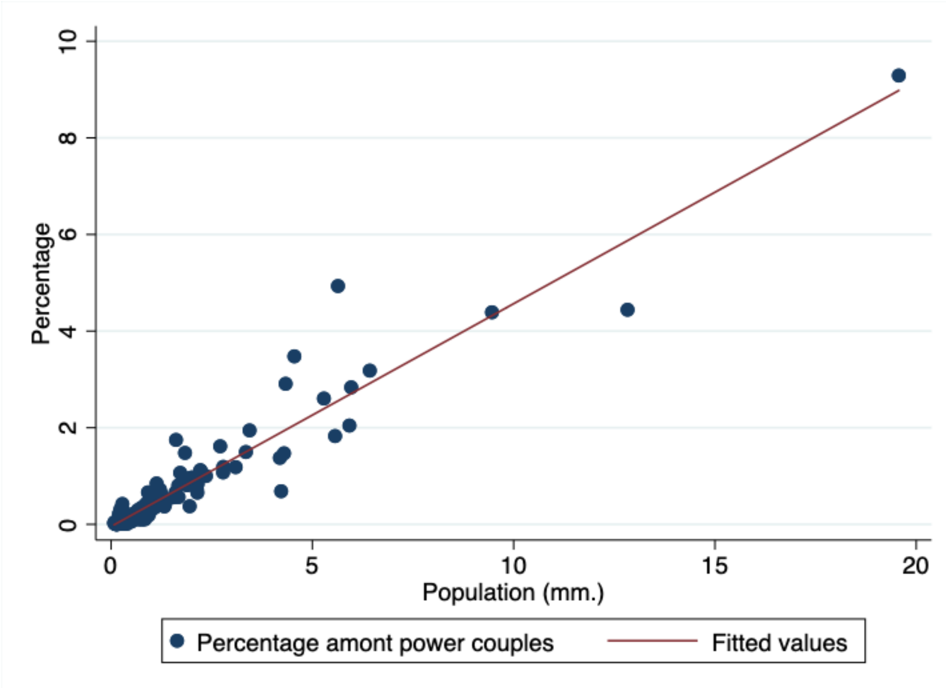


Figure 2.1: Where Do Power Couples Locate

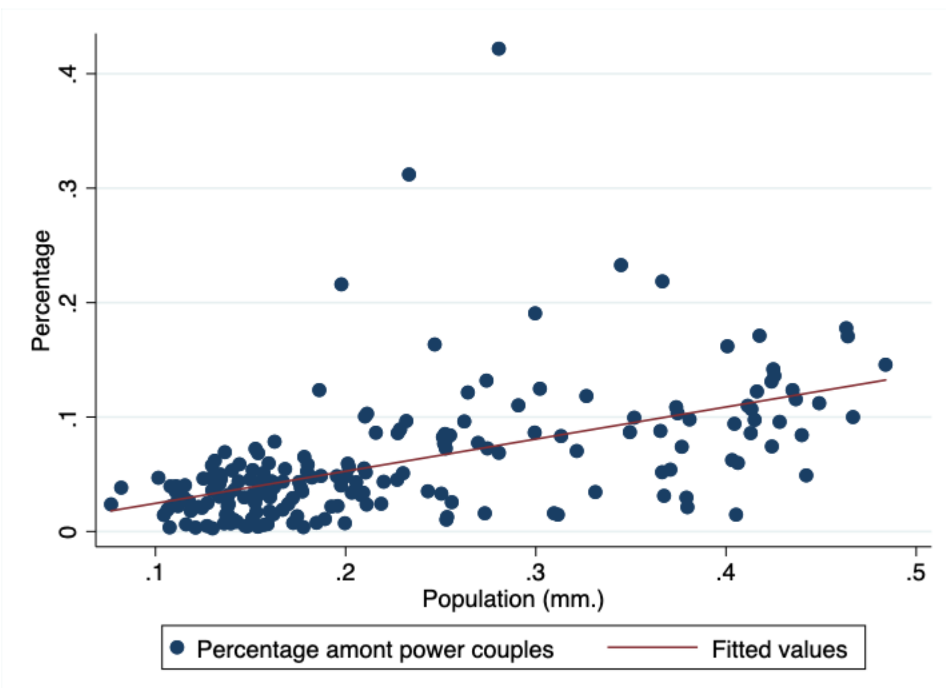


Figure 2.2: Where Do Power Couples Locate Among Medium to Small Cities

Table 2.1 Broad Degree of Field Composition

Rank	Broad Degree Fields (Husband's Primary Field)	Broad Degree Fields (Wife's Primary Field)	Percentage
1	business	business	6.8729
2	business	education administration and teaching	3.5742
3	business	medical and health sciences and services	2.9091
4	engineering	business	2.6579
5	engineering	engineering	2.1607
6	education administration and teaching	education administration and teaching	2.0376
7	engineering	medical and health sciences and services	1.8387
8	engineering	education administration and teaching	1.5138
9	social sciences	business	1.4090
10	business	psychology	1.4086
11	business	social sciences	1.3784
12	business	communications	1.3718
13	social sciences	social sciences	1.2675
14	biology and life sciences	biology and life sciences	1.2127
15	medical and health sciences and services	medical and health sciences and services	1.2012
16	computer and information sciences	business	1.1345
17	social sciences	education administration and teaching	0.9946
18	engineering	biology and life sciences	0.9334
19	business	biology and life sciences	0.8779
20	engineering	social sciences	0.8227
⋮	⋮	⋮	⋮
1163	communication technologies	library science	0.0001
1164	public affairs, policy, and social work	engineering technologies	0.0001
1165	electrical and mechanic repairs and technologies	library science	0.0001
1166	architecture	cosmetology services and culinary arts	0.0001
1167	interdisciplinary and multi-disciplinary studies (general)	engineering technologies	0.0001
1168	philosophy and religious studies	cosmetology services and culinary arts	0.0001
1169	nuclear, industrial radiology, and biological technologies	construction services	0.0001
1170	law	philosophy and religious studies	0.0001
1171	law	criminal justice and fire protection	0.0001
1172	law	theology and religious vocations	0.0001
1173	library science	linguistics and foreign languages	0.0001
1174	library science	family and consumer sciences	0.0001
1175	electrical and mechanic repairs and technologies	agriculture	0.0001
1176	theology and religious vocations	engineering technologies	0.0001
1177	communication technologies	law	0.0001
1178	electrical and mechanic repairs and technologies	architecture	0.0001
1179	interdisciplinary and multi-disciplinary studies (general)	nuclear, industrial radiology, and biological technologies	0.0001
1180	public affairs, policy, and social work	transportation sciences and technologies	0.0001
