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DUAL-THIN MARRIAGE AND LABOR MARKETS: LOCATION CHOICES AND EMPLOYMENT OUTCOMES FOR PH.D. WORKERS

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ABSTRACT

This dissertation comprises two papers that examine the employment outcomes and location choices of Ph.D.-trained individuals that often face dual-thin marriage and labor markets. The first paper investigates the degree to which single Ph.D.-trained workers, both domestic and foreign-born, face trade-offs between marriage and labor market opportunities. When job markets are not geographically overlapping with marriage markets, single PhDs may be forced to choose between metropolitan areas (MSAs) that offer better employment opportunities versus better marriage markets. I find significant evidence of a "sorting" effect – the local marriage market is a location-specific consumer amenity for which highly trained foreign-born singles may sacrifice real wage in equilibrium to access a more active dating environment. The second paper uses differencing strategies to compare the location choices of foreign-born versus domestic-born Ph.D.-trained workers. Results suggest that single foreign-born Ph.D. workers are partly willing to forgo the greater labor market opportunities found in large MSAs in exchange for a more active dating scene. In contrast, findings on married foreign-born Ph.D. workers echo those from Costa and Kahn (2000) that highly educated couples are disproportionately drawn to large MSAs in order to solve their job market co-location challenge.

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Chapter 1

Dual-Thin Marriage and Labor Markets: Location Choices and Employment Outcomes for Ph.D. Workers

The theme of this dissertation is that spatial features of marriage markets and in particular their links to labor markets affect where highly educated households choose to live as well as their employment outcomes. Two papers, presented in chapters 2 and 3, use U.S. Census data for 1990, 2000 and 2010 to investigate the degree to which Ph.D.-trained workers, both domestic and foreign-born, face trade-offs between marriage and labor market opportunities. One treats the local marriage market as a location-specific consumer amenity, and looks at the degree to which single Ph.D. worker may sacrifice real wage in equilibrium to access a more active dating environment. The other uses differencing strategies to compare the location choices of foreign-born versus domestic-born Ph.D.-trained workers, and highlights the role of marriage markets and job co-location in driving their location decisions.

Single Ph.D. workers that have few marriage market opportunities in their active labor markets may be willing to work in a lower-wage metropolitan area (MSA) if that MSA provides access to a more active dating environment. The paper in Chapter 2 provides evidence of such a "sorting" effect for single, foreign-born, female PhDs, who has potential dating pools in a limited number of MSAs and are especially likely to face with dual thin markets. Locating in an MSA with 1,000 more own-ethnic college-above single men – the likely dating pool – reduces their wage of by roughly 2 percentage points. This effect is larger for young versus older women. No such effect arises for domestic Ph.D.-trained single women who have geographically expansive marriage markets. Trade-offs between marriage market opportunities and labor market outcomes appear to be smaller for single male PhDs.

The paper in Chapter 3 investigates the degree to which the local marriage market and job co-location pressure affect the location choices of foreign-born Ph.D. singles and couples differently compared to their US-born counterparts. A core modeling principle is that larger MSAs help to alleviate job market co-location problems for high-skilled couples while large local own-ethnic populations offer better dating opportunities for high-skilled singles. Single Chinese and Indian PhDs are disproportionately drawn to MSAs with large own-ethnic college-above populations even when such populations are not necessarily situated in large MSAs. Conversely, foreign-born Ph.D. couples are drawn to large MSAs regardless of the size of the local own-ethnic population. These and other patterns suggest that single foreign-born Ph.D. workers are partly willing to forgo the greater labor market opportunities found in large MSAs in exchange for a more active dating scene. Results on married foreign-born Ph.D. workers echo those from Costa and Kahn (2000) that highly educated couples are disproportionately drawn to large metropolitan areas in order to solve their job market co-location challenge.

Chapter 2

Marriage Versus Employment: The Impact of Dual-Thin Markets on Employment Outcomes for Single Ph.D. Workers

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1. Introduction

Single Ph.D. workers often have two priorities: to secure a job that is well matched to their training and to find a marriage partner. Ph.D. labor markets are also notoriously thin in the sense that there are a limited number of metropolitan areas (MSAs) in which individuals can obtain high-quality employment.[1] The same is often true for foreign-born[2] Ph.D. marriage markets. That is because foreign-born Ph.D. workers display a strong tendency to marry individuals with at least a college degree and within their own ethnicity (see Table 1, which will be discussed shortly). Moreover, among foreign-born Ph.D. workers, highly educated own-ethnic potential dates are generally not ubiquitous in the host country. For these reasons, when faced with dual thin labor and marriage markets, single, foreign-born Ph.D. workers are especially likely to face trade-offs between marriage and labor market opportunities. As a result, they may accept inferior labor market outcomes in exchange for improved marriage market opportunities. This paper explores evidence and implications of such trade-offs for foreign-born and domestic Ph.D. workers in the United States.

For several reasons, tradeoffs between labor and marriage market opportunities for highly skilled individuals could have important effects on the location and intensity of innovative activity in the U.S. In part this is because Ph.D.-trained workers, and especially those not born in the U.S., account for a significant share of new product innovation. According to the RIETI-Georgia Tech inventor survey, 46 percent of the inventors who file patents in the U.S. have a doctoral degree (Walsh and Nagaoka, 2009). Moreover, foreign-born Ph.D. workers are overrepresented in the STEM (Science, Technology, Engineering, and Mathematics) fields. In

[1] Appendix Table A5 documents the distribution of Ph.D. jobs by industry in 1990 and 2010.
[2] Domestic or US Born is defined as born in the U.S.A. or those born abroad with American Parent(s), and all the other are foreign born.

the 2010 American Community Survey (ACS), among the scientists and engineers with a Ph.D., nearly 55 percent are foreign born, and roughly 30 percent are born in China or India.[3]

It is also important to recognize that Ph.D. workers and especially those who are foreign born do indeed face thin marriage markets. One contributing reason is that Ph.D. workers disproportionately marry individuals with a college or higher level of education.[4] Besides, foreign-born Ph.D. workers marry primarily within their ethnicity. Table 1 provides evidence of these marriage patterns.[5] In Panel A Column (6), 71.5% of US-born male Ph.D. holders marry a US-born woman with at least a college education attainment. Similarly, among Chinese and Indian male PhDs, 80.6% and 72.4% marry an own-ethnic woman with at least a college education level, respectively. Moreover, foreign-born female PhDs display a further strong tendency to marry a Ph.D. of their ethnicity: roughly 30% marry a Ph.D. of own ethnicity compared to just 10% for their male counterparts.[6] It should also be noted that there are few MSAs in the U.S. with large numbers of single, foreign-born college-educated workers but many more MSAs with sizable numbers of domestic-born college-educated singles.[7] This distribution of potential dating pools suggests that single, foreign-born highly trained workers are likely to face much sharper trade-offs between marriage and labor market opportunities than their domestic-born counterparts.

[3] Since 1990, there is an exceptional growth of U.S. patents created by ethnic inventors. Notably, the share of patents created by Chinese and Indian inventors increased from 2% in 1990 to 9% and to 6% as of the year 2004, respectively (Kerr, 2010). During the 1990-2010 period, the female share of Ph.D. STEM workers rises from 24% in 1990 to 31% in 2000, and 40% in 2010.
[4] A college above education level (or col+) refers to having received at least 4-year college education attainment.
[5] The marriage patterns of PhDs in Census 1990 and ACS 2010 are very similar to the Census 2000.
[6] These patterns are consistent with the literature on the trend towards positive assortative mating based on schooling (e.g. Greenwood et al., 2014 and 2016) and evidence of marriage within ethnicity (e.g. Angrist, 2002). To explain such marriage patterns, the literature on family formation has extended beyond the Becker's (1981) theory of a household-based firm, in which husband and wife specialize in the market and domestic spheres, respectively. In particular, recent works (e.g., Chiappori et al., 2009) focus on consumption complementarities and insurance as motivations for marriage. For more discussion on this topic, see Stevenson and Wolfers (2007).
[7] Appendix Table A4-1 and A4-2 document the number of MSAs that provide active dating opportunities for Ph.D. workers by ethnicity.

I consider two mechanisms when modeling the manner in which marriage and labor market outcomes are linked for Ph.D. workers in the United States. The primary mechanism is a sorting effect. Workers that have few marriage market opportunities in their active labor markets may be willing to work in a lower-wage MSA if that MSA provides access to a more active dating environment. Beyond that, a distraction effect may also exist. An active dating scene may cause singles to reduce their hours worked to free up time for dating. This effect could also contribute to lower productivity and wage and reduce an individual's annual earnings.

To investigate these issues, I consider several indicators of labor market outcomes, including an individual's hourly wage, hours worked per year and annual earnings. For each outcome measure, I estimate the manner and extent to which the quality of a local marriage market affects the labor market outcome for foreign-born Ph.D. workers and especially those that face dual thin labor and marriage markets in comparison to their US-born counterparts. All of the estimation is conducted using Census data from the Integrated Public-Use Microdata Series (IPUMS, Ruggles et al., 2010) for the survey years 1990, 2000 and 2010.

This paper is closely related to the literature on residential migration decision and quality of life. Previous studies have shown that households choose metropolitan locations in part by trading off employment opportunities for location-specific consumer amenities (e.g. Greenwood et al. 1991; Gabriel et al. 2003; Blomquist, 2006; Albouy, 2008; Chen and Rosenthal, 2008; Dahl and Sorenson, 2010). Moreover, particular attention has been paid to the colocation pressure that explains the educated power couples' increasing tendency to live in a large metropolitan area (e.g. Costa and Kahn, 2000). For singles, marriage market opportunities are an important location-specific amenity that affects their location choices, but there is very limited work

investigating this topic.[8] Gautier et al. (2010) develop a model that emphasizes the important role of cities as marriage markets for singles. Their framework abstracts away the labor market and focuses on location choices between the city and the suburb.[9] Stark (1988) emphasizes that labor markets and marriage markets interact in a manner that affects migration — migration that facilitates a match in one market will also influence the prospects available and the outcome obtained in the other market. This paper contributes to the literature by highlighting the premarital trade-offs between labor and marriage market opportunities for Ph.D.-trained singles, an influential group that has rarely been investigated by empirical works.

Given that the local marriage market is a location-specific consumer amenity, the key hypothesis I test is that single Ph.D. workers may select into metropolitan areas with lower real wage rates in exchange for being in a better marriage market, ceteris paribus. This follows previous papers in the Rosen-Roback tradition (e.g. Rosen, 1979; Roback, 1982; Greenwood et al. 1991; Gabriel et al. 2003; Blomquist, 2006; Albouy, 2008; Chen and Rosenthal, 2008). In all of the empirical models later in the paper, I measure the local marriage market (denoted as *M)* for a given person by counting potential dates in the MSA. More precisely, *M* is defined as the number of singles in an MSA of the opposite gender for the individual in question, within that person's ethnicity, and with a college or higher level of education.

I next extend my model to take explicit account of situations in which single Ph.D. workers operate in dual thin labor and marriage markets. To do this, I add a control variable that indicates whether a worker is faced with a dual thin market ("*2MktThin*"). In specifying the

[8] Compton and Pollak (2007) revisit the job market colocation effect put forward by Costa and Kahn (2000), and they argue that the rising concentration of highly educated couples in large cities has more to do with the greater opportunity for highly educated singles to meet in large urban centers.
[9] According to Gautier et al. (2010), singles are willing to pay a premium in terms of higher housing prices to locate in cities, the dense areas where they can meet more potential partners than in rural areas.

variable "*2MktThin*", an individual is coded as facing a dual thin market if (i) there are few MSAs with "active" local marriage markets based on values for *M* and (ii) there are few MSAs with "active" local labor markets. The precise manner in which "thick" and "thin", "active" and "inactive" are defined for these purposes is made clear later in the paper. Here it is sufficient to note that individuals facing dual thin markets earn lower wages than other comparable workers who do not operate in a dual-thin market setting.

Key findings in the paper are as follows. For single, foreign-born, female Ph.D. workers, locating in an MSA with 1,000 more single men of their own ethnicity and with college above education levels – the likely dating pool – reduces their equilibrium wage rates by roughly 2 percentage points. This effect grows to 7.2 percentage points when these women face dual thin markets and it is also larger for young women (age 25 to 44) than older women (age 45 to 65). No such effect arises for single, US-born Ph.D. women, who have geographically expansive marriage markets. Secondly, I find that the distraction effect that reduces hours worked, possibly to free up time for dating, is present in some models but less robust. A better local dating pool decreases work hours by a small magnitude for single female PhDs, both domestic and foreign-born. Thirdly, I find a significant effect on annual earnings for single, foreign-born female PhDs. Increasing the number of potential dates by 1,000 people in the MSA reduces their annual earnings by 2.4 percent, while it has no impact on their US-born counterparts.

I also find that the trade-offs between marriage market opportunities and labor market outcomes appear to be smaller for single male Ph.D. workers, particularly at the young age. This result suggests that Ph.D.-trained single men, in general, may be more likely to prioritize the labor market opportunities when choosing where to locate. Such gender disparity may reflect, to some extent, the social norms on gender roles and expectations within marriage. Another

contributing factor may be the thinner marriage markets faced by Ph.D. women because it is more common for a man to marry a less educated woman than the reverse situation (see Table 1).

The rest of the paper is organized as follows. Section 2 presents the theoretical framework and driving mechanisms. Section 3 describes data and sample. Section 4 introduces estimation equations, and Section 5 presents main results. Section 6 extends the estimating model to explore the trade-offs for those facing dual thin markets and Section 7 concludes.

2. Theoretical Framework and Main Mechanisms

This section analyzes the impact of tradeoffs between marriage and labor market opportunities on three labor market outcomes, including wage, hours worked per year and annual earnings. In all cases, the focus is on highly trained singles. As noted earlier, the primary mechanism, a sorting effect, is emphasized, and the secondary effect of distraction is also considered. Sorting occurs when Ph.D. workers may tradeoff job opportunities to live in a lower-wage MSA in exchange for being in a more active dating environment. A distraction effect occurs when an active dating scene causes a single Ph.D. worker to reduce hours worked to free up time for dating. Each mechanism is modeled below, and their likely impact on foreign-born relative to domestic-born workers is then discussed.

2.1. Sorting Effect

The sorting effect is based on the well-known theoretical framework investigating the relationship between location-specific amenities and wage (i.e., Roback, 1982; Greenwood et al. 1991; Gabriel et al. 2003; Blomquist, 2006; Albouy, 2008; Chen and Rosenthal, 2008). I assume that the local marriage market *M* is a consumer amenity that affects single Ph.D. workers' utility

but has no direct effect on productivity. In this paper, the local marriage market *M* is measured by the number of potential dates available in an MSA. As the literature on search and matching (e.g. see discussion in Burdett and Coles, 1999) has emphasized that the long-term partnership formation as with marriage and employment is a time-consuming activity because of market frictions and heterogeneity of agents. For this reason, access to a large local market increases the arrival rate and contact with potential partners that have different characteristics, and it is expected to be an appealing amenity for single Ph.D. workers.

In an open-city model, single Ph.D. workers would earn lower real equilibrium wage rates for being in a better marriage market, ceteris paribus. As Figure 1 shows, holding constant the attributes of the local economic environment *A*, on the labor supply side, real wage must adjust so that mobile workers are indifferent between locations. The upward-sloping worker's utility curves equal to a system-wide level, U^*. On the labor demand side, wage equals the value of workers' marginal products, and the downward-sloping curve gives firms zero profit, $\pi(A) = 0$. The equilibrium wage at the location *a* is given by w_a^* where the zero-profit curve intersects equal-utility curve $U(A,\ M_a) = U^*$. Suppose local marriage market quality increases, $M_a < M_b$, workers' utility curve shifts down to maintain the utility level U^*. This is because single highly trained workers are willing to sacrifice part of real wage in exchange for better marriage opportunities in the local area. If the zero-profit function were vertical, then wage would decrease by the full amount of the vertical shift in the iso-utility locus, w_b^{**}- w_a^* in the figure. Given a downward-sloping labor demand curve, we would observe the impact of local marriage markets on equilibrium wage is w_b^*- w_a^* in Figure 1.

This sorting effect in principle should only reduce equilibrium wage of single, foreign-born Ph.D. workers who face dual thin markets. For highly trained singles, the ideal location

should offer them abundant high-quality opportunities to find a match in both job and marriage markets. While for foreign-born PhDs, there is a small number of MSAs offering active labor markets and the same goes for their marriage markets. When facing dual thin markets, single foreign-born PhDs can hardly find an ideal location if marriage opportunities are not spatially tied up with their high-quality jobs. Instead, they are forced to make a choice — either to (i) sacrifice marriage market opportunities for being in an active labor market or to (ii) select into an active dating environment but accept a lower wage than that would otherwise occur. If they put a high priority on marriage opportunities, they may choose the latter option.[10] In this case, better local marriage markets should have a negative impact on their equilibrium wage.

Consider a model investigating the impact of the local marriage market M on the labor market outcome Y: $Y = \alpha M + f(X, A) + \varepsilon$. In this model, the function $f(X, A)$ depends on individual characteristics X and location attributes A, ε is an error term, and α is the coefficient of interest. Following the analysis above, among those facing dual thin markets, and as indicated in the first column of Table 2 Panel A, the sorting effect should cause the sign for α to be negative when the outcome measure Y is wage.

Sorting may also affect observed hours worked and annual earnings of single PhDs that face dual thin markets. This is because individuals that choose to live in lower-wage MSAs in exchange for access to better dating opportunities may also want to change their working hours due to the change in wages. In such instances, lower wages could encourage individuals to work longer hours because of income effects. However, it should also be noted that those with a strong preference for dating might seek out jobs that require fewer hours worked to leave ample time

[10] Previous studies have paid attention to the gender difference in make such a choice (e.g. See discussion in Stark, 1988). For example, Smith and Thomas (1998) find that for Malaysia family and marriage consideration drive the migration for the female while for the male the labor market consideration is the priority.

for an active social life. Depending on the size of the substitution and income effect of the labor supply curve, the net effect of sorting on observed hours worked can be either positive or negative, and therefore, is potentially ambiguous. Since annual earnings are given by the product of hours worked per year and wage, the sorting effect on annual earnings is also ambiguous.

Such trade-offs from the sorting mechanism are unlikely to occur to those who are not in dual thin markets such as domestic-born Ph.D. workers. They are operating in one of the following two subcases: (i) both marriage and labor markets are thick, (ii) either labor markets or marriage markets are thick. For those in the former subcase, there should be no need to make these trade-offs, because ideal MSA locations are ubiquitous to provide them opportunities to develop a career and to search for a life partner. For those in the latter subcase, there should be little need to make trade-offs as well. That is because they potentially can secure an ideal MSA location by pursuing the opportunities in the thin markets for which they have location constraints. For example, for single Ph.D. workers that face with thick labor markets and thin marriage markets at the national level, they can choose to live in an MSA with active dating environment, conditional on that high-quality job opportunities are also available in that area. For these reasons, no sorting effect should arise for those not facing dual thin markets, as indicated in the first column of Table 2 Panel B.

2.2.Distraction Effect

The distraction effect in principle may reduce the hours worked for all highly trained singles, regardless of how thick their marriage markets might be at the national level. Dating takes time and energy. With more potential dates available in the local area, the relative price of searching for a potential life partner in the local market decreases. In this way, living or working

in an active dating scene may cause single Ph.D. workers to reduce hours worked to free up time for dating and parties. Such behaviors may potentially have an adverse impact on the Ph.D. workers' productivity, and be observed by employers, which can lead to lower wage rates.[11] Therefore, in Table 2 Panel A and B, as Column (2) indicates, distraction should cause the sign of α to be negative for hours worked per year and potentially also for wage and annual earnings. Since this study focuses on full-time Ph.D. workers, a notoriously career-oriented group, the distraction effect is assumed to be a secondary effect and relatively small in magnitude.

2.3.Differential Marriage Market Effects: Foreign-born vs. US-born

The total impact of the local marriage market *M* on the labor market outcome *Y* is the combined effects of sorting and distraction. In Table 2, Column (1) and (2) is for sorting and distraction effect, respectively, and Column (3) is for local marriage market effects.

Table 2 Panel A analyzes those facing dual thin markets (e.g., single foreign-born PhDs). Among these individuals, as indicated in Column (3), the local marriage market effect should have a negative sign for α when outcome measure *Y* is wage. When *Y* is hours worked or annual earnings, the sign of α is ambiguous but very likely to be negative.

Table 2 Panel B analyzes those not facing dual thin markets, which includes US-born single PhDs. As outlined in the previous discussion, only distraction effect may be present for such individuals. Therefore, in Panel B Column (3), better local marriage markets should have an adverse impact on three outcome measures, which causes the sign of α to be negative.

[11] Previous studies (e.g., Akerlof, 1976; Rosenthal and Strange, 2008) have demonstrated that hour worked may signal productivity and the degree of hard work. Akerlof's (1976) theory of rat race shows that in some situations, workers may work long hours to signal their unobservable productivity. Rosenthal and Strange (2008) find empirical evidence to support the theory and they demonstrate that agglomeration increases hours worked among professional workers.

Differencing Panel A and Panel B, I obtain Panel C, which indicates the differential marriage market effects between the foreign-born and the US-born. In doing so, I assume that for a given improvement in the local marriage market, the distraction effect for single US-born PhDs is no more than that for their foreign-born counterparts.[12] Given that the sorting effect should only occur to those facing dual thin markets, improvement in the local marriage market is expected to further reduce equilibrium wage of single foreign-born PhDs relative to the comparable single US-born PhDs. Therefore, as Panel C Column (3) indicates, when outcome measure is wage, the sign of the differential marriage market effects is evident: it should be negative. While for hours worked and annual earnings, the sign of the differential marriage market effects is still ambiguous.

3. Census Data and Core Sample

The primary data for the study is drawn from the individual-level files of the census for the survey years 1990, 2000, and 2010 as obtained from the IPUMS website.[13] Data for 1990 and 2000 are based on 5 percent samples of the underlying Census population while data for 2010 are from the 1 percent sample from American Community Surveys (ACS). My core sample pools together 18,796 single Ph.D. workers from three survey years, among which 8,647 are female, and 10,149 are male.[14]

The core sample is confined to individuals with a doctoral degree, age between 25 and 65 and marital status reported as single (defined as never married, divorced or widowed). They are

[12] This assumption is reasonable. Facing thin marriage markets, single foreign-born PhDs might be more sensitive to the increase in the number of potential dates in the local area, and they also may have stronger tendency to shift time away from work towards pursuing such opportunities.
[13] See www.ipums.org, Ruggles et al., 2010.
[14] Given the similar marriage patterns of PhDs from 1990 to 2010, I assume that the Ph.D.-trained individuals' preference for an ideal marriage partner has not changed much during this period, and I pool these observations together to get a larger sample size.

full-time workers, [15] not self-employed and live in identifiable MSAs.[16] They have reported their annual earnings,[17] occupations, birth regions, primary industries, and other related information. To have a sharp comparison between the US born and the foreign born, I toss out approximately 1,000 foreign-born Ph.D. workers that have been in the United States for more than 20 years, for they may be well assimilated into the host country and they are very similar to their domestic-born counterparts. In the same spirit, I also construct a pooling-year sample for married Ph.D. workers, among which there are 12,621 women and 39,973 men.

Table 3 presents sample means and standard deviations for key variables in these samples. I obtained the MSA level measures by aggregating individual observations using person weights. On average, single Ph.D. workers live in MSAs with more potential dates compared to the MSAs in which married Ph.D. workers are located. This is suggestive that single Ph.D. workers may indeed seek out MSAs with active dating opportunities relative to location decisions of married PhDs. Single Ph.D. workers also are less likely to have children at home as would be expected. Married male Ph.D. workers earn more in terms of wage and annual earnings than other Ph.D. workers. For the other variables listed in Table 3, including demographic attributes and other labor market measures such as the tendency to work in STEM occupations, the sample means are similar for married versus single and male versus female Ph.D. workers.

[15] Full-time workers refer to those who worked greater or equal to 35 hours per week last year. Among all single, PhD-trained individuals who were not at school, more than 88% report that their usual hours worked per week is greater than 35 hours. Since single Ph.D.-trained individuals have invested a lot in their education and are supposed to be breadwinners, and also the first-order story in this paper is the wage effect from the sorting mechanism, I only focus on full-time workers in the core sample. I have also done some robustness checks by including all those single Ph.D.-holders. In doing so, for those who did not work, I use 10 percentile wage in the sample as their wage and code their hours worked per year as zero, and my results are almost unchanged.

[16] The metropolitan area codes are based primarily on the 4-digit OMB codes of 1990 metropolitan areas.

[17] A worker's annual earnings in this paper refer to this person's total pre-tax wage and salary income - that is, money received an employee - for the previous year (Decennial Census) or past 12 months (ACS).

4. Estimating the Marriage Market Effects

This section introduces a double interaction model that investigates the differential marriage market effects between the US born and the foreign born.[18] The basic idea is to regress log (hourly wage) of a given Ph.D. worker on the local marriage market *M*, the indicator of being foreign-born, and the interaction term between *M* and the foreign-born indicator, controlling for a rich set of observable characteristics and fixed effects. Although I also estimate models with other dependent variables: hours worked per year and log (annual earnings), the discussion mainly focuses on the wage model.

The estimating equation is as following:

$$Y_{i,j,e,c,t} = \alpha_1 M_{e,c,t} + \alpha_2 ForeignBorn + \alpha_3 M_{e,c,t} \times ForeignBorn + X_i\beta + A_{c,t}\gamma + \delta_c + \eta_j + \mu_t + e_{i,j,e,c,t}\,, \quad (1)$$

where *i* denotes individual, *j* is for industry, *e* for ethnic group, *c* for MSA and *t* for year.

Individual *i*'s local marriage market, denoted as $M_{e,c,t}$, is measured by the number of singles of the opposite gender with a college or higher level of education and within individual *i*'s ethnic group *e*, at MSA *c*, for survey year *t*. The coefficient α_1 captures the impact of local marriage markets for the US born, and its sign should be negative (see Column (3) in Table 2 Panel B). The coefficient on the foreign born indicator, α_2, measures the average difference of the outcome measure between foreign-born and US-born Ph.D. workers. The coefficient of interest is α_3, and it reflects the additional effects from local marriage markets for the foreign-born relative to their US-born counterparts. As outlined in Section 2, foreign-born PhDs are on

[18] I have also tried a baseline regression without the interaction term $M \times ForeignBorn$. The point estimate on M in the baseline regression is positive and not significant (see Appendix Table A1-1 for details).

average more likely to face with dual thin markets and make sharper trade-offs, and α_3 is expected to be negative when the outcome measure is wage.

The estimating equation controls for a vector of individual *i*'s demographic and socioeconomic attributes X_i. For example, X_i includes age, age squared, English speaking ability, occupation's median earned income,[19] being foreign born or not, residing in the U.S. no more than ten years, in a STEM occupation, having own children at home, Hispanic origin, black race, living in the home state.

Moreover, the regression controls for location-specific time-variant attributes $A_{c,t}$. This is because these characteristics contributing to agglomeration economies affect workers' wage, and they are also potentially correlated with the size of the local dating pool. In particular, I control for the total population at MSA *c* for year *t* (a measure for urbanization effects) and the number of workers in own industry *j* at the MSA *c* for year *t* (a measure for localization effects).[20] Urban literature has a long debate on the degree to which productivity of firms increases when other firms from the same industry ("localizations") versus from other industries ("urbanization") locate nearby (see more discussion in Rosenthal and Strange, 2004). This study documents the two effects of agglomeration when considering the productivities of Ph.D. workers, which so far is still in a lack in the urban literature.

The estimating equation also includes several fixed effects. MSA fixed effects δ_c capture the time-invariant location attributes like sunshine, river, mountains, air quality, distance to the

[19] I use the variable ("ERSCOR90") constructed by IPUMS. This variable assigns a measure of the median earned income for each occupation. It is standardized as a "z-score" and then converted to a percentile rank. It reports the percentage of persons in occupations having lower standardized median earnings than the respondent's occupation. For more details, please see https://usa.ipums.org/usa-action/variables/ERSCOR90#description_section.

[20] $A_{c,t}$ also includes MSA-year specific average working age and earnings, and the number of own-ethnic workers that are present in the MSA but are not the potential dates for individual *i* in year t. The latter one helps to mitigate the concern that the key coefficient estimate would reflect the degree to which Ph.D. workers are willing to give up real wage to have access to other ethnic specific amenities that are present in that MSA in a given year.

country border, coastal proximity, the number of universities, and the cost of living, etc. Industry fixed effects η_j capture the time-invariant attributes for a specific industry such as its ethnic concentration, gender density, average skill levels and work hours. Year fixed effects μ_t control for the year-specific national-wide shock. In addition, $e_{i,j,e,c,t}$ is the classical error term.

The identification of the marriage market effect relies on changes in the dating pool in a particular MSA over time as well as the variations of dating pool across MSAs for a given year. The magnitude of α_3 is partly driven by how foreign-born Ph.D.-trained individuals evaluate the location-specific amenity *M* relative to job opportunities when facing the dual thin markets, which may be highly correlated with individual characteristics that are unobservable to researchers. Such characteristics, which may include the person's physical attractiveness, desire to get married, eagerness to pursue career success, and so on, can vary across individuals and also change over time for a given person. Since the repeated cross-section data for the analysis could not allow one to track individuals over time, I cannot include individual fixed effects to rule out person-specific time-invariant attributes. But I do investigate Ph.D. workers by gender and age in the following analysis, trying to shed light on this point. The estimate of α_3 would be upward biased in magnitude if foreign-born single PhDs are less productive and meanwhile more eager to get married. Analogically, if a disproportionately large share of foreign-born single PhDs in the sample do not worry about their marriage opportunities and choose to live in an MSA with high-quality jobs when facing with dual thin markets, the estimate of α_3 would be a lower-bound in magnitude.[21]

[21] This may be especially true for those who have no desire to get married shortly when choosing where to live. It may also apply to those that anticipate a good marriage prospect no matter where they go. On the other hand, it is important to recognize that attractive singles may also have a strong incentive to live in an MSA with an active dating environment, as such individuals benefit most from a dense market (Gautier et al., 2010).

5. Results

In the discussion below, I first present estimates based on hourly wage for single Ph.D. workers. In particular, I examine differences in estimates for young versus older and male versus female among single Ph.D. workers. Then these comparisons are done for additional models that use hours worked per year and annual earnings as the dependent variables. Lastly, I present results for married Ph.D. workers. For this demographic group, I expect the distraction effect to be limited and the sorting effect will also have attenuated for reasons described later.