1181	area, ethnic, and civilization studies	cosmetology services and culinary arts	0.0000
1182	philosophy and religious studies	communication technologies	0.0000

Note: The percentage is weighted.

Table 2.2 Degree Match Rate Crosstab

Husb. has Degree Match	Wife has Degree Match								
	0			**1**			**Total**		
	No.	Col %	Cum %	No.	Col %	Cum %	No.	Col %	Cum %
0	37,753	27.7	32.3	98,309	72.3	21.4	136,062	100.0	23.6
1	79,268	18.0	67.7	361,592	82.0	78.6	440,860	100.0	76.4
Total	117,021	20.3	100.0	459,901	79.7	100.0	576,922	100.0	100.0

Table 2.3 Major Match Rate Crosstab

Husb. has Major Match	Wife has Major Match								
	0			**1**			**Total**		
	No.	Col %	Cum %	No.	Col %	Cum %	No.	Col %	Cum %
0	338,886	76.9	78.8	101,670	23.1	69.2	440,556	100.0	76.4
1	91,094	66.8	21.2	45,272	33.2	30.8	136,366	100.0	23.6
Total	429,980	74.5	100.0	146,942	25.5	100.0	576,922	100.0	100.0

Table 2.4 Both Match Rate Crosstab

Degree match(both)	Major match(both)								
	0			**1**			**Total**		
	No.	Col %	Cum %	No.	Col %	Cum %	No.	Col %	Cum %
0	208,877	97.0	39.3	6,453	3.0	14.3	215,330	100.0	37.3
1	322,773	89.3	60.7	38,819	10.7	85.7	361,592	100.0	62.7
Total	531,650	92.2	100.0	45,272	7.8	100.0	576,922	100.0	100.0

Table 2.5 Summary statistics

	Mean	SD	Min	Max
Dependent Var.				
Husb. has Major Match	0.24	0.42	0	1
Wife has Major Match	0.25	0.44	0	1
Both have Major Match	0.08	0.27	0	1
Husb. has Degree Match	0.76	0.42	0	1
Wife has Degree Match	0.80	0.40	0	1
Both have Degree Match	0.63	0.48	0	1
Agglomeration				
Population (mm.)	5.02	5.56	0	20
Husband's MajMktSize (mm.)	0.12	0.28	0	5
Wife's MajMktSize (mm.)	0.11	0.24	0	6
Demographic				
Husband's Age	44.28	10.11	21	64
Wife's Age	42.54	9.90	21	64
Both White	0.77	0.42	0	1
Both Black	0.04	0.19	0	1
Same Broad Degree Field	0.19	0.39	0	1
Same Detailed Degree Field	0.10	0.30	0	1
Having Children in household	0.65	0.48	0	1
Husband has a graduate degree	0.44	0.50	0	1
Wife has a graduate degree	0.48	0.50	0	1

Table 2.6 Baseline Model - Degree Match

	Individual Level			Household Level					
				Husb.			Wife		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
MajMktSize (mm.)	0.0153**		0.0153**	0.0120*		0.0120*	−0.0001		−0.0001
	(0.0067)		(0.0067)	(0.0063)		(0.0063)	(0.0074)		(0.0074)
Population (mm.)		0.0100***	0.0100***		0.0200***	0.0200***		0.0071***	0.0071***
		(0.0018)	(0.0018)		(0.0040)	(0.0040)		(0.0024)	(0.0024)
N	3579077	3579077	3579077	574243	574243	574243	574242	574242	574242
R^2	0.061	0.061	0.061	0.062	0.063	0.063	0.062	0.062	0.062
City FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coeficients of major-related market size on husband and wife represent major-related market size for husband and wife seperately.

Table 2.7 Baseline Model - Major Match

	Individual Level			Household Level					
				Husb.			Wife		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
MajMktSize (mm.)	0.0133***		0.0133***	0.0387***		0.0387***	0.0287***		0.0287***
	(0.0042)		(0.0042)	(0.0103)		(0.0103)	(0.0093)		(0.0093)
Population (mm.)		−0.0032***	−0.0032***		−0.0038**	−0.0038**		−0.0048*	−0.0048*
		(0.0009)	(0.0009)		(0.0018)	(0.0018)		(0.0025)	(0.0025))
N	2195255	2195255	2195255	574243	574243	574243	574242	574242	574242
R^2	0.206	0.206	0.206	0.161	0.160	0.161	0.273	0.273	0.273
City FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coeficients of major-related market size on husband and wife represent major-related market size for husband and wife seperately.

Table 2.8 Interaction Model

	Individual Level		Household Level			
			Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)	(5)	(6)
MajMktSize (mm.)	0.0642***	0.0487***	0.0552***	0.1353***	0.0508***	0.1074***
	(0.0070)	(0.0071)	(0.0108)	(0.0246)	(0.0099)	(0.0206)
Population (mm.)	0.0101***	−0.0032***	0.0164***	−0.0032*	0.0073***	−0.0044*
	(0.0018)	(0.0009)	(0.0035)	(0.0019)	(0.0024)	(0.0025)
MajMktSize × Population	−0.0036***	−0.0026***	−0.0028***	−0.0063***	−0.0033***	−0.0051***
	(0.0004)	(0.0004)	(0.0005)	(0.0006)	(0.0005)	(0.0012)
N	3579077	2195255	574243	574243	574242	574242
R^2	0.061	0.206	0.059	0.161	0.052	0.273
City FE	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.9 Interaction Model - Compare with different genders

	Individual Level				Household Level			
	Male		Female		Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MajMktSize (mm.)	0.0694***	0.0539***	0.0509***	0.0389***	0.0552***	0.1353***	0.0508***	0.1074***
	(0.0076)	(0.0116)	(0.0082)	(0.0072)	(0.0108)	(0.0246)	(0.0099)	(0.0206)
Population (mm.)	0.0149***	−0.0003	0.0057***	−0.0057***	0.0164***	−0.0032*	0.0073***	−0.0044*
	(0.0026)	(0.0014)	(0.0018)	(0.0010)	(0.0035)	(0.0019)	(0.0024)	(0.0025)
MajMktSize × Population	−0.0034***	−0.0024***	−0.0036***	−0.0028***	−0.0028***	−0.0063***	−0.0033***	−0.0051***
	(0.0005)	(0.0006)	(0.0005)	(0.0004)	(0.0005)	(0.0006)	(0.0005)	(0.0012)
N	1784383	1108218	1794693	1087036	574243	574243	574242	574242
R^2	0.064	0.167	0.060	0.257	0.059	0.161	0.052	0.273
City FE	✓	✓	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.10 Interaction Model - Conditional on Spouse's Job Match Quality

	Husb.'s Quality Conditional on Wife's		Wife's Quality Conditional on Husb.'s	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.0529***	0.1304***	0.0515***	0.1372***
	(0.0103)	(0.0318)	(0.0093)	(0.0254)
Population (mm.)	0.0185***	−0.0000	0.0081***	−0.0070*
	(0.0035)	(0.0027)	(0.0026)	(0.0042)
MajMktSize × Population	−0.0028***	−0.0055***	−0.0032***	−0.0062***
	(0.0006)	(0.0017)	(0.0005)	(0.0014)
N	506261	146210	502325	135690
R^2	0.061	0.183	0.049	0.291
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.11 Interaction Model - Joint Results

	Both Have a Degree Match			Both Have a Major Match		
	(1)	(2)	(3)	(4)	(5)	(6)
Population (mm.)	0.0163***	0.0196***	0.0169***	−0.0055***	−0.0037***	−0.0025**
	(0.0035)	(0.0038)	(0.0036)	(0.0011)	(0.0012)	(0.0011)
MajMktSize (mm.)(Husb.)	0.0462***		0.0457***	0.0245**		0.0227**
	(0.0086)		(0.0083)	(0.0096)		(0.0089)
MajMktSize (mm.)(Wife)		0.0681***	0.0599***		0.0339***	0.0309***
		(0.0100)	(0.0094)		(0.0094)	(0.0087)
MajMktSize × Population (Husb.)	−0.0026***		−0.0025***	−0.0010**		−0.0009**
	(0.0005)		(0.0005)	(0.0005)		(0.0004)
MajMktSize × Population (Wife)		−0.0040***	−0.0036***		−0.0018***	−0.0017***
		(0.0005)	(0.0005)		(0.0005)	(0.0005)
N	574243	574242	574241	574243	574242	574241
R^2	0.043	0.034	0.062	0.059	0.071	0.112
City FE	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.12 Household FE Model