5.1. Wage by Age and Gender for Single Ph.D. Workers

Table 4 provides evidence that locating in an MSA with more potential dates of their own ethnicity and with college above education levels – the likely dating pool – reduces the equilibrium wage for single, foreign-born, Ph.D. workers on average, while no such effect arises for their US-born counterparts. Moreover, the marriage market effects on wage are different for young (age 25 to 44) versus older (age 45 to 65) [22] and for male versus female.

Table 4 Column (1) present estimates for single female PhDs in the core sample (age 25 to 65). Coefficient estimate on *M* suggests that no significant marriage market effect arises for the wage of single, US-born female PhDs. Given that the sorting is unlikely to occur to the US-born PhDs, this estimate reveals that the distraction effect does not affect their wage as well. The coefficient estimate on the interaction term is -0.019, significant at 5% level. This estimate suggests that for every 1,000 more single men within their ethnicity and with college above education present in the MSA, the equilibrium wage of single, foreign-born, female Ph.D. workers on average decrease by roughly 2 percentage points. Such differential marriage market

[22] I also split sample in a way so that individuals aged 25 to 39 fall into young age group and those aged 40 to 65 fall into older group. Results are robust to such change of the definition for young versus old.

effects between the foreign-born and their US-born counterparts are consistent with the analysis in Section 2. Foreign-born female PhDs display a strong tendency to marry highly educated men within their ethnicity, and they face with thin marriage markets in comparison with their US-born counterparts. Operating in dual thin marriage and labor markets, they choose to sacrifice their real wage for living in an MSA with a better local marriage market. Additionally, the estimate of localization effects in Column (1) is 0.183, twice as large as that for urbanization effects, 0.083. The larger impact from localization echoes the old debate in the urban literature about the relative importance of the city size and the industrial concentration on productivity (e.g. Rosenthal and Strange, 2004; Martin et al., 2011).[23]

The next two columns of Table 4 split single female PhDs into two age groups: young women (age 25 to 44) and the older women (age 45 to 65), respectively. The wage impact of local marriage markets on single foreign-born female PhDs enlarges to 2.9 percentage points for young women (Columns 2), while it is almost gone for the older women (Columns 3). This noticeable effect for young women is consistent with the literature that usually views this group as prone-marriage. For instance, as women may anticipate their physical attractiveness, which is often valued as a desirable trait in the marriage market, declines with age, they are more active in searching for potential dates at a young age to avoid "being left on the shelf" (e.g., Cole and

[23] Rosenthal and Strange (2004) survey the urban literature that investigates the productivity advantages of the city size and the industrial concentration. They report that the elasticity of productivity with respect to the size of the city or to the size of the industry is generally between 3% and 8%. To make my estimates comparable to previous studies, I also run the model that uses log (MSA total population) and log (MSA employment in their own industry) instead of using the absolute value. In this double-log specification, I obtain significant estimates for localization effects on Ph.D. workers' productivity: on average, the elasticity of wage with respect to the size of the industry is roughly 4% to 5% among Ph.D. workers. But the urbanization effect is not statistically different from zero. This result speaks to the recent studies by Marin et al. (2011), which also find little evidence of urbanization effects. Their work uses French plant-level data from 1996 to 2004 and GMM estimation to show that firms in the short run benefit from localization economies.

Francesconi, 2011).[24] Moreover, since the decrease in the fecundity of women who have passed 30 is generally acknowledged,[25] single women age mid-30s may have a significant concern regarding future fertility loss and thus are eager to get married (e.g., Giolito, 2004). For these reasons, young women may be more willing to accept inferior labor market outcomes in order to access better marriage markets. In contrast, the older single Ph.D. women may have invested more in their career and possibly already taken the life as it is; therefore, they are in no rush to be in a relationship and less likely to sacrifice their job opportunities.

Column (4) to (6) present an analogy results for single male Ph.D. workers by age. The marriage market effect seems to become smaller among single, foreign-born male PhDs, and this gender disparity is especially apparent in young age group. Among the core sample (age 25 to 65) in Column (4), the local marriage market effect on wage for single, foreign-born male PhDs is 1.1 percentage points, roughly 60 percent as large as that of the comparable foreign-born female PhDs in Column (1).[26] As would be expected, no such effect arises for single, US-born male PhDs. Local marriage markets do not affect young men in Column (5), but a significant effect is present among the older men in Column (6). One possible explanation for such discrepancy is that single men with stronger career opportunities have a greater option value to

[24] Cole and Francesconi (2011) also emphasize that more equal career opportunities for women (captured by greater schooling and better occupations) can enlarge their choice set of marriage partners, which potentially explain the recent increase of toyboy marriage, in which the woman is at least 5 years older than her partner. In my sample, I find roughly 5% of married Ph.D. women aged 45 to 65 are in toyboy marriage, larger than 2.8%, the number for young Ph.D. women aged 25 to 44. However, these numbers are still small as compared to the share of Ph.D. women that have an older or identical age husband, which is more than 80%.

[25] In 2014, the American College of Obstetricians and Gynecologists, together with the American Society for Reproductive Medicine, issued a Committee Opinion on Female Age-Related Fertility Decline. According to these medical experts, "the fecundity of women decreases gradually but significantly beginning approximately at age 32 years and decreases more rapidly after age 37 years." See more details at http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Gynecologic-Practice/Female-Age-Related-Fertility-Decline.

[26] Among the core sample of single Ph.D. workers (age 25 to 65) in which I pool male and female together, this effect is 1.4 percentage points, significant at 1% level. For more details, see Appendix Table A1-2. Table A1-2 reports estimates of the double-interaction models for three labor market outcome measures among the core sample that combines both genders.

defer marriage. Ph.D.-trained single men at a young age may be ambitious to develop their career and would not trade off job opportunities for marriage opportunities. On the other hand, they are also popular among women in the marriage market. In contrast, the older Ph.D. men, who may have their career going and still being single, are on average more desperate and aggressively pursuing opportunities to find a life partner.

The larger marriage market effect for single female PhDs, especially in young age, may reflect the gender roles and expectations within marriage to some extent. Ph.D.-trained young women, who may be concerned about the increasing risk of fertility loss and declining marriage prospect as they age, are on average more likely to put a high priority on marriage opportunities than Ph.D.-trained young men. Moreover, Ph.D.-trained single women have a limited pool of what are traditionally considered as the "marriageable" men — those who are better educated or earn more than they do. As the marriage patterns in Table 1 show, regarding the frequency to marry a Ph.D.-holding individual within own ethnicity, the share for Ph.D.-trained women is nearly three times as large as that for Ph.D.-trained men. The thinner marriage markets for single female PhDs may also cause them more willing to trade off job opportunities for being an active marriage market.

5.2. Hours Worked and Annual Earnings for Single Ph.D. Workers

Table 5-1 and Table 5-2 do the same exercise as Table 4 does but change dependent variables as hours worked per year and annual earnings, respectively. These three tables together provide significant evidence that on average, single female foreign-born PhDs, especially those at a young age, accept less annual earnings for improved local marriage markets, and the sorting rather than the distraction effect primarily drives such results.

Table 5-1 shows that the distraction effect that reduces hours worked, possibly to free up time for dating, is present but tiny in magnitude. Among single female Ph.D. workers (age 25 to 65) in Column (1), for every 1,000 increase in the number of potential dates in the MSA, the Ph.D.-trained single women, both domestic and foreign born, work approximately 1.8 hours fewer per year than they otherwise would be. This distraction effect is significant and tiny still for young women in Column (2), and it is nearly gone for the older women in Column (3). This marriage market effect is not different between the domestic and foreign born. But it is also noted that on average, foreign-born women work roughly two weeks fewer per year than their US-born counterparts. This gap of hours worked does not exist among Ph.D.-trained single men from Column (4) to (6). Moreover, local marriage markets have no significant impact on work hours among Ph.D.-trained single men, except for a small effect present for foreign-born young men in Column (5): these individuals work roughly 15 hours fewer per year for every 1,000 increase in the number of potential dates in the MSA. Recall that in Table 3, single Ph.D. workers on average work 2,310 hours per year. All these estimates suggest that the distraction effect on hours worked per year is minuscule and Ph.D.-trained singles do indeed work hard.

Table 5-2 demonstrates that improving the size of local marriage markets reduces annual earnings of single, foreign-born Ph.D. workers, with a larger effect for women than for men. In Column (1), for every 1,000 more potential dates living in the MSA, the annual earnings of single, foreign-born female PhDs reduce by 2.4 percentage points. This marriage market effect is significant and large for young women and older men – 3.2 percentage points and 1.8 percentage points, respectively. In contrast, neither the older women nor young men experience such effects.

As outlined in Section 2, the impact of local marriage markets on annual earnings can be decomposed into the effects of wage and hours worked per year. Given the tiny distraction effect

in Table 5-1, the estimates for annual earnings in Table 5-2 almost mimic the pattern of wage results in Table 4. This comparison indicates that sorting is the primary driving mechanism through which single, foreign-born PhDs, especially women, tradeoff their labor market opportunities for improved local marriage markets. The estimates suggest that doubling the size of the local potential dating pool, single, foreign-born Ph.D. workers on average earn approximately 1,195 U.S. dollars less per year.[27] Since this effect is primarily attributable to the capitalization of the local marriage markets, policymakers that are interested in initiating and enhancing innovation in local areas may find it appealing to invite highly trained immigrants by subsidizing them with a tax credit for several years.[28]

5.3. Married Ph.D. Workers vs. Single Ph.D. Workers

This section discusses the manner and the degree to which these trade-offs change after marriage. Once married, the distraction effect should attenuate toward zero if Ph.D. workers are happily married and are no longer searching for potential dates. Concerning the sorting effect, it might still be present among married foreign-born Ph.D. workers. That is because some of those facing dual thin markets chose to live in a lower-wage MSA with an active dating scene when they were single, and they stay in the same MSA after marriage. This location lock will tend to occur when moving costs are higher than the benefits from relocating the household. Conversely, once married, some foreign-born Ph.D. workers may have a tendency to relocate to another city

[27] I calculate this number by using estimates among core sample that combines both genders. First, I multiply the sample mean of annual earnings, 56,000 (in 1999 U.S. dollars), by 1.5%, which is the estimate of marriage market effect on earnings of single, foreign-born Ph.D. workers (see Appendix Table A1-2 Column 3). Then I adjust for inflation and convert the number into U.S. dollars of the year 2015 by using the latest US government CPI data published on May 17, 2016.

[28] Such policy would contribute to a self-reinforcing growth of the highly skilled ethnic community, which may attract high-tech firms that intensively use educated workers to the local areas and possibly generate agglomeration economies. On the other hand, this plan may also be controversial because such policies would appear to be unfair to some immigrant groups, such as the Hispanics, who are more likely to have low education attainments.

that offers higher wages but a less active dating environment. In this way, the marriage market effect on wage would vanish for the latter group. For these reasons, the coefficient estimate on the interaction term, $M \times Foreign\text{-}Born$, should be smaller for married Ph.D. workers compared to that of single Ph.D. workers.

Table 5-3 presents labor market outcomes for married Ph.D. workers (age 25 to 65) by gender.[29] The first two columns of Table 5-3 show that the distraction effect that reduces hours worked disappears for most married PhDs. However, a small effect persists for married, foreign-born Ph.D. men in Column (2): those individuals work 9.5 hours fewer per year for every 1,000 increase in the number of potential dates in the MSA. The wage estimates in Column (3) and (4) suggest that the sorting effect seems to exist still among married foreign-born Ph.D. workers, with similar magnitudes to those for their single counterparts in Table 4. Given the attenuation of hours worked effect and the presence of wage effect, it is not surprising that local marriage market affects annual earnings for married foreign-born PhDs in the last two columns, with smaller magnitudes relative to those for the comparable single PhDs in Table 5-2.

Then I further explore the reduced wage effect for those that relocated to another MSA after marriage in Table 5-4. I restrict the sample to young (age 25 to 44) married Ph.D. women who moved to their current MSA after having been married,[30] and I pools this subsample with

[29] All the specifications in Table 5-4 control for the characteristics of the Ph.D. worker's spouse, for example, spouse's education, age and so on. That is because once married, a worker's labor supplies may no longer be a personal decision but is decided from the view of the household.

[30] To identify this group, I take advantage of two variables in the ACS 2010: (i) the year in which the person last married, and (ii) whether a person moved to current MSA within past year. Young females who reported marital status as married are classified into this group if they moved to their current MSA within past year and last married no later than the year of 2008. And I also classify into this group another 112 young married women who married before the year of 1996 but have not reported whether they moved within past year. That is because highly trained young couples that age below 30 are mobile, and they seldom stay in the same MSA for more than 15 years.

young single Ph.D. women to conduct a comparison.[31] As indicated by earlier results in Table 4, a strong sorting effect is present among young, single, foreign-born Ph.D. women. Moreover, as just discussed, this marriage market effect may vanish for these women if they relocate to another MSA after they get married. To test the differential wage effects between these two groups, in the estimating equation, I control for an indicator of being single as well as its interaction with the foreign-born indicator and the local marriage market, $M \times Foreign\text{-}Born \times Single$. The coefficient estimate on this triple interaction term is expected to be negative.

In making this comparison, Table 5-4 also takes account of the influences of children on women's job and location choices.[32] Column (1) directly controls for the indicator of having own children present in the household while Column (2) further restricts the sample to households without children. I prefer the approach of Column (2) because married women, as the summary statistics suggest, are more likely to have children at home than comparable single women. Column (1) obtains a positive coefficient estimate on the indicator of having own children at home, which is primarily driven by the higher wage that married women earn by relocating after they got married. Meanwhile, the coefficient estimate on the triple interaction term, $M \times Foreign\text{-}Born \times Single$, is not significantly different from zero. Column (2) rules out the influence of children by only looking at no kid households. Column (2) demonstrates that among young, foreign-born female PhDs who have no child at home, increasing the size of the local marriage market has no impact on the wage of married women who moved to their current MSA after they have been married, while it significantly reduces the wage for single women. For

[31] I do not run a separate regression for young married women who relocate after marriage because the size of this subsample is relatively small. Beyond that, due to a similar concern for the power issue, I cannot draw on married women who moved to current MSA before marriage to conduct a robustness check.

[32] Besides women's predominant role in child rearing, the moving cost is relatively high for married couples with kids than those without kids (see discussion in Gautier et al., 2010).

young US-born female PhDs, regardless of their marital status, no such effect arises. These results are consistent with my expectation.[33]

6. Extensions

In this section, I examine the trade-offs for single Ph.D. workers that face dual thin marriage and labor markets by estimating a triple interaction model. In particular, among the foreign-born PhDs, I further differentiate between those that do operate in a dual-thin market setting and those that do not. To do so, I construct a dual-thin-market indicator "*2MktThin*", which is equal to one if a Ph.D. worker's marriage and labor markets are both thin as measured across the U.S. and zero otherwise. I add to the equation (1) this variable and its interaction with *M* × *Foreign-Born*. The estimating equation becomes:

$$Y_{i,j,e,c,t} = \alpha_1 M_{e,c,t} + \alpha_2 ForeignBorn + \alpha_3 M_{e,c,t} \times ForeignBorn + \alpha_4 2MktThin +$$

$$\alpha_5 M_{e,c,t} \times ForeignBorn \times 2MktThin + X_i\beta + A_{c,t}\gamma + \delta_c + \eta_j + \mu_t + e_{i,j,e,c,t} \quad . \quad (2)$$

As discussed in Section 2, sorting effects should in principle only affect individuals who face dual thin markets, while for those comparable workers who do not face dual thin markets, there should be little need to make such trade-offs. The coefficient α_3 captures the differential distraction effects between the foreign-born who do not face dual thin markets and their US-born counterparts. Since earlier results suggest that distraction effect is small for all Ph.D. workers, the magnitude of α_3 should be close to zero. The coefficient of interest, α_5, in contrast, captures

[33] I have noticed that the co-location effect or other unobservable attributes may have affected the estimates. Studies on the migration of couples demonstrated the importance of husbands' career opportunities and that wives are typically the "tied movers" who participate in moves that result in a loss for themselves but positive net returns for the family (e.g., Nivalainen, 2004; Compton and Pollak, 2007). Even if the wage results of married female PhDs do include the tied mover effect, it still makes sense. In this case, the actual magnitude of the marriage market effect for the married female PhDs should be more positive than the estimates I have presented for this group, that is, the differential effect between single and married may have been underestimated.

the additional marriage market effect for foreign-born workers who have dual thin markets. Among demographic groups that put a high priority on marriage market opportunities, α_5 is expected to have a negative sign when the outcome measure is wage.

The main empirical challenge is to choose reasonable cutoffs to construct the dummy variable "*2MktThin.*" In the following discussion, I will first show how I select the preferred cutoffs to define a dual thin market. Once the preferred cutoffs have been established, I then present a complete set of results based on the associated definition of "*2MktThin.*" Briefly, for now, the preferred definition of "*2MktThin*" is one that maximizes the magnitude of the negative coefficient α_5 in estimating equation (3) for single female Ph.D. workers in the core sample. It is also worth noting here that robustness results presented shortly make clear that the preferred definition for "*2MktThin*" is readily apparent when comparing across alternate definitions of "*2MktThin*."

6.1. Dual Thin Markets

This section first describes my preferred definition of a dual thin market. Then it outlines conceptual and numerical arguments used to select the cutoffs that define the "*2MktThin*" variable. Lastly, the section considers alternative estimates based on a grid search over different cutoffs for the number of MSAs that must provide active dating opportunities and active employment opportunities for an individual to be coded as facing a dual-thin market.

In the preferred definition, a Ph.D. worker is coded as facing a dual thin market if the following two conditions are satisfied. First, the number of active marriage markets is less than 36 MSAs in the U.S. ("*marriage markets are thin"*). Secondly, the number of active labor markets is less than 36 MSAs in the U.S. ("*labor markets are thin"*). In this definition, an active

marriage market refers to an MSA with the value of *M* – the number of own-ethnic singles of the opposite gender and with college above education levels – greater than or equal to 200. An active labor market refers to an MSA with the number of own-industry Ph.D. workers greater than or equal to 200.[34] Specified in this way, the indicator "*2MktThin*" varies by ethnicity, industry, and gender, and it varies across years as well. Ethnic composition in the U.S. has tremendous changes for the period 1990-2010. I treat the variations of dual thin markets as exogenous for individuals.

Choosing cutoffs to define the dual-thin-market indicator "*2MktThin*" is necessarily ad hoc. Nevertheless, numerical and conceptual arguments do provide guidance. As analyzed in Section 2, sorting effects are likely to be most pronounced for individuals who face dual thin markets. Because such people will find it difficult to locate in an MSA with both a sizable dating pool and high-quality job opportunities, and they may be forced to choose between MSAs that offer better job opportunities versus better marriage markets. While for those comparable workers who do not face dual thin markets, there should be little need to make such trade-offs. As suggested by earlier results, single female Ph.D. workers on average put a high priority on marriage market opportunities. Estimating the wage model among single female Ph.D. workers, the equation (3) is expected to yield estimates for which $\alpha_5 < 0$ and $\alpha_3 \approx 0$.

Among the core sample of single female PhDs, if $\alpha_5 < 0$ and $\alpha_3 \approx 0$ hold, it indicates that the coefficient estimate $\widehat{\alpha_5}$ at the true cutoffs to define a dual thin market should be more negative than estimates obtained under alternative cutoffs among this demographic group. That is because when the cutoffs are set either lower or higher than the true cutoffs — but not in an extreme way — the definition of "*2MktThin*" would be more restricted or looser than it should be. As a result, a proportion of single Ph.D. workers who face dual thin markets will be

[34] In this way, the US-born will always be coded as 0 for the variable "*2MktThin*", and some of the foreign-born will fall into the category of facing dual thin markets.

misclassified as those not facing dual thin markets or vice versa. Such misclassification should cause $\widehat{\alpha_3}$, the coefficient estimate on *M* × *Foreign-Born*, to be more negative while cause $\widehat{\alpha_5}$, the coefficient estimate on *M* × *Foreign-Born* × *2MktThin*, to head in a positive direction.

To check whether such a negative spike of $\widehat{\alpha_5}$ is present, I conduct a grid search for using alternative cutoffs to define a dual thin in estimating wage model for single female Ph.D. workers.[35] If it is present, for reasons described above, I will choose the cutoffs that maximize the magnitude of the negative coefficient estimate $\widehat{\alpha_5}$ as my preferred ones.

Figure 2 provides a three-dimensional view on how the coefficient estimate $\widehat{\alpha_5}$ changes as cutoffs to define a dual thin market move. In this grid research, whether an MSA has "active" opportunities for marriage and job market is defined as described earlier.[36] While the cutoffs for the number of MSAs that provide active opportunities, below which a person is coded as having thin labor markets and as having thin marriage markets, are exhaustively chosen from the range of [0 MSA, 360 MSAs]. In this way, there are 130,321 cutoff pairs to define the "*2MktThin*" variable. For each cutoff pair, I estimate wage model of equation (3) for single female PhDs in the core sample to obtain the coefficient estimate $\widehat{\alpha_5}$ on the triple interaction term. In Figure 2, each point (x, y, z) represents a cutoff pair x-y on the horizontal X-Y plane — where x is the thin labor markets cutoff and y the thin marriage markets cutoff — and z on the vertical axis is the

[35] Estimates in Section 5 indicate that sorting effect is present among single, foreign-born female PhDs. Therefore, discussion here focuses on single female PhDs. For single male PhDs, I also conduct a grid research regarding using alternative cutoffs to define a dual thin market and plot the corresponding surface and contour plot of $\widehat{\alpha_5}$. I cannot find significant evidence that the sorting effect lowers wage rates for single male Ph.D. workers who are facing the dual thin markets. Some estimates for single male PhDs from this grid research are in the Appendix Table A2.

[36] For a given person, an MSA with at least 200 own-ethnic college-above potential dates is defined as an active marriage market, and an active labor market refers to an MSA with at least 200 own-industry Ph.D. jobs. I repeat the exercise by changing these local-level cutoffs to define whether an MSA has active opportunities for marriage and labor market. Not surprisingly, the wage results are also sensitive to the local-level cutoffs. When the magnitudes of the local-level cutoffs rise, the corresponding national-level cutoff pair to define that marriage and labor markets are thin become more restricted to find the deep negative spike of $\widehat{\alpha_5}$. In the appendix, Table A4-1 and A4-2 document the inter-MSA distribution of own-ethnic potential dates with col+ education levels, and Table A5 reports the distribution of own-industry jobs for Ph.D. workers.

point estimate $\widehat{\alpha_5}$ obtained when x-y cutoff pair is used to define a dual thin market.[37] A sharp downward spike on the Z-axis exists at the corner of the X-Y plane, where the cutoff for thin labor markets and that for thin marriage markets are both around 35 MSAs.

Figure 3 is the corresponding contour plot for Figure 2. Such a two-dimension view is obtained when we look straight down along the Z-axis from the top of the surface plot. Figure 3 demonstrates that only one small black area is present around the point (35 MSAs, 35 MSAs) on the X-Y plane, indicating that $\widehat{\alpha_5}$ would hit the deep negative spike if and only if the dual-thin-market indicator "*2MktThin*" is defined under a cutoff pair within this small black area. Therefore, I choose (36 MSAs, 36 MSAs) from the small area as the preferred cutoffs.

Table 6-1 selects nine different sets of cutoffs from this grid research for single female PhDs, and it documents how the other coefficient estimates, such as $\widehat{\alpha_3}$, changes under different definitions of dual thin markets (the variable "*2MktThin*"). Table 6-1 Column (4) uses the preferred cutoffs and obtains a significant negative estimate -0.072 for $\widehat{\alpha_5}$; as would be expected, that estimate is sharply more negative than all other estimates based on alternative classifications of dual thin markets. As discussed above, when moving away from Column (4) to (2), as the cutoffs set lower and the definition of "*2MktThin*" becomes increasingly restricted than it should be, a proportion of single Ph.D. workers that face dual thin markets are misclassified as not facing dual thin markets. In this case, $\widehat{\alpha_3}$, the coefficient estimate on *M* × *Foreign-Born*, becomes more negative, while $\widehat{\alpha_5}$ heads in a positive direction. Analogically, Column (4) to (8)

[37] For example, in Figure 2 the point (31 MSAs, 36 MSAs, -0.065) refers to the estimate $\widehat{\alpha_5}$ = -0.065 when a person is defined as facing a dual market if the number of active labor markets < 31 MSAs and the number of active marriage markets < 36 MSAs. In Figure 2 and 3, both x and y are integers fallen into the range of [30 MSAs, 360 MSAs]. That is because when cutoffs are set too low, there would be an extremely small number of observations that take value 1 for the variable "2MktThin" and the resulting estimates would not make sense. Besides, to plot these figures, when the cutoffs are set too high so that the estimating equation goes back to the double interaction model, $\widehat{\alpha_5}$ is set to 0.

show that when cutoffs are set increasingly higher, some of those not facing dual thin markets are mislabeled as having dual thin markets, resulting in a more negative $\widehat{\alpha_3}$ and a more positive $\widehat{\alpha_5}$. It is also worth noting here that when choosing extremely low cutoffs (e.g. 1 MSA in the first column) or extremely high cutoffs (e.g. 361 MSAs in the last column), either no one or all individuals would be characterized as facing a dual thin market. These extreme definitions cause the variable "*2MktThin"* to drop out of the regression and the specification reverts to the double interaction model of Table 4 Column (1).

6.2. Single Ph.D. Workers Facing Dual Thin Markets

This section presents estimates of the triple interaction model for single Ph.D. workers, using the preferred definition for a dual thin market. Table 6-2, 6-3 and 6-4 report hourly wage, hours worked per year and annual earnings, respectively. These tables demonstrate that among single Ph.D. workers that are facing dual thin markets, sorting effect grows significantly for young (age 25 to 44) women, while for the older women (age 45 to 65) and men in general, they would not sacrifice job opportunities for better marriage market opportunities.[38]

Table 6-2 provides evidence that a sorting effect lowers equilibrium wage rates for single female PhDs who face dual thin markets, and in particular for those at a young age. Among core sample in Column (1), all else equal, locating in an MSA with 1,000 more potential dates reduces the wage of this group by 7.2 percentage points. No such effect arises for either single US-born Ph.D. women or single foreign-born Ph.D. women who do not face dual thin markets. Besides, when facing dual thin markets, this effect grows to 11 percentage points for young women in

[38] Appendix Table A3 presents estimates of the triple interaction model for married Ph.D. workers, which is an analogical exercise for Table 5-4. As would be expected, among those married PhDs, when facing dual thin markets, the local marriage market has no impact on their hours worked per year, while the sorting effect is still present for their wage, and the magnitude is smaller than that of single Ph.D. women facing dual thin markets.

Column (2) but is not present for the older women in Column (3). As Column (4) to (6) suggest, single Ph.D. men, regardless of their age, would not choose to live in a lower-wage MSA when experiencing dual thin markets.

Furthermore, Table 6-3 and 6-4 show that when facing dual thin markets, old women and young men work more and earn more for more potential dates present in the MSA, while no significant effect arises for either young women or old men. For example, for every 1,000 more potential dates living in the MSA, old single Ph.D. women work roughly 2 weeks more per year and earn 14 percent more in annual earnings. One possible explanation is that when encountering dual thin markets, old women and young men choose to live in an MSA with high-quality job opportunities. Meanwhile, these locations happen to have some potential dates for them.[39] The results obtained may be driven by some unobservable attributes of these workers, such as their eagerness to achieve career success, high expectation for a potential partner, in a lack of desire to get married, etc.

7. Conclusions

This paper investigates the degree to which Ph.D.-trained workers — both domestic and foreign-born — face trade-offs between marriage and labor market opportunities. This work is important because Ph.D.-trained STEM workers, of which a sizable proportion are foreign born, account for a large share of innovation in the US. Ph.D. Labor markets are thin because high-quality jobs are not ubiquitous. Moreover, foreign-born PhDs face thin marriage markets compared to their U.S-born counterparts. That is because foreign-born PhDs, and especially

[39] For example, among the older women that are facing dual thin markets, 59% live in an MSA with both active labor and marriage market, 18% in an MSA that only has active marriage market, and the rest in neither an active labor market nor an active marriage market.

those from China and India, display a strong tendency to marry highly educated individuals within their own ethnicity. This narrows the dating pool and summary measures confirm that there are relatively few MSAs in the United States that offer active dating environment for these sorts of workers. Facing dual thin marriage and labor markets, single, foreign-born Ph.D. workers must sometimes choose between MSAs that provide better job opportunities versus better marriage markets.

I present evidence that on average, single, foreign-born, female Ph.D. workers accept inferior labor market outcomes in exchange for improved marriage market opportunities. I also show that this result is primarily driven by the soring of such individuals into MSAs with a more active dating environment. All else equal, locating in an MSA with 1,000 more single men of their own ethnicity and with at least college education levels decreases their equilibrium wage and annual earnings by roughly 2 percent. No such effect arises for single, US-born female PhDs who have geographically expansive marriage markets. The distraction effect that reduces hours worked, possibly to free up time for dating, is present in some models and small in magnitude. In addition, I conclude that the trade-offs between marriage market opportunities and labor market outcomes are smaller for single male Ph.D. workers, especially at young age. This gender disparity suggests that Ph.D.-trained single men may be more likely to put a high priority on job opportunities when choosing where to locate.

This paper also is also relevant for other instances in which highly skilled individuals face thin labor markets and also seek spouses within narrowly defined demographic traits. Examples beyond ethnicity could include religious background, political attitudes, or other defining cultural traits. In future work, it would be informative to study what is the price some are willing to pay to search love and find long-term domestic happiness.

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Figure 1*: Local Attributes (*A*), Local Marriage Market Opportunities (*M*), and Wage (w)*

Local Marriage market (*M*) is a consumer amenity that affects worker utility but has no direct effect on productivity. Assume $M_a < M_b$.