	Husb. Has a Better Degree Match				Husb. Has a Better Major Match			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$MajMktSize_{Husb.} - MajMktSize_{Wife}$	0.0053	0.0053	0.0400***	0.0399***	0.0310***	0.0310***	0.1225***	0.1225***
	(0.0053)	(0.0053)	(0.0108)	(0.0108)	(0.0089)	(0.0089)	(0.0176)	(0.0176)
Population (mm.)		0.0079**	0.0079**			0.0004	0.0005	
		(0.0035)	(0.0035)			(0.0033)	(0.0033)	
$(MajMktSize_{Husb.} - MajMktSize_{Wife}) \times Pop.$			−0.0019***	−0.0019***			−0.0049***	−0.0049***
			(0.0005)	(0.0005)			(0.0008)	(0.0008)
N	574241	574241	574241	574241	574241	574241	574241	574241
R^2	0.047	0.047	0.047	0.047	0.204	0.204	0.204	0.204
City FE	✓	✓	✓	✓	✓	✓	✓	✓
Major FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendices

Appendix A Helsley and Strange (1990)

This appendix contains technical derivations of expected employment per firm and the expected distance between workers and firms.

$|x-y|$ is a random variable representing the distance between the skills of a worker and the job requirement of the firm at x. For $0 < d < (1/2)$, there are two values of y on the unit circle satisfying $|x-y| = d$. Recalling that y is uniformly distributed on the unit circle, this implies that the probability density of $|x-y|$ is given by

$$f(d) \equiv Pr\{|x-y| = d\} = 2, \quad 0 < d < \frac{1}{2}. \tag{A.1}$$

The probability that a worker's skill lies in the firm's market area is

$$Pr\{|x-y| < \frac{1}{2m}\} = 2\int_0^{\frac{1}{2m}} d\mu = \frac{1}{m}. \tag{A.2}$$

To an individual firm, the event of employing a particular worker is a Bernoulli random variable: the worker is either in the firm's market area (the successful outcome) or not (the unsuccessful outcome). From (A.2), the probability of success, in this case, employment, equals the length of the firm's market area, $1/m$. This implies that the number of workers in the firm's market area (the number of successes), $\Omega(x)$, is a binomial random variable with parameters n and $1/m$, and that expected employment equals

$$E[\Omega] = \frac{n}{m}. \tag{A.3}$$

For $0 < d < (1/2)$, the probability of $|x-y| = d$ conditioned on $y \in (x - \frac{1}{2m}, x + \frac{1}{2m})$ is

$$Pr\{|x-y| = d : y \in (x - \frac{1}{2m}, x + \frac{1}{2m})\} = \frac{Pr\{|x-y| = d : y \in (x - \frac{1}{2m}, x + \frac{1}{2m})}{Pr\{y \in (x - \frac{1}{2m}, x + \frac{1}{2m})\}}. \tag{A.4}$$

Since y is uniformly distributed on the unit circle, the numerator on the right of (A.4) equals 2 for $d < 1/(2m)$ and zero otherwise. The denominator on the right of (A.4) equals $1/m$ from (A.2). Hence, the conditional probability density of $|x - y|$ given that $y \in (x - \frac{1}{2m}, x + \frac{1}{2m})$ equals

$$g(|x-y| : y \in (x - \frac{1}{2m}, x + \frac{1}{2m})) = \begin{cases} 2m & d < \frac{1}{2m}) \\ 0 & \text{otherwise} \end{cases} \tag{A.5}$$

Finally, from (A.5), the expected value of $|x-y|$ conditional on $y \in (x - \frac{1}{2m}, x + \frac{1}{2m})$ is

$$E[|x-y| : y \in (x - \frac{1}{2m}, x + \frac{1}{2m})] = 2m \int_0^{\frac{1}{2m}} \sigma d\sigma = \frac{1}{4m}. \tag{A.6}$$

Then the model predicts that the expected quality of the match between job requirements and skills improves as the number of firms increases. In this model, there is no friction in a market, and matches are chosen. Thus, the growth of a city always improves match quality.

However, in reality, there is friction in workers' job search processes and workers cannot necessarily find their most suitable jobs. Then the theoretical analysis by Sato (2001) is particularly instrumental because it suggests that the relationship between job match quality and city size may not be as clear-cut as it appears when friction exists.

Following the basic set ups of Helsley and Strange (1990), Sato (2001) relaxes the assumption of non-random match. Now workers must expend time and energy to find acceptable jobs. Job contacts in a market with u unemployed workers and v vacancies are generated by a Poisson process with an aggregate rate of $\theta(u, v)$, $\theta_u > 0, \theta_v > 0$, whose function is homogeneous of degree λ. Thus, the matching function can exhibit decreasing, constant, or increasing returns to scale.