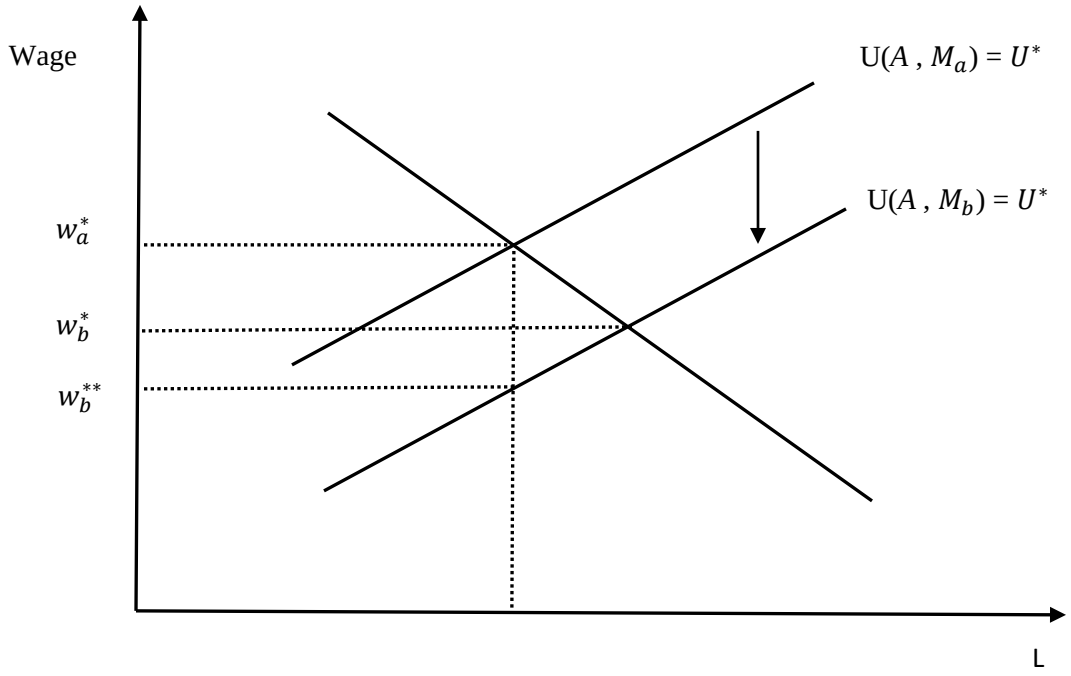

Figure 2: Surface Plot of Coefficient Estimate ($\widehat{\alpha_5}$) on *M*Foreign-born*2MktThin*

Sample of Single Female Ph.D. Workers, Age 25 to 65, Dependent Variable = log (Hourly Wage)

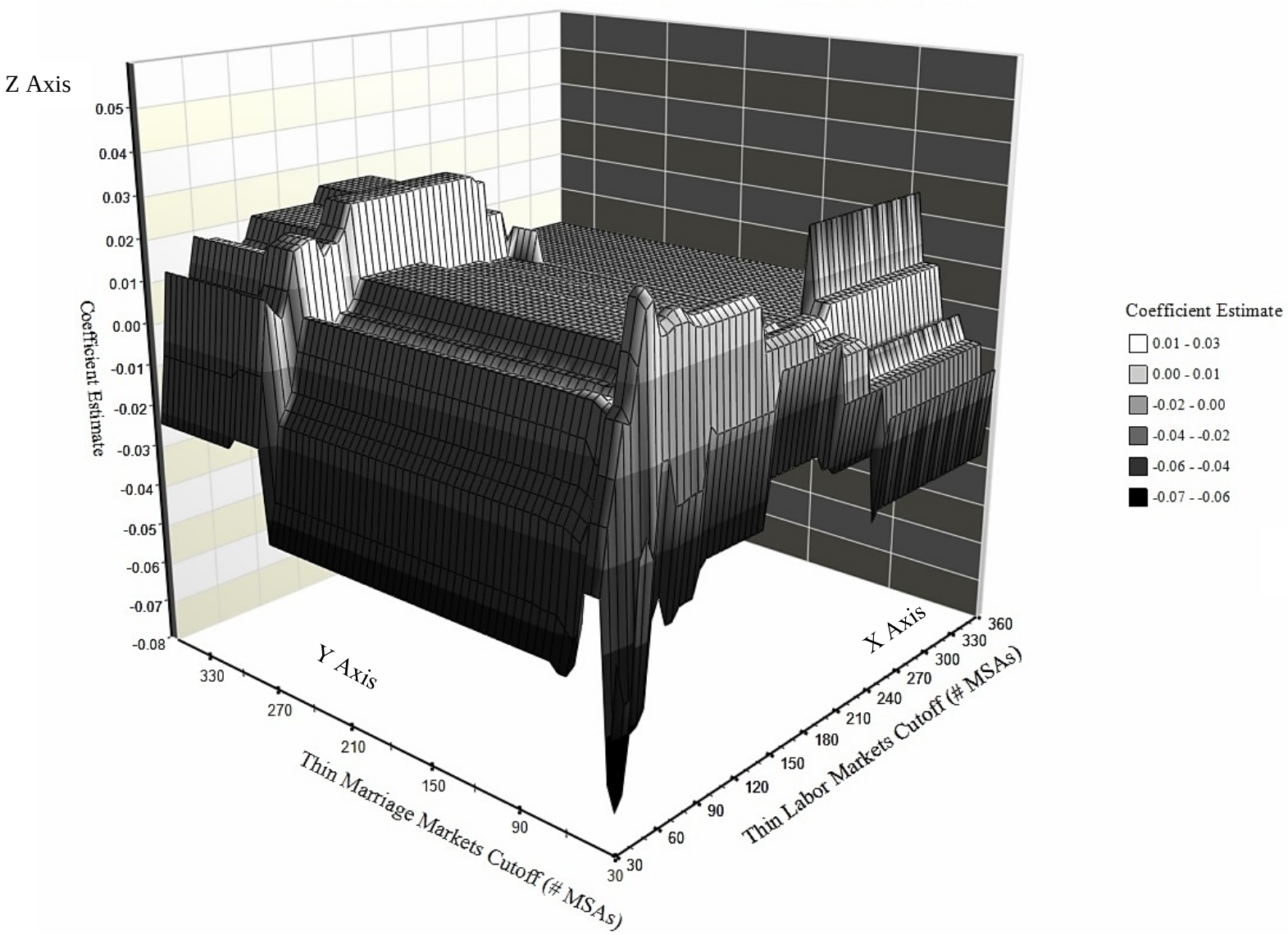

Figure 3: Contour Plot of Coefficient Estimate ($\widehat{\alpha_5}$) *on M*Foreign-born*2MktThin*

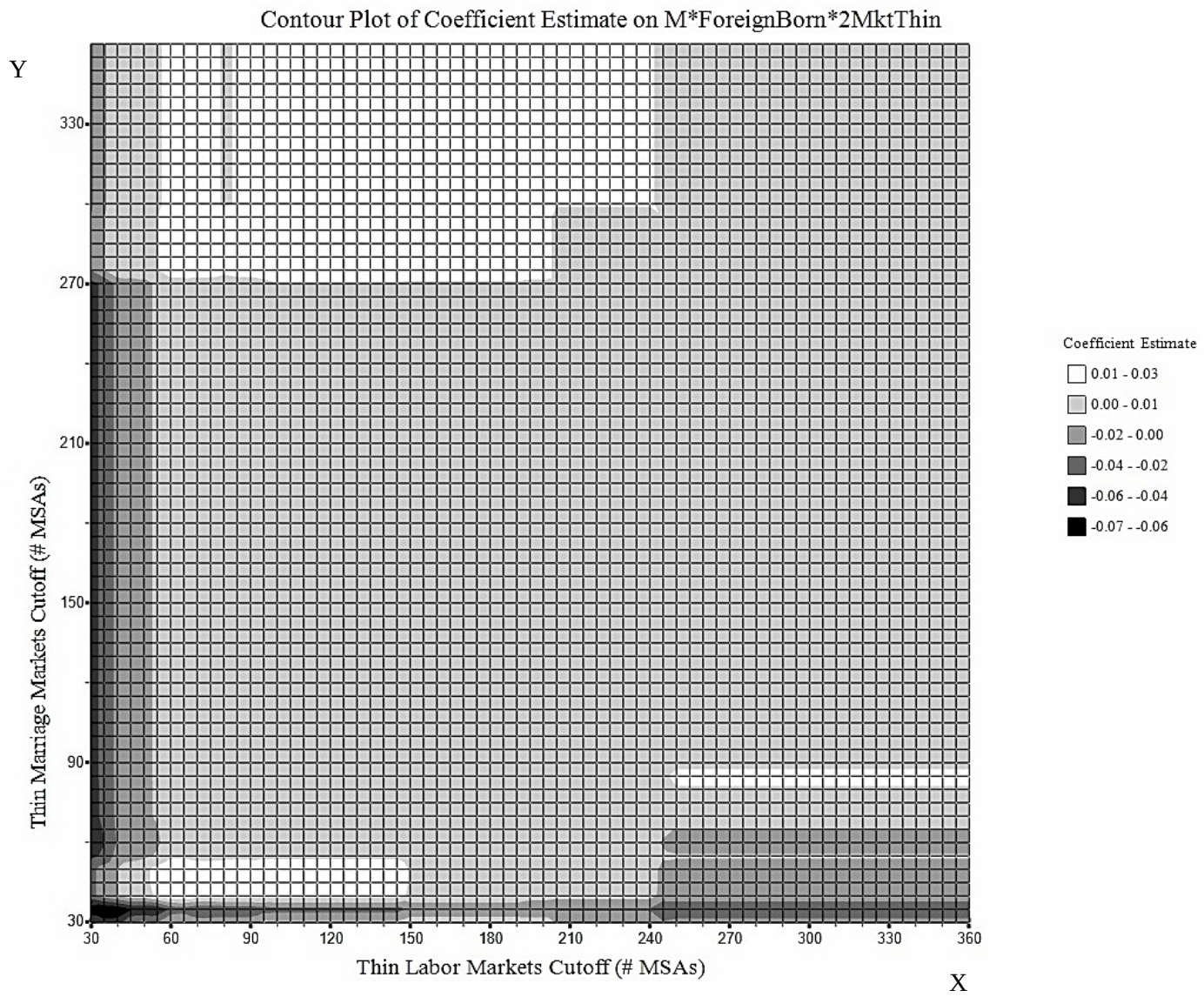

Table 1: Marriage Patterns for Ph.D. Holders by Birth Region (BR), Census Year 2000 [a]

Panel A: Marriage Patterns for Male Ph.D. Holders, Age 25 to 65

Male PhDs' Birth Region(BR) [b]	**Frequency of Wife's Education Level and Birth Region(BR) (in Percentage)**					
	(1) Wife from Same Birth Region	(2) US-Born Wife	(3) Wife with a Ph.D. Degree	(4) Wife with Col+ Education [c]	(5) Same-BR Wife with a Ph.D. Degree	(6) Same-BR Wife with Col+ Education [c]
US-born	92.8	92.8	12.3	77.1	10.8	71.5
Foreign-born	71.6	19.6	15.1	80.7	10.0	57.5
China	95.1	2.4	13.6	84.7	12.8	80.6
India	83.9	10.4	14.9	86.9	12.0	72.6
Korea	94.7	3.6	8.6	85.8	7.9	81.8
Philippines	71.8	21.4	16.9	82.2	14.1	64.9
Eastern Europe	78.6	13.8	22.1	86.7	17.5	70.0
Western Europe	41.2	42.3	16.1	81.7	6.7	31.9

Panel B: Marriage Patterns for Female Ph.D. Holders, Age 25 to 65

Female PhDs' Birth Region(BR) [b]	**Frequency of Husband's Education Level and Birth Region(BR) (in Percentage)**					
	(1) Husband from Same Birth Region	(2) US-Born Husband	(3) Husband with a Ph.D. Degree	(4) Husband with Col+ Education [c]	(5) Same-BR Husband with a Ph.D. Degree	(6) Same-BR Husband with Col+ Education
US-born	93.1	93.1	31.6	83.9	28.2	77.9
Foreign-born	59.7	29.9	48.0	89.8	30.2	53.6
China	78.5	15.2	56.2	96.3	44.1	75.8
India	83.6	12.2	51.6	96.3	44.9	81.1
Korea	66.2	24.7	54.8	90.1	33.7	60.5
Philippines	51.4	40.0	27.0	76.0	14.3	42.1
Eastern Europe	70.6	18.9	54.8	90.7	42.1	65.2
Western Europe	29.8	56.7	46.6	94.3	17.6	29.2

[a] Data are 5% sample decennial census 2000 and are extracted from IPUMS (Ruggles et al., 2010). This table is confined to the married individuals who have a PhD degree. Moreover, these individuals are living in married-couple households in which both spouses are present and have reported their education levels, nativities and places of birth.

[b] US-born is defined as born in the U.S.A. or those born abroad with American Parent(s) and all the others are defined as foreign-born. I group countries into 22 regions mostly based on United Nations Statistics Division, see Appendix Table A4-1 and Table A4-2 for the whole list of birth regions.

[c] Col+ (College-above) education refers to having received at least 4-year college education attainment.

Table 2: Effect of Local Marriage Markets (M) on Labor Market Outcomes (Y)

Consider a model $\boldsymbol{Y} = \alpha M + f(X, A) + \varepsilon$, where *f(X, A)* denotes a function of individual characteristics *X* and location attributes *A*, and ε is a classical error term.

Panel A: Single PhDs Facing Dual Thin Markets

	Sign of α		
Labor Market Outcome *(Y)*	(1) Primary Effect: Sorting	(2) Secondary Effect: Distraction	(3) Two Effects Combined
Hourly Wage	Negative	Negative	Negative
Hours Worked per Year	Ambiguous	Negative	Ambiguous
Annual Earnings	Ambiguous	Negative	Ambiguous

Panel B: Single PhDs Who Are Not Facing Dual Thin Markets

	Sign of α		
Labor Market Outcome *(Y)*	(1) Primary Effect: Sorting	(2) Secondary Effect: Distraction	(3) Two Effects Combined
Hourly Wage	Zero	Negative	Negative
Hours Worked per Year	Zero	Negative	Negative
Annual Earnings	Zero	Negative	Negative

Panel C: Differential Effects: Panel A - Panel B

Labor Market Outcome *(Y)*	**Sign of α**		
	(1) Primary Effect: Sorting	(2) Secondary Effect: Distraction	(3) Two Effects Combined
Hourly Wage	Negative	Negative (close to zero)	**Negative**
Hours Worked per Year	Ambiguous	Negative (close to zero)	Ambiguous
Annual Earnings	Ambiguous	Negative (close to zero)	Ambiguous

Note: Each cell of Panel C is the corresponding cell of Panel A subtracting that of Panel B. I assume that the magnitude of the distraction effect for those facing dual thin markets in Panel A is no less than that for those who are not facing dual thin markets in Panel B.