Workers' skills and firms' technologies are still indexed on a circle, but now the length of the circumference by defined equals to $2K(K > 0)$. Therefore, K represents the size of the *skill space* for workers and firms. When a new technology is invented, it requires a new skill. This extends the skill space to increase K, which implies that workers and firms are more heterogeneous. Workers and firms know the distribution of technologies and skills *ex-ante*. Imperfect match is inevitable, but not all mismatches are alike. The per capita output is assumed to be the same as equation (2.2).

With the exogenous aggregate rate of job separation, exogenous discount rate, and exogenous unemployment insurance, his model first predicts that when the technology of the search exhibits increasing returns to scale, a simultaneous increase in the number of unemployed workers and firms with vacancies raises the contact rate for each unemployed worker and for each firm with a vacancy. This causes workers to be more selective and lowers the reservation skill-technology difference. However, when friction exists and matches are random, agglomeration economies do not always emerge. The model also predicts that with the number of workers constant, workers and firms become more heterogeneous when more skills are made available to workers and firms. It then becomes more difficult for a worker with a particular skill to find a firm with a skill requirement matching their skills. Larger cities certainly have more workers, but they also seem likely to have a wide choice of skills and technologies. Thus, Sato (2001) provides micro-foundation testing as to match quality is dampened in markets with larger skill spaces.

Appendix B Match rate for detailed degree of fields and Abel and Deitz (2015)'s measures of matching quality

This appendix first present the full match rate results for 173 detailed degree fields that are recroded in the ACS and then discussing how Abel and Deitz (2015) construct their measures of degree match and major match in order to compare the match rate results. The full match rate results for 173 detailed degree fields are listed below.

Table B.1 Match Rate For Detailed Degree Fields

Detailed Degree Fields	Major Match Rate	Degree Match Rate
General Education	60.89	75.3
Mathematics Teacher Education	60.41	84.63
Elementary Education	58.85	79.7
Teacher Education: Multiple Levels	58.53	79.93
Pharmacy, Pharmaceutical Sciences, And Administration	56.55	82.22
Treatment Therapy Professions	55.4	79.11
Medical Assisting Services	54.88	34.76
Language And Drama Education	54.68	79.52
Art And Music Education	53.32	78.17
Accounting	51.55	74.62
Science And Computer Teacher Education	51.39	79.48
General Business	50.51	54.64
Communication Disorders Sciences And Services	48.93	83.53
Cosmetology Services And Culinary Arts	48.11	16.86
Miscellaneous Business And Medical Administration	47.53	52.22
Secondary Teacher Education	45.63	76.22
Actuarial Science	44.38	80.73
Health And Medical Preparatory Programs	43.69	80.18
Social Science Or History Teacher Education	43.58	74.47
Computer Science	43.35	79.45

Continued on next page

Table B.1 – continued from previous page

Detailed Degree Fields	Major Match Rate	Degree Match Rate
Civil Engineering	40.5	74.13
Miscellaneous Health Medical Professions	39.76	69.17
General Medical And Health Services	37.88	61.74
Computer Programming And Data Processing	37.78	69.37
Miscellaneous Education	37.34	67.07
Computer And Information Systems	37.26	70.49
Finance	37.04	68.84
Environmental Engineering	36.26	79.26
Physical And Health Education Teaching	36.05	64.69
Transportation Sciences And Technologies	35.47	57.22
Pre-Law And Legal Studies	35.03	46.81
Educational Administration And Supervision	34.05	86.23
Medical Technologies Technicians	33.48	51.17
Commercial Art And Graphic Design	33.45	64.58
Library Science	32.62	73.82
Information Sciences	32.55	73.45
Petroleum Engineering	32.31	75.81
Operations, Logistics And E-Commerce	32.23	49.82
Theology And Religious Vocations	31.8	62.98
General Engineering	31.26	70.14
Geological And Geophysical Engineering	29.78	77.96
Computer Engineering	29.77	83.76
Computer Information Management And Security	29.03	64.78
Human Resources And Personnel Management	28.47	63.77
Architectural Engineering	28.3	70.67
Nuclear Engineering	27.8	78.25
Marketing And Marketing Research	27.38	53.31
Nutrition Sciences	27.15	67.48
Atmospheric Sciences And Meteorology	25.9	74.48
Aerospace Engineering	24.54	82.51
Plant Science And Agronomy	24.26	47.57