Table 3: Sample Means for Key Variables
(Standard Deviation Reported in Pretenses)
Fulltime Ph.D. Workers, Age 25 to 65, Pooling Years (1990, 2000 and 2010)

	Single Ph.D. Workers (Core Sample)			Married Ph.D. Workers	
	Both Genders	Female	Male	Female	Male
Hourly Wages (in 1 U.S. dollar of year 1999)	26.1 (29.2)	25.0 (23.1)	27.1 (33.5)	26.6 (19.9)	32.6 (33.6)
Annual Earnings (in 1,000s of 1999 U.S. dollars)	56.0 (31.8)	53.7 (28.4)	58.1 (34.3)	57.3 (33.1)	73.3 (38.7)
Usual Hours Worked per Week	47.7 (9.94)	47.3 (9.53)	48.0 (10.3)	46.2 (8.62)	47.7 (9.32)
Hours Worked per Year	2,310 (646.3)	2,282 (619.7)	2,334 (667.3)	2,229 (583.9)	2,378 (573.5)
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender at year t (1,000s)	60.0 (73.2)	58.1 (67.5)	61.6 (77.7)	50.4 (62.8)	49.9 (68.5)
Total MSA Population at year t (millions)	1.34 (1.23)	1.34 (1.24)	1.33 (1.22)	1.26 (1.17)	1.16 (1.12)
MSA Employment in Own Industry at year t (millions)	0.107 (0.126)	0.108 (0.122)	0.107 (0.129)	0.103 (0.114)	0.094 (0.119)
Age	43.6 (10.3)	44.3 (10.3)	43.1 (10.3)	44.0 (9.29)	46.4 (9.36)
Foreign-Born	0.160 (0.367)	0.126 (0.332)	0.189 (0.392)	0.181 (0.385)	0.207 (0.405)
Hispanic Origin	0.040 (0.195)	0.043 (0.203)	0.037 (0.188)	0.039 (0.193)	0.025 (0.156)
Race is black	0.071 (0.256)	0.093 (0.290)	0.052 (0.222)	0.056 (0.229)	0.031 (0.174)
Has Own Children at Home	0.109 (0.312)	0.154 (0.361)	0.071 (0.257)	0.534 (0.499)	0.629 (0.483)
English Speaking Ability High	0.959 (0.198)	0.964 (0.187)	0.955 (0.208)	0.956 (0.204)	0.949 (0.222)
Live in Home State	0.261 (0.439)	0.288 (0.453)	0.238 (0.426)	0.249 (0.433)	0.203 (0.402)
Years in the U.S. ≤ 10	0.104 (0.305)	0.081 (0.272)	0.124 (0.329)	0.095 (0.293)	0.108 (0.311)
Occupation's Median Earned Income Score in Percentile	76.4 (47.1)	74.4 (38.9)	78.0 (53.0)	76.6 (44.6)	82.1 (68.3)
In a STEM Occupation	0.341 (0.474)	0.308 (0.462)	0.369 (0.483)	0.327 (0.469)	0.357 (0.479)
MSA Average Annual Earnings at year t (in 1,000s of U.S. dollars)	22.6 (4.51)	22.5 (4.51)	22.7 (4.51)	22.6 (4.55)	22.4 (4.56)
MSA Average Working Age at year t	24.3 (1.75)	24.3 (1.77)	24.3 (1.73)	24.4 (1.72)	24.4 (1.73)
Observation	18,796	8,647	10,149	12,621	39,973

Table 4: HOURLY WAGE in Different Age Groups by Gender

Dependent Variable = log (Hourly Wage)						
	Single Female Ph.D. Workers			Single Male Ph.D. Workers		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	6.4e-04 (8.8e-04)	8.3e-04 (7.2e-04)	5.0e-04 (0.001)	-1.5e-04 (2.6e-04)	5.6e-04 (3.6e-04)	-0.002*** (4.5e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.016 (0.035)	0.077* (0.043)	-0.095 (0.068)	0.056 (0.035)	0.094** (0.047)	-0.041 (0.064)
M × Foreign-Born	-0.019** (0.010)	-0.029*** (0.011)	-0.008 (0.008)	-0.011* (0.006)	-0.008 (0.010)	-0.023** (0.010)
Urbanization Effects						
Total MSA Population (millions)	0.083* (0.045)	-0.006 (0.459)	0.191** (0.80)	0.091** (0.046)	0.079 (0.078)	0.142 (0.0969)
Localization Effects						
MSA Employment in Own Industry (millions)	0.183 (0.130)	0.155 (0.142)	0.178 (0.169)	-0.090 (0.119)	-0.222 (0.151)	0.0357 (0.144)
MSA Fixed Effects	299	270	278	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.178	0.220	0.177	0.225	0.233	0.256
Observations	8,647	4,432	4,215	10,149	5,709	4,440

[a] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. Hourly wage = annual earnings / hours worked per year. Hours worked per Year = usual hours worked per week × weeks worked last year. ACS 2010 only reports the range of weeks a worker worked in previous 12 months, and I use the midpoint as the representative level for an individual's working weeks.

[b] To reserve space here, I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 5-1: HOURS WORKED PER YEAR in Different Age Groups by Gender

Dependent Variable = Hours Worked per Year						
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	-1.803**	-2.666**	-0.250	-0.197	-0.898	1.460
	(0.761)	(1.065)	(0.884)	(0.760)	(0.782)	(1.190)
Foreign-Born (=1 if the worker is not a US-Born)	-101.1**	-99.42**	-85.10	-9.838	-23.39	4.685
	(45.71)	(45.33)	(86.00)	(37.76)	(49.15)	(66.86)
M × Foreign-Born	-5.808	-4.357	-5.331	-8.722	-14.80*	6.362
	(11.32)	(20.66)	(13.68)	(8.166)	(8.644)	(13.02)
Urbanization Effects						
Total MSA Population (millions)	20.50	95.44	-70.91	6.165	-2.856	-13.96
	(54.55)	(92.86)	(126.0)	(44.82)	(77.88)	(75.83)
Localization Effects						
MSA Employment in Own Industry (millions)	23.75	-162.0	246.9	24.36	87.65	-128.4
	(112.5)	(150.1)	(171.7)	(119.4)	(132.4)	(158.9)
MSA Fixed Effects	299	270	278	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.070	0.098	0.123	0.063	0.085	0.110
Observations	8,647	4,432	4,215	10,149	5,709	4,440

[a] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. Hours worked per Year = usual hours worked per week × weeks worked last year. ACS 2010 only reports the range of weeks a worker worked in previous 12 months, and I use the midpoint as the representative level for an individual's working weeks.

[b] I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 5-2: ANNUAL EARNINGS in Different Age Groups by Gender

Dependent Variable = log (Annual Earnings)						
	Single Female Ph.D. Workers			Single Male Ph.D. Workers		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	-5.6e-04 (7.8e-04)	-6.3e-04 (7.0e-04)	-2.3e-04 (0.001)	-2.6e-04 (5.4e-04)	7.6e-05 (6.4e-04)	-9.0e-04 (5.8e-04)
Foreign-Born (=1 if the worker is not a US-Born)	-0.027 (0.037)	0.026 (0.042)	-0.103 (0.0913)	0.058* (0.033)	0.084** (0.042)	-0.015 (0.072)
M × Foreign-Born	-0.024** (0.011)	-0.032*** (0.011)	-0.012 (0.017)	-0.013 (0.008)	-0.012 (0.014)	-0.018* (0.010)
Urbanization Effects						
Total MSA Population (millions)	0.107* (0.058)	0.044 (0.072)	0.179 (0.133)	0.065 (0.058)	0.054 (0.081)	0.098 (0.089)
Localization Effects						
MSA Employment in Own Industry (millions)	0.227** (0.109)	0.088 (0.136)	0.332** (0.137)	-0.088 (0.122)	-0.152 (0.137)	-0.088 (0.185)
MSA Fixed Effects	299	270	278	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.189	0.240	0.196	0.215	0.251	0.211
Observations	8,647	4,432	4,215	10,149	5,709	4,440

[a] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[b] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 5-3: Labor Market Outcomes for Married Ph.D. Workers by Gender, Age 25 to 65

	Hours Worked per Year		log (Hourly Wage)		log (Annual Earnings)	
	(1) Female	(2) Male	(3) Female	(4) Male	(5) Female	(6) Male
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	-0.309 (0.409)	0.012 (0.145)	-3.7e-04 (4.1e-04)	2.9e-04* (1.7e-04)	-5.2e-04 (4.5e-04)	4.1e-04** (1.8e-04)
Foreign-Born (=1 if the worker is not a US-Born)	-112.7*** (26.95)	-126.0*** (17.92)	-0.035 (0.024)	0.032** (0.016)	-0.075*** (0.028)	-0.021 (0.017)
M × Foreign-Born	-4.838 (4.673)	-9.542*** (2.450)	-0.018** (0.007)	-0.008*** (0.003)	-0.018** (0.008)	-0.012*** (0.004)
Urbanization Effects						
Total MSA Population (millions)	-45.08 (37.16)	-53.79** (22.56)	0.106* (0.057)	0.057*** (0.021)	0.092 (0.069)	0.028 (0.021)
Localization Effects						
MSA Employment in Own Industry (millions)	11.68 (83.74)	35.52 (59.72)	-0.104 (0.136)	-0.069 (0.051)	-0.086 (0.166)	-0.048 (0.065)
MSA Fixed Effects	310	319	310	319	310	319
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.072	0.063	0.161	0.187	0.167	0.185
Observations	12,621	39,973	12,621	39,973	12,621	39,973

a Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on MSA count of other own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age, MSA average annual earnings, and also those on individual characteristics of the worker, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on characteristics of the worker's spouse, e.g. spouse's education, age, age square, employ status, English speaking ability, whether in a STEM occupation, occupation's median earned income and living in home state or not.

b Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 5-4: Influence of Marriage and Children

HOURLY WAGE for Young (Age 25 to 44) Female Ph.D. Workers

Dependent Variable = log (Hourly Wage)		
	All Single Women + Married Women Who Moved to Current MSA Post-Marriage	
	(1) With or Without Own Children In the Household	(2) Without Own Child In the Household
MSA Count of Own-Ethnic Col+ Single of Opposite Gender in 1,000s (***M***)	5.3e-04	2.7e-04
	(5.4e-04)	(6.3e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.067*	0.136***
	(0.038)	(0.041)
Single	0.111	-0.665
	(0.480)	(0.668)
M × Foreign-Born	-0.023**	-0.009
	(0.010)	(0.017)
M × Foreign-Born × Single	-0.008	-0.024**
	(0.007)	(0.011)
Has Own Children in the Household	0.081***	-
	(0.021)	-
MSA Fixed Effects	285	264
Industry Fixed Effects	21	21
Year Fixed Effects	Yes	Yes
Individual Characteristics	Yes	Yes
R-squared	0.247	0.222
Observations	5,600	4,214

a Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on urbanization effects, localization effects, MSA count of own-ethnic workers excluding Col+ single of the opposite gender, MSA average working age, MSA average annual earnings, and also on individual characteristics of the worker, e.g. age, square of age, occupation's median earned income, Hispanic origin, Black race, English Speaking Ability high or medium, no household member age 14+ speaks English very well, years in the U.S. ≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on characteristics of the worker's spouse, e.g. spouse's education, age, age squared, employ status, English speaking ability.

b Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Extensions -Table 6-1: Both Marriage Markets and Labor Markets Are Thin, Using Different Cutoffs

HOURLY WAGE for Single Female Ph.D. Workers, Age 25 to 65

	Dependent Variable = log (Hourly Wage)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Marriage Markets Are Thin if Number of Active Marriage Markets	< 1 MSA	<31 MSAs	<36 MSAs	<36 MSAs	<36 MSAs	<41 MSAs	<81 MSAs	<161 MSAs	<361 MSAs
Labor Markets Are Thin if Number of Active Labor Markets	<1 MSA	<31 MSAs	<31 MSAs	<36 MSAs	<41 MSAs	<41 MSAs	<81 MSAs	<161 MSAs	<361 MSAs
MSA Own-Ethnic Col+ Single Men in 1,000s (**M**)	6.4e-04 (8.8e-04)	6.1e-04 (8.8e-04)	6.2e-04 (8.5e-04)	6.2e-04 (8.6e-04)	6.1e-04 (8.5e-04)	6.6e-04 (8.6e-04)	6.7e-04 (8.7e-04)	7.2e-04 (8.9e-04)	6.4e-04 (8.8e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.016 (0.035)	0.017 (0.036)	0.014 (0.036)	0.011 (0.036)	0.008 (0.037)	0.001 (0.035)	0.0059 (0.036)	-0.011 (0.041)	0.016 (0.035)
Both Marriage and Labor Markets are Thin (**2MktThin**)	- -	-0.015 (0.152)	0.062 (0.111)	0.105 (0.096)	0.106 (0.090)	0.121* (0.072)	0.040 (0.053)	0.066 (0.049)	- -
M × Foreign-Born	-0.019** (0.010)	-0.020** (0.010)	-0.017 (0.011)	-0.016 (0.011)	-0.016 (0.011)	-0.018 (0.011)	-0.020 (0.013)	-0.024** (0.012)	-0.019** (0.010)
M × Foreign-Born × **2MktThin**	- -	-0.039 (0.057)	-0.065*** (0.025)	-0.072*** (0.021)	-0.069*** (0.022)	-0.004 (0.036)	0.003 (0.014)	0.009 (0.010)	- -
Observations with **2MktThin=1**	0	40	55	67	92	119	342	550	8647
R-squared	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178
Observations	8,647	8,647	8,647	8,647	8,647	8,647	8,647	8,647	8,647

[a] For a person, an MSA is an active marriage market if the number of own-ethnic col+ singles of the opposite gender ≥ 200; an MSA is classified as an active labor market if the number of own-industry Ph.D. workers ≥ 200. Under these local cutoffs to define an MSA as an active marriage or labor market, each column in this table change the national-level cutoffs to define whether an individual is faced with a dual thin market. The variable "2MktThin" = 1 if marriage and labor markets are both thin for a person and 0 otherwise. Sample is restricted to Ph.D. fulltime workers whose usual hours worked per week ≥ 35hours. And I pool observations from the survey years 1990, 2000 and 2010.

[b] To reserve space I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on urbanization effect, localization effect, MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year. I also include year fixed effects, MSA fixed effects and industry fixed effects.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Extensions -Table 6-2: Both Marriage Markets and Labor Markets Are Thin, Using the Preferred Definition

HOURLY WAGE in Different Age Groups by Gender

Dependent Variable = log (Hourly Wage)						
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	6.2e-04	7.5e-04	5.2e-04	-1.2e-04	5.8e-04	-0.002***
	(8.6e-04)	(6.9e-04)	(0.001)	(2.6e-04)	(3.6e-04)	(4.7e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.011	0.072*	-0.082	0.045	0.095**	-0.037
	(0.036)	(0.043)	(0.071)	(0.033)	(0.044)	(0.065)
Both Marriage and Labor Markets for This Worker are Thin (**2MktThin**)	0.105	0.123	-0.157	0.095	-0.008	-0.031
	(0.096)	(0.115)	(0.168)	(0.0648)	(0.065)	(0.162)
M × Foreign-Born	-0.016	-0.028**	-0.012	-0.012**	-0.010	-0.024**
	(0.011)	(0.012)	(0.008)	(0.005)	(0.010)	(0.010)
M × Foreign-Born × **2MktThin**	-0.072***	-0.110**	0.054	0.014	0.021	0.011
	(0.021)	(0.047)	(0.057)	(0.013)	(0.015)	(0.023)
MSA Fixed Effects	299	270	278	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.178	0.220	0.177	0.225	0.233	0.256
Observations	8,647	4,434	4,215	10,151	5,709	4,440

[a] Both marriage and labor markets are thin for a given worker if the number of active marriage markets < 36 MSAs and the number of active labor markets < 36 MSAs. An MSA is classified as an active marriage market if the number of own-ethnic col+ singles of the opposite gender ≥ 200. An MSA is defined as an active labor market if the number of own-industry Ph.D. workers ≥ 200.

[b] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on urbanization effect, localization effect, MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Extensions-Table 6-3: Both Marriage Markets and Labor Markets Are Thin, Using the Preferred Definition

HOURS WORKED PER YEAR in Different Age Groups by Gender

Dependent Variable = Hours Worked per Year						
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s **(M)**	-1.822**	-2.729**	-0.216	-0.160	-0.857	1.467
	(0.772)	(1.098)	(0.868)	(0.752)	(0.786)	(1.158)
Foreign-Born (=1 if the worker is not a US-Born)	-87.53*	-86.77*	-64.51	6.589	-5.722	7.402
	(45.80)	(45.20)	(85.65)	(38.80)	(49.82)	(66.46)
Both Marriage and Labor Markets for This Worker are Thin (**2MktThin**)	-216.7*	-247.6	-252.0	-129.2*	-131.6	-23.46
	(119.0)	(159.9)	(219.1)	(70.95)	(84.00)	(126.2)
M × Foreign-Born	-8.704	-7.455	-13.10	-12.33	-19.26**	5.696
	(12.08)	(21.89)	(12.25)	(9.386)	(8.807)	(14.04)
M × Foreign-Born × **2MktThin**	50.90*	48.00	98.20**	33.89*	43.56***	5.364
	(26.95)	(37.97)	(43.48)	(18.82)	(12.54)	(47.16)
MSA Fixed Effects	299	270	278	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.071	0.101	0.086	0.063	0.086	0.112
Observations	8,652	4,434	4,215	10,151	5,710	4,441

[a] Both marriage and labor markets are thin for a given worker if the number of active marriage markets < 36 MSAs and the number of active labor markets < 36 MSAs. An MSA is classified as an active marriage market if the number of own-ethnic col+ single of the opposite gender ≥ 200. An MSA is defined as an active labor market if the number of own-industry Ph.D. workers ≥ 200.

[b] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S. ≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on urbanization effect, localization effect, MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Extensions-Table 6-4: Both Marriage Markets and Labor Markets Are Thin, Using the Preferred Definition

ANNUAL EARNINGS in Different Age Groups by Gender

Dependent Variable = log (Annual Earnings)						
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	(1) Female Age 25 to 65	(2) Female Age 25 to 44	(3) Female Age 45 to 65	(4) Male Age 25 to 65	(5) Male Age 25 to 44	(6) Male Age 45 to 65
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	-5.9e-04	-7.3e-04	-1.7e-05	-2.2e-04	1.2e-04	-8.9e-04
	(7.7e-04)	(7.0e-04)	(0.001)	(5.5e-04)	(6.5e-04)	(5.7e-04)
Foreign-Born (=1 if the worker is not a US-Born)	-0.023	0.028	-0.070	0.058*	0.098**	-0.011
	(0.038)	(0.043)	(0.089)	(0.032)	(0.040)	(0.071)
Both Marriage and Labor Markets for This Worker are Thin (**2MktThin**)	-0.037	-0.014	-0.389	0.004	-0.108	-0.040
	(0.108)	(0.100)	(0.254)	(0.069)	(0.074)	(0.162)
M × Foreign-Born	-0.023**	-0.032***	-0.022	-0.016**	-0.018	-0.020**
	(0.012)	(0.012)	(0.015)	(0.008)	(0.013)	(0.010)
M × Foreign-Born × **2MktThin**	-0.030	-0.074	0.138**	0.035***	0.051***	0.012
	(0.028)	(0.053)	(0.066)	(0.012)	(0.016)	(0.021)
MSA Fixed Effects	299	269	270	305	282	283
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.190	0.241	0.196	0.215	0.251	0.211
Observations	8,647	4,434	4,215	10,151	5,709	4,440

[a] Both marriage and labor markets are thin for a given worker if the number of active marriage markets < 36 MSAs and the number of active labor markets < 36 MSAs. An MSA is classified as an active marriage market if the number of own-ethnic col+ single of the opposite gender ≥ 200. An MSA is defined as an active labor market if the number of own-industry Ph.D. workers ≥ 200.

[b] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on urbanization effect, localization effect, MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Appendix

Table A1-1: HOURLY WAGE for Single Female Ph.D. Workers, Age 25 to 65 [a]

Dependent Variable = log (Hourly Wage)			
	(1)	(2)	(3)
MSA Own-Ethnic Col+ Single Men in 1,000s (**M**)	0.001*	0.001*	6.4e-04
	(6.6e-04)	(6.7e-04)	(8.8e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.005	0.006	0.016
	(0.034)	(0.034)	(0.035)
M × Foreign-Born	-	-	-0.019**
	-	-	(0.010)
Urbanization Effects			
Total MSA Population (millions)	0.081*	0.068	0.083*
	(0.043)	(0.043)	(0.045)
Localization Effects			
MSA Employment in Own Industry (millions)	-	0.174	0.183
	-	(0.133)	(0.130)
MSA Fixed Effects	299	299	299
Industry Fixed Effects	21	21	21
Year Fixed Effects	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes
R-squared	0.177	0.177	0.178
Observations	8,647	8,647	8,647

[a] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. Hourly wage = annual earnings / hours worked per year. Hours worked per Year = usual hours worked per week × weeks worked last year. ACS 2010 only reports the range of weeks a worker worked in previous 12 months, and I use the midpoint as the representative level for an individual's working weeks.

[b] To reserve space here I suppress the coefficient estimates on individual characteristics, e.g., age, square of age, occupation's median earned income, having own children present in the house or not, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state or not, and also those on MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender in 1,000s, MSA average working age and MSA average annual earnings at the given survey year.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table A1-2: Labor Market Outcomes for <u>All Single Ph.D. Workers (Male + Female)</u>, Age 25 to 65

	(1) **log (Hourly Wage)**	(2) **Hours Worked per Year**	(3) **log (Annual Earnings)**
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	2.4e-04 (2.0e-04)	-0.141 (0.437)	-1.5e-05 (3.0e-04)
Foreign-Born(=1 if the worker is not a US-Born)	0.042* (0.025)	-47.76 (30.40)	0.023 (0.026)
M × Foreign-Born	-0.014*** (0.004)	-4.890 (6.659)	-0.015*** (0.005)
<u>Urbanization Effects</u>			
Total MSA Population (millions)	0.085** (0.037)	-7.138 (38.07)	0.070 (0.049)
<u>Localization Effects</u>			
MSA Employment in Own Industry (millions)	0.001 (0.106)	33.38 (67.61)	0.023 (0.105)
MSA Fixed Effects	311	311	311
Industry Fixed Effects	21	21	21
Year Fixed Effects	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes
R-squared	0.184	0.046	0.184
Observations	18,796	18,803	18,796

a Sample is restricted to fulltime Ph.D. worker whose usual hours worked per week ≥ 35hours. I pool observations from the survey years 1990, 2000 and 2010. Hourly wage = annual earnings / hours worked per year. Hours worked per Year = usual hours worked per week × weeks worked last year. ACS 2010 only reports the range of weeks a worker worked in previous 12 months, and I use the midpoint as the representative level for his/her working weeks.

b I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S. ≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year.

c Standard errors are clustered at MSA level and reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table A2: Both Marriage Markets and Labor Markets Are Thin, Using Different Cutoffs

HOURLY WAGE for Single Male Ph.D. Workers, Age 25 to 65

Dependent Variable = log (Hourly Wage)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Marriage Markets Are Thin if the Number of Active Marriage Markets	< 1 MSA	<31 MSAs	<36 MSAs	<36 MSAs	<36 MSAs	<41 MSAs	<81 MSAs	<161 MSAs	<361 MSAs
Labor Markets Are Thin if the Number of Active Labor Markets	<1 MSA	<31 MSAs	<31 MSAs	<36 MSAs	<41 MSAs	<41 MSAs	<81 MSAs	<161 MSAs	<361 MSAs
MSA Own-Ethnic Col+ Single Women in 1,000s (**M**)	-1.4e-04	-1.3e-04	-1.5e-04	-1.2e-04	-1.2e-04	-1.1e-04	-1.5e-04	-1.6e-04	-1.4e-04
	(2.6e-04)	(2.6e-04)	(2.6e-04)	(2.6e-04)	(2.7e-04)	(2.7e-04)	(2.6e-04)	(2.7e-04)	(2.6e-04)
Foreign-Born (=1 if the worker is not a US-Born)	0.056	0.049	0.042	0.045	0.046	0.045	0.040	0.018	0.056
	(0.035)	(0.035)	(0.033)	(0.033)	(0.033)	(0.033)	(0.035)	(0.040)	(0.035)
Both Marriage and Labor Markets are Thin (**2MktThin**)	-	0.098	0.116*	0.095	0.066	0.079	0.045	0.072*	-
	-	(0.070)	(0.0673)	(0.065)	(0.065)	(0.065)	(0.038)	(0.039)	-
M × Foreign-Born	-0.011*	-0.010	-0.010*	-0.012**	-0.012***	-0.013***	-0.018***	-0.022***	-0.011*
	(0.006)	(0.006)	(0.005)	(0.00516)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)
M × Foreign-Born × **2MktThin**	-	0.030	-0.005	0.014	0.013	0.016	0.015**	0.015**	-
	-	(0.033)	(0.015)	(0.013)	(0.019)	(0.016)	(0.007)	(0.006)	-
Observations with **2MktThin=1**	0	155	232	252	293	329	723	1,088	10,149
R-squared	0.224	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.224
Observations	10,149	10,149	10,149	10,149	10,149	10,149	10,149	10,149	10,149

[a] An MSA is an active marriage market if the number of own-ethnic col+ singles of the opposite gender ≥ 200. An MSA is an active labor market if the number of own-industry Ph.D. workers ≥ 200. Under these local cutoffs to define an MSA as an active marriage or as an active labor market, each column in this table change the national-level cutoffs to define whether an individual is faced with a dual thin market. The variable "*2MktThin*" = 1 if marriage and labor markets are both thin for a person and 0 otherwise. Sample is restricted to Ph.D. fulltime workers whose usual hours worked per week ≥ 35hours, and I pool observations from the survey years 1990, 2000 and 2010.

[b] To reserve space I suppress the coefficient estimates on individual characteristics, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥ 20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on urbanization effects, localization effects, MSA count of own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age and MSA average annual earnings at the given survey year. I also include year fixed effects, MSA fixed effects and industry fixed effects.

[c] Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table A3: Both Marriage Markets and Labor Markets Are Thin, Using the Preferred Definition

Labor Market Outcomes for Married Ph.D. Workers by Gender, Age 25 to 65

	Hours Worked per Year		log (Hourly Wage)		log (Annual Earnings)	
	(1) Female	(2) Male	(3) Female	(4) Male	(5) Female	(6) Male
MSA Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s (**M**)	-0.328 (0.409)	0.0215 (0.149)	-4.3e-04 (4.2e-04)	2.7e-04 (1.7e-04)	-6.0e-04 (4.5e-04)	3.9e-04** (1.8e-04)
Foreign-Born (=1 if the worker is not a US-Born)	-116.6*** (27.43)	-122.8*** (18.26)	-0.037 (0.024)	0.016 (0.016)	-0.081*** (0.028)	-0.035** (0.018)
Both Marriage and Labor Markets for This Worker are Thin (**2MktThin**)	73.75 (62.41)	-25.75 (20.02)	0.024 (0.066)	0.121*** (0.025)	0.108 (0.081)	0.108*** (0.025)
M × Foreign-Born	-3.429 (5.261)	-10.72*** (2.126)	-0.016** (0.007)	-0.007*** (0.003)	-0.015* (0.009)	-0.012*** (0.004)
M × Foreign-Born × **2MktThin**	-32.14 (31.09)	9.726 (12.03)	-0.046*** (0.017)	-0.004 (0.007)	-0.083** (0.036)	0.001 (0.008)
MSA Fixed Effects	310	319	310	319	310	319
Industry Fixed Effects	21	21	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.073	0.063	0.161	0.188	0.168	0.185
Observations	12,621	39,973	12,621	39,973	12,621	39,973

a Both marriage and labor markets are thin for a given worker if the number of active marriage markets < 36 MSAs and the number of active labor markets < 36 MSAs. An MSA is classified as an active marriage market if the number of own-ethnic col+ single of the opposite gender ≥ 200. An MSA is defined as an active labor market if the number of own-industry Ph.D. workers ≥ 200.

b Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I pooling observations from the survey years 1990, 2000 and 2010. I suppress the coefficient estimates on urbanization effects, localization effects, MSA count of other own-ethnic workers excluding the Col+ singles of the opposite gender, MSA average working age, MSA average annual earnings, and also those on individual characteristics of the worker, e.g. age, square of age, occupation's median earned income, having own children present in the house, number of own children age ≤ 4, age of eldest own child in household ≥20, Hispanic origin, Black race, English speaking ability high or medium, no household member age 14+ speaks English very well, years in the U.S.≤ 10, in a STEM occupation, working on wage/salary in private sectors, living in home state, and also those on characteristics of the worker's spouse, e.g. spouse's education, age, age square, employ status, English speaking ability, whether in a STEM occupation, occupation's median earned income and living in home state or not.

c Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table A4-1: Distribution of Col+ Single Men among U.S. MSAs by Ethnicity (Birth Region):

Number of MSAs in 6 Size Categories, [a]
Size Categories Based on MSA Count of Own-Ethnic Col+ Single Men (*M*)
Year 1990 and Year 2010

	(1)		(2)		(3)		(4)		(5)		(6)	
MSA Size Categories Are Based on *MSA Count of Own-Ethnic Col+ Single Men (M)*	$200 \leq M \leq 499$		$500 \leq M \leq 999$		$1000 \leq M \leq 1999$		$2000 \leq M \leq 3999$		$4000 \leq M \leq 7999$		$M \geq 8000$	
	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010
Ethnicity (Birth Region)												
United States	2[b]	3	18	10	53	34	73	54	47	80	80	116
Canada	10	17	5	15	2	2	0	2	0	0	0	0
Other North America	0	0	0	0	0	0	0	0	0	0	0	0
Central America and Caribbean	16	31	11	16	5	14	0	14	2	4	1	3
Southern America	14	31	4	10	1	8	2	4	1	2	0	1
Northern Europe	16	18	6	14	3	6	1	1	0	1	0	0
Western Europe	13	26	8	10	2	3	1	1	0	1	0	0
Southern Europe	10	21	4	9	1	3	1	0	0	1	0	0
Eastern Europe	15	29	3	10	1	9	2	2	0	1	0	1
China	10	31	6	17	4	5	0	4	2	3	0	2
Japan	7	10	0	2	2	2	0	0	0	0	0	0
Korea	6	19	0	6	1	6	1	0	0	2	0	0
Other East Asia	0	2	0	0	0	0	0	0	0	0	0	0
Philippines	10	20	4	7	4	8	0	6	1	0	0	1
Vietnam	7	12	1	13	3	5	0	3	0	1	0	0
Other Southeast Asia	8	17	1	9	1	3	0	1	0	0	0	0
India	20	34	7	22	4	15	2	13	0	3	0	1
Other South Asia	7	11	6	8	2	2	0	1	1	1	0	0
Middle East	9	19	5	10	0	1	2	3	0	0	0	0
Africa	13	31	6	15	2	7	2	7	0	2	0	0
Oceania	2	5	0	2	0	1	0	0	0	0	0	0
Other	8	0	6	0	1	0	1	0	0	0	0	0

[a] Column (1) to (6) represent six size categories based on the number of single men within their own ethnicity and with a college or higher level of education at the MSA for a given year.

[b] Each cell in the table reports the number of MSAs fall into one size category for a given ethnicity and year. For example, for the US-born, the first column under the year 1990 shows that in 1990, there are 2 MSAs across the U.S. that have a MSA count of US-born col+ single men between 200 and 499.