Continued on next page

Table B.1 – continued from previous page

Detailed Degree Fields	Major Match Rate	Degree Match Rate
Geosciences	24.02	76.5
Special Needs Education	23.88	84.55
Miscellaneous Engineering	23.84	62.58
Geology And Earth Science	23.73	71.51
Film, Video And Photographic Arts	22.1	53.48
Fine Arts	21.79	57.46
Mathematics	21.62	78.11
Statistics And Decision Science	21.55	76.62
Soil Science	20.47	62.61
Hospitality Management	20.2	37.03
Miscellaneous Biology	20.2	70.78
Astronomy And Astrophysics	19.97	81.34
Chemistry	18.91	77.16
Business Management And Administration	18.83	55
Electrical Engineering	18.77	79.81
Clinical Psychology	18.75	74.98
Industrial And Manufacturing Engineering	18.64	69.56
General Agriculture	18.54	46.43
Physics	18.24	82.72
Journalism	18.12	68.04
Family And Consumer Sciences	17.81	59.73
Health And Medical Administrative Services	17.65	56.6
Molecular Biology	16.75	81.26
Applied Mathematics	16.53	82.36
Early Childhood Education	15.91	67.29
Engineering Mechanics, Physics, And Science	15.68	76.59
Mass Media	15.52	59.44
Music	15.37	63.47
Miscellaneous Engineering Technologies	15.28	58.93
Drama And Theater Arts	14.69	53.58
Chemical Engineering	14.53	77.97

Continued on next page

Table B.1 – continued from previous page

Detailed Degree Fields	Major Match Rate	Degree Match Rate
Botany	14.37	66.9
Ecology	14.32	62.57
Genetics	14.31	81.91
Computer Networking And Telecommunications	14.06	59.47
French, German, Latin And Other Common Foreign Language Studies	13.92	68.98
Engineering Technologies	13.84	60.38
Social Work	13.78	74.75
Biochemical Sciences	13.69	79.94
Community And Public Health	13.37	62.45
Architecture	13.36	70.54
Linguistics And Comparative Language And Literature	12.85	63.69
Forestry	12.8	55.48
Management Information Systems And Statistics	12.8	72.34
Miscellaneous Agriculture	12.15	66.63
Mining And Mineral Engineering	12.05	62.98
Biology	11.91	74.16
Food Science	11.89	61.24
Physical Sciences	11.76	64.8
School Student Counseling	11.31	81.59
Communication Technologies	11.13	54.97
Animal Sciences	11.12	57.63
Studio Arts	11.06	56.4
International Business	10.8	57.21
Criminal Justice And Fire Protection	10.7	41.15
Mechanical Engineering	10.6	78
Natural Resources Management	10.55	57.95
English Language And Literature	10.5	68.28
Oceanography	10.5	65.71
Agriculture Production And Management	10.49	43.34
Visual And Performing Arts	10.45	57.56
Art History And Criticism	10.31	62.91

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Table B.1 – continued from previous page

Detailed Degree Fields	Major Match Rate	Degree Match Rate
Microbiology	10.3	74.5
Human Services And Community Organization	9.76	60.44
Geography	9.71	62.54
Anthropology And Archeology	9.42	64.27
Construction Services	9.17	34.21
Miscellaneous Social Sciences	8.82	67.38
History	8.78	65.77
Philosophy And Religious Studies	8.76	69.33
Advertising And Public Relations	8.56	61.77
Materials Engineering And Materials Science	8.45	76.11
Other Foreign Languages	8.43	63.24
Zoology	8.36	75.66
Naval Architecture And Marine Engineering	7.96	65.21
Biological Engineering	7.96	68.67
Public Policy	7.77	72.93
Business Economics	7.41	65.72
Psychology	7.33	66.77
Biomedical Engineering	7.29	80.38
Composition And Speech	7.19	61.62
Engineering And Industrial Management	7.08	60.77
General Social Sciences	6.88	60.49
Humanities	6.77	60.28
Miscellaneous Psychology	6.77	66.5
Economics	6.76	68.52
Physiology	6.7	72.65
Communications	6.67	58.89
Metallurgical Engineering	6.48	74.16
Agricultural Economics	6.47	57.94
United States History	6.23	64.71
Area, Ethnic, And Civilization Studies	6.09	68.28
Mechanical Engineering Related Technologies	5.87	60.69

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Table B.1 – continued from previous page

Detailed Degree Fields	Major Match Rate	Degree Match Rate
Physical Fitness, Parks, Recreation, And Leisure	5.86	54.07
Pharmacology	5.41	81.51
Cognitive Science And Biopsychology	5.31	80.05
Electrical And Mechanic Repairs And Technologies	5.13	26.75
Environmental Science	4.89	63.11
Interdisciplinary And Multi-Disciplinary Studies (General)	4.84	66.67
Electrical Engineering Technology	4.77	66.34
Intercultural And International Studies	4.51	64.4
International Relations	4.36	70.5
Sociology	4.09	60.77
Public Administration	4.03	58.44
Industrial Production Technologies	3.69	55.53
Political Science And Government	3.64	68.17
Mathematics And Computer Science	3.4	83.66
Miscellaneous Fine Arts	3.1	52.59
Educational Psychology	2.82	79.4
Interdisciplinary Social Sciences	2.5	62.24
Neuroscience	2.22	77.59
Liberal Arts	1.92	57.37
Criminology	1.73	46.77
Nuclear, Industrial Radiology, And Biological Technologies	1.63	38.02
Multi-Disciplinary Or General Science	1.29	62.78
Materials Science	1.07	83.78
Social Psychology	.91	64.49
Industrial And Organizational Psychology	.85	64.04
Counseling Psychology	.64	76.17
Nursing	.44	88.69
Court Reporting	.37	36.69
Total, all majors	22.56	68.89

Degree Match

Abel and Deitz (2015) using data from the U.S. Department of Labor's Occupational Information Network (O*NET) to define whether an occupation in the 2010 American Community Survey (ACS) requires a college degree.

The O*NET system contains occupation-level data for hundreds of detailed occupations collected via interviews of incumbent workers and input from professional occupational analysts. They use the following question from the O*NET Education and Training Questionnaire to determine whether an occupation requires a college degree: "If someone were being hired to perform this job, indicate that level of education that would be *required*?"

Respondents can then select from the following twelve education levels: "Less than a High School Diploma, High School Diploma, Post-Secondary Certificate, Some College Courses, Associate's Degree, Bachelor's Degree, Post-Baccalaureate Certificate, Master's Degree, Post-Master's Certificate, First Professional Degree, Doctoral Degree, and Post-Doctoral Training." They would consider a college education a requirement for a given occupation if more than 50% of the respondents working in that occupation indicated that at least a Bachelor's degree was *required* to perform the job. [3]

O*NET and ACS report the person's primary occupation according to the Standard Occupational Classification (SOC). Abel and Deitz (2015) then verifying whether an occupation in ACS *requires* a college education using O*NET schemes. Individuals have a *Degree Match* if they work in an occupation that *requires* a college degree. Unemployed workers, by definition, are a non-match.

Major Match

Abel and Deitz (2015) measure the relevance of the occupations for majors in the 2010 ACS using a crosswalk between them combined with two other crosswalks. First, they construct a crosswalk linking majors listed in the 2010 ACS to majors in the Classification

[3] They performed a sensitivity analysis using 40% and 60% thresholds. Their paper's main job matching results are not sensitive to their choice of thresholds.

of Instructional Programs (CIP). They combine it with a crosswalk provided by the Department of Education's National Center for Education Statistics (NCES), linking majors listed in the CIP to occupations in the SOC. Individuals whose major and occupation match one of the combinations in the crosswalk are defined as a *major match*. Notice that the ACS allows individuals to report up to two detailed majors when completing the survey. Abel and Deitz (2015) allow individuals to match if either of their listed majors corresponds to their occupation. Table B.1 presents original Table 1 in Abel and Deitz (2015), which lists the match rate for selected majors.

Table B.2 Abel and Deitz (2015) Job Match Rate For Selected Majors (%)

College Major	Degree Match	Major Match
Architecture	64.6	42.0
Journalism	57.0	20.5
Computer Science	72.8	32.7
Elementary Education	77.1	52.9
Computer Engineering	80.1	34.1
Mechanical Engineering	72.9	18.3
Liberal Arts	51.1	1.3
Mathematics	72.3	5.8
Philosophy and Religious Studies	63.5	5.2
Chemistry	74.0	18.6
Studio Arts	44.4	20.4
Accounting	68.3	53.3
Business Management	48.7	39.1
Finance	60.6	38.0
History	59.8	2.7
Total, all majors	62.1	27.3

Appendix C Correlation between major-related market size and job match outcomes controlling for selective migration types

This appendix presents the results of an investigation into the correlation between the size of major-related labor markets and job match outcomes for power couples, based on different migration types. To identify movers, I used data from the American Community Surveys, looking for individuals who no longer reside in the same house and who now live in a different metropolitan area compared to one year ago. I further classified couples according to several migration types: (1) when the wife joined the husband, (2) when the husband joined the wife, (3) when both husband and wife moved together from one metropolitan area to another, and (4) when both husband and wife moved together from a rural area to an urban area. Note that I did not consider the migration type in which both husband and wife moved together from an urban area to a rural area, as my key variable, major-related labor market size, is only available for identifiable metropolitan areas. Thus, I was unable to investigate the correlation between major-related market size and job match outcomes for individuals located in non-identifiable metropolitan areas.

I then analyzed the correlation between major-related market size and job match outcomes, conditional on different migration types, which are described below:

$$Prob(Degree/MajorMatch)_{husb./wife} = F(MajMktSize_{husb./wife}|MigrationType_i),$$

where i represents different migration types as I described above.

Among all 576,922 power couples, 99.5% currently live in big cities, and almost 89% of them did not move from one year ago. Thus, I first examined the correlation between major-related market size and job match outcomes for power couples who stayed in the same place as the previous year. The results in Table C.1 suggest that for power couples who stayed in the same place, a larger major-related market size leads to a higher probability of having a degree or major match for both the husband and wife, while a larger population leads to a higher probability of having a degree match for both the husband and wife and a lower probability of the wife having a major match. However, the results show no significant effect on the probability of the husband having a major match. In addition, the effect of major-related market size decreases with an increase in population. The results in Table C.1 are consistent with individual results and general power couples' results.

I then investigated the power couples where at least one of them had moved from one year ago. The results in Table C.2 suggest that major-related market size again leads to a higher probability of having a degree or major match for both the husband and wife. A larger population leads to a lower probability of having a major match for both the husband and wife but does not have a significant effect on having a degree match for both the husband and wife. The effect of major-related market size decreases as the population increases on the probability of having a degree match for both the husband and wife and on the probability of having a major match only for the wife. Compared to individual level results and general power couples' results, we can see a less significant effect of major-related market size on having a major match for the husband and wife if one of them has moved from one year ago.

I further investigated the movers by different types. Table C.3 and Table C.4 present the results for movers when the wife joined the husband and when the husband joined the wife, respectively. The major-related market size only shows a positive significant effect on the probability of having a degree match for the husband when the wife joined the husband. These results could suggest an endogenous issue when examining the effect of labor market size on job match outcomes. Further research needs to be done regarding these issues.

Lastly, I investigated the correlation between major-related market size and job match outcomes for power couples who moved between different metropolitan areas and those who moved from a non-identifiable metropolitan area to an identifiable metropolitan area. Table C.5 and Table C.6 present the results for these two types. The major-related market size shows a positive significant effect on the husband's job match outcomes when couples moved between different metropolitan areas, but only on the probability of the wife having a degree match when couples moved from a rural to an urban area. The results also show a positive effect on degree match but a negative effect on major match from population size when couples moved between urban areas. In addition, the effect of population only shows a significant effect on the probability of the wife having a major match when couples moved from a rural to an urban area.

Table C.1 Interaction Model - Both Stay

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.0522***	0.1256***	0.0533***	0.0736***
	(0.0105)	(0.0207)	(0.0109)	(0.0178)
Population (mm.)	0.0204***	0.0000	0.0097***	−0.0052***
	(0.0040)	(0.0016)	(0.0021)	(0.0015)
MajMktSize × Population	−0.0026***	−0.0059***	−0.0035***	−0.0038***
	(0.0006)	(0.0011)	(0.0006)	(0.0010)
N	658423	658423	747502	747502
R^2	0.063	0.157	0.063	0.288
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.2 Interaction Model - Movers

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.1065***	0.0954*	0.1040***	0.1084*
	(0.0386)	(0.0539)	(0.0392)	(0.0579)
Population (mm.)	0.0157	−0.0201***	0.0058	−0.0152***
	(0.0104)	(0.0064)	(0.0090)	(0.0055)
MajMktSize × Population (Husb.)	−0.0044*	−0.0054	−0.0076***	−0.0058*
	(0.0023)	(0.0035)	(0.0026)	(0.0035)
N	23801	23801	26442	26442
R^2	0.085	0.173	0.084	0.240
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.3 Interaction Model - When Wife Join

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.3383**	0.0084	−0.1339	0.1918
	(0.1520)	(0.1876)	(0.1714)	(0.2322)
Population (mm.)	0.0088	−0.0215	−0.0331	−0.0168
	(0.0228)	(0.0488)	(0.0311)	(0.0546)
MajMktSize × Population	−0.0112	0.0106	0.0035	−0.0130
	(0.0082)	(0.0112)	(0.0091)	(0.0145)
N	2031	2031	2229	2229
R^2	0.301	0.324	0.236	0.383
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.4 Interaction Model - When Husband Join

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.0901	−0.1726	0.1301	0.0504
	(0.1492)	(0.1568)	(0.1846)	(0.1775)
Population (mm.)	0.0153	0.0084	0.0213	0.0104
	(0.0289)	(0.0255)	(0.0268)	(0.0205)
MajMktSize × Population	0.0076	0.0257***	−0.0074	−0.0000
	(0.0088)	(0.0084)	(0.0105)	(0.0099)
N	1577	1577	1877	1877
R^2	0.289	0.324	0.272	0.414
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.5 Interaction Model - Move From Urban To Urban

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	0.1222**	0.1622***	0.0232	0.1115
	(0.0509)	(0.0618)	(0.0512)	(0.0704)
Population (mm.)	0.0109	−0.0415***	0.0184*	−0.0243*
	(0.0132)	(0.0118)	(0.0106)	(0.0146)
MajMktSize × Population	−0.0059*	−0.0125***	−0.0027	−0.0064
	(0.0030)	(0.0039)	(0.0032)	(0.0040)
N	12339	12339	13399	13399
R^2	0.096	0.188	0.094	0.241
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.6 Interaction Model - Move From Rural To Urban

	Husb.		Wife	
	Degree Match	Major Match	Degree Match	Major Match
	(1)	(2)	(3)	(4)
MajMktSize (mm.)	−0.0877	0.0185	0.2801***	0.0751
	(0.0732)	(0.1280)	(0.0822)	(0.1298)
Population (mm.)	0.0166	−0.0071	−0.0009	−0.0196***
	(0.0149)	(0.0053)	(0.0107)	(0.0046)
MajMktSize × Population	−0.0010	−0.0017	−0.0180***	−0.0044
	(0.0043)	(0.0070)	(0.0067)	(0.0085)
N	7005	7005	8072	8072
R^2	0.136	0.218	0.123	0.280
City FE	✓	✓	✓	✓
Major FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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