Table A4-2: Distribution of Col+ Single Women among U.S. MSAs by Ethnicity (Birth Region):

Number of MSAs in 6 Size Categories, [a]
Size Categories Based on MSA Count of Own-Ethnic Co+ Single Women (*W*)
Year 1990 and Year 2010

	(1)		(2)		(3)		(4)		(5)		(6)	
MSA Size Categories Are Based on *MSA Count of Own-Ethnic Col+ Single Women (W)*	$200 \leq W \leq 499$		$500 \leq W \leq 999$		$1000 \leq W \leq 1999$		$2000 \leq W \leq 3999$		$4000 \leq W \leq 7999$		$W \geq 8000$	
	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010
Ethnicity (Birth Region)												
United States	0[b]	0	20	4	54	17	64	55	50	75	85	146
Canada	13	24	2	8	2	3	0	2	0	0	0	0
Other North America	0	2	0	0	0	0	0	0	0	0	0	0
Central America and Caribbean	15	35	11	24	4	14	1	11	1	5	2	4
Southern America	7	26	4	17	2	9	1	5	1	2	0	2
Northern Europe	10	25	7	6	2	4	1	1	0	1	0	0
Western Europe	18	19	4	9	2	4	1	2	0	1	0	0
Southern Europe	5	20	2	7	0	2	1	1	0	0	0	0
Eastern Europe	9	25	2	21	2	9	1	1	0	2	0	2
China	11	32	5	13	1	7	1	3	2	4	0	2
Japan	1	15	2	4	0	1	0	1	0	1	0	0
Korea	6	26	2	7	2	6	0	4	0	2	0	0
Other East Asia	0	2	0	0	0	0	0	0	0	0	0	0
Philippines	8	28	10	10	4	12	3	8	1	4	1	1
Vietnam	5	18	4	9	0	6	0	2	0	1	0	0
Other Southeast Asia	7	17	0	9	1	4	0	1	0	0	0	0
India	11	33	2	17	1	7	0	7	0	1	0	0
Other South Asia	6	13	1	3	1	1	0	2	0	0	0	0
Middle East	2	13	2	5	1	2	0	2	0	0	0	0
Africa	7	20	3	14	1	6	0	2	0	1	0	0
Oceania	2	5	0	4	0	2	0	0	0	0	0	0
Other	8	2	2	0	1	0	1	0	0	0	0	0

[a] Column (1) to (6) represent six size categories based on the number of single women with own ethnicity and with a college or higher level of education at the MSA for a given year.

[b] Each cell in the table reports the number of MSAs fall into one size category for a given ethnicity and year. For example, for the US-born, the first column under year 1990 shows that in 1990, there is no MSA in the U.S that has a MSA count of US-born col+ single women falling between 200 and 499.

Table A5: Number of MSAs in 4 Size Categories Based on MSA Count of Own-Industry Ph.D. Workers (I)

PANEL A: Year 1990

MSA Size Categories Are Based on ***MSA Count of Own-Industry Ph.D. Workers (I)***	$100 \leq I \leq 199$	$200 \leq I \leq 499$	$500 \leq I \leq 999$	$I \geq 1000$
Industry				
Agriculture	9	2	0	0
Mining	2	2	1	1
Construction	13	7	2	0
Manufacturing	36	28	20	21
Transportation, Communication, Electricity and Gas	21	7	5	0
Wholesale	14	10	2	0
Retail	26	8	4	1
FIRE	28	12	8	3
Computer and Data Processing	13	8	2	0
Health Service	48	50	19	23
Legal Service	29	14	3	3
Education	41	66	48	90
Social Service	13	5	1	1
Museum, Art, Zoo	3	1	0	0
Membership Organization	30	17	3	3
Engineering	15	4	4	0
Accounting, Audit	2	1	0	0
R&D, Testing	21	22	12	12
Management and Public Relation	24	23	7	8
Other Services	20	10	3	1
Public Administration	33	31	10	3

PANEL B: Year 2010

MSA Size Categories Are Based on ***MSA Count of Own-Industry Ph.D. Workers (I)***	$100 \leq I \leq 199$	$200 \leq I \leq 499$	$500 \leq I \leq 999$	$I \geq 1000$
Industry				
Agriculture	27	17	2	0
Mining	5	2	0	1
Construction	14	5	2	0
Manufacturing	32	40	26	31
Transportation, Communication, Electricity and Gas	16	17	10	2
Wholesale	15	13	2	0
Retail	47	34	21	9
FIRE	29	25	12	7
Computer and Data Processing	14	13	11	5
Health Service	37	62	58	71
Legal Service	26	38	26	14
Education	41	66	48	90
Social Service	22	26	7	0
Museum, Art, Zoo	6	6	1	0
Membership Organization	33	49	13	8
Engineering	30	20	3	4
Accounting, Audit	7	5	0	0
R&D, Testing	26	41	17	22
Management and Public Relation	41	28	13	9
Other Services	23	19	10	3
Public Administration	38	50	23	10

Chapter 3

Marriage Market Versus Job Co-Location: Location Choices of Ph.D.-Trained Singles and Couples

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1. Introduction

From 1990 to 2010, Ph.D. workers increasingly concentrate in large metropolitan areas (MSAs) in the United States. The share of Ph.D. workers located in large MSAs is 25.2% in 1990, 32.5% in 2000, and 39.4% in 2010 (Appendix Table A1). Moreover, during this period, nearly half of foreign-born[40] Ph.D. workers live in bigger cities that have a large population of their own ethnicity. One possible driver for such trend is the job co-location pressure faced by dual-career households — as highlighted by Costa and Kahn (2000), large cities can offer more opportunities for both spouses in the family to secure a high-quality job that is also within a reasonable commute from their home. Another contributing reason may be that Ph.D.-trained singles prefer to live in large cities to access better dating opportunities, as pointed out by Compton and Pollak (2007). This may be especially true for foreign-born Ph.D. workers. That is because foreign-born PhDs disproportionately marry individuals with at least a college degree and within their own ethnicity (Table 1, I will discuss shortly). Moreover, their highly educated own-ethnic potential dates are often not ubiquitous in the host country. For these reasons, single Ph.D. workers facing thin marriage markets may choose to live in bigger cities that can provide an active dating environment.[41] This paper explores evidence and implications of the relative importance of marriage markets versus job co-location effects in driving location choices of Ph.D. workers, in particular for those not born in the US.

The degree to which local marriage markets can attract Ph.D.-trained workers could have substantial impacts on the intensity of innovative activity in the local areas. In part, that is because Ph.D.-trained workers, and especially those foreign-born, account for a significant share

[40] Foreign-born is defined as those who are not born in the United States and neither parent is American.
[41] For example, as indicated by Table 2-1 and 2-1, among the Top 25 MSAs in 2010 that have scores of new-arrival Ph.D. workers from China and India, most of them are large or midsize cities with historically sizable Chinese and Indian population.

of new product innovation in the United States. According to the RIETI Georgia Tech inventor survey, 46 % of the inventors who file patents in the U.S. have a doctoral degree (Walsh and Nagaoka, 2009). Moreover, foreign-born Ph.D. workers are overrepresented in the STEM (Science, Technology, Engineering, and Mathematics) fields. Among the scientists and engineers with a Ph.D., nearly 55% are foreign born, and roughly 30% are born in China or India.[42] As Figure 1 shows, across top 30 MSAs that generate a large number of high-quality patents in the year 2001,[43] the number of patents created almost lines up with the MSA count of new-arrival Ph.D. STEM workers from China and India in 2000.

It is also important to recognize that foreign-born Ph.D. workers face with thin marriage markets in the sense that there are a few MSAs that can provide them an active dating environment. That is because Ph.D. workers tend to marry individuals with a college or higher level of education. Besides, foreign-born Ph.D. workers, especially for those from China and India, marry primarily within their ethnicity. Table 1 provides evidence of these marriage patterns. In Panel A Column (6), 71.5% of US-born male Ph.D. holders marry a US-born woman with at least a four-year college education attainment. Similarly, among Chinese and Indian male PhDs, 80.6% and 72.4% marry an own-ethnic woman with at least a college degree, respectively. Moreover, Chinese and Indian female PhDs display a further strong tendency to marry a Ph.D. of their ethnicity: roughly 45% marry a Ph.D. of own ethnicity compared to just 13% for their male counterparts. Since there are few MSAs in the U.S. with scores of single, foreign-born college-educated workers, single foreign-born PhDs may have more restriction in choosing where to live

[42] Since 1990, there is an exceptional growth of U.S. patents created by ethnic inventors. According to Kerr (2010), the share of patents created by Chinese and Indian inventors increased from about 2% in the year 1990 to 9% and to 6% in 2004, respectively.

[43] High-quality patents here refer to top cited patents that received a number of citations among top 10% within its own technology category.

compared to their domestic born counterparts, who can find sizable numbers of potential dates in many more MSAs.[44]

I focus on and differentiate between two household types when modeling the manner in which Ph.D. workers choose among different city sizes. One household type is "Super-Power Singles" (SPS), which refers to Ph.D. workers who reported their marital status as never married, divorced or widowed. The other household type is "Super-Power Couples" (SPC), in which both spouses in the household have a Ph.D. degree. The increasing concentration of Ph.D. workers in large cities may be caused by increasing returns to education, rising valuation on urban amenities such as access to museums and other cultural activities. Moreover, as mentioned earlier, Super-Power Singles may choose to live in large cities to access an active dating environment, while Super-Power Couples may prefer large cities to solve their job co-location problem.

To identify the effect of local marriage markets in driving Ph.D. workers' location choices, I adopt the triple-differencing strategy of Costa and Kahn (2000). To examine the co-location pressure, Costa and Kahn (2000) compare power couples (college-educated couples) with low-power couples (households in which neither spouse has a college education) to difference out the marriage market effects for singles. This paper highlights the differential marriage market opportunities between foreign-born versus domestic-born. In particular, I use Chinese and Indian as representative ethnic groups and compare their trends of location choices to that of the domestic-born. Such comparison is conducted first within and then across the household type. The aim of doing so is to rule out the impact of increasing returns to education, different tastes on urban amenities, and different pressure for job co-location. The procedure and the underlying assumptions for these purposes are made clear later in the paper.

[44] For more details, see Appendix Table A2-1 and A2-2, which document the distribution of college above workers among U.S. cities by ethnicity.

To better capture the size and quality of labor and marriage markets, I estimate a three-tiered model in which the triple-differencing strategy is conducted for different classifications of city size categories. The first-tier model, following Costa and Kahn (2000), uses the MSA's total population to classify MSAs into large, middle and small size. In contrast, the second-tier model uses the size of the own-ethnic population present in the MSA to classify city size categories. The third-tier model combines the criteria applied in the first two models: large and midsize MSAs in terms of the total population are further classified into those with a large or small size of the own-ethnic college-above population. The third-tier model is the preferred one because it controls for the scale and quality of both Ph.D. labor and marriage markets in a given city type, which also to some extent capture the density of potential dates in the local area. All of these estimations use US census data for the survey years 1990, 2000 and 2010.

The paper has two main findings as follows. First, facing thinner marriage markets, the stronger desire to access an active dating environment causes immigrant Ph.D.-trained singles to live in cities with denser potential dates. Foreign-born single Ph.D. workers on average display a stronger tendency relative to their US-born counterparts to live in MSAs with a large size of their own-ethnic population. In particular, the stronger marriage market effect explains the greater tendency of Chinese and Indian Ph.D. women to live in midsize MSAs with a large size of the own-ethnic college-above population by 4 to 7 percentage points. Evidence of the marriage market effect is present for Ph.D. men but less robust. This gender disparity is consistent with the fact that foreign-born Ph.D. women face with thinner marriage markets as compared to the Ph.D. men within their own ethnicity, for it might be more common for men to marry less educated women than the reverse situation. Secondly, findings in this paper suggest that the size and quality of local labor markets are key drivers of the location choices of Super-Power Couples.

Chinese and Indian Super-Power Couples display a stronger tendency relative to their US-born counterparts to live in large MSAs in terms of total population, regardless of the size of their own ethnic population in the local area. Job co-location effects seem to dominate marriage market effects in explaining the greater increasing tendency of Chinese and Indian Ph.D. workers to live in large MSAs.

The rest of the paper is organized as follows. Section 2 reviews previous studies and highlights the contributions of this paper. Section 3 uses a multinomial logit model to analyze the Ph.D. workers' location choices and presents the predicted average probabilities of choosing among different city sizes for the survey years 1990, 2000 and 2010. Section 4 describes the differencing strategy to investigate the relative importance of marriage market and job co-location effects. Section 5 first presents key results of the three-tiered model based on different classifications of city size categories, and then a robustness check is conducted by estimating a linear probability model for a more restricted subsample. Section 6 discusses the policy implication of this paper and Section 7 concludes.

2. Previous Studies

Highly trained workers tend to move to places with high-quality jobs and are sensitive to regional wage differences (e.g. Borjas, 2001;[45] Chen and Rosenthal, 2008;[46] Dahl and Sorenson, 2010). On the other hand, highly educated workers often place high weights on social factors and

[45] Borjas (2001) find that the new-arrival immigrants, compared to their US-born counterparts, are much more likely to be clustered in states that offer the highest wages for the types of skills they can offer. Fang and Brown (1999) also find that Chinese highly educated workers are not closely tied to the ethnic enclave economy as their low-skilled peers do.

[46] Chen and Rosenthal (2008) demonstrate that young, highly educated households tend to move to places with high quality of business environment and that this tendency is especially pronounced among power couples who are subjected to job market co-location problem.

urban amenities when choosing a metropolitan location. Dahl and Sorenson (2010) use panel data of the Danish population to show that technical workers have strong preferences for living close to family and friends.[47] Gottlieb and Joseph (2006) estimate random parameter logit models to investigate the migration decisions of science and technology graduates across the U.S. cities. They find that Ph.D. graduates pay greater attention to location-specific amenities than other degree holders and that some foreign-born students after graduation migrate to places where their ethnic groups are concentrated.

Marriage market opportunities are an important location-specific amenity that might affect the migration decisions of highly educated singles, but there is very limited work investigating this topic. Gautier et al. (2010) provide evidence that singles are willing to pay a housing price premium to locate in cities, the dense areas where they can meet more potential partners than in rural areas.[48] In this paper, I focus on the impact of marriage market opportunities in driving the metropolitan location choices for Ph.D.-trained singles.

In particular, to highlight the impact of the local marriage market on foreign-born versus domestic born Ph.D. workers, I modify and develop the differencing strategy used in Costa and Kahn (2000). Costa and Kahn (2000) put forward job co-location pressure in explaining the increasing concentration of college-educated couples ("Power Couples") in large MSAs from 1940 to 1990. As mentioned earlier, the key idea is that large MSAs appeal to power couples because such cities can provide high-quality jobs for both spouses in the dual career household.

[47] Previous studies (e.g., Altonji and Card, 1991; Card, 2001; Peri 2011; Hunt and Gauthier-Loiselle, 2010; and Kerr and Lincoln, 2010) have used this phenomenon to examine the impact of immigrants on the local economy in the host country. They usually use the interaction of past immigrant stocks and migration trends as an instrument for observed local changes.

[48] This is consistent with the literature on search and matching (e.g. see discussion in Burdett and Coles, 1999) that emphasized that the long-term partnership formation as with marriage and employment is a time-consuming activity because of market frictions and heterogeneity of agents. Therefore, access to a thick local market increases the arrival rate and contact with potential partners.

To identify such a job co-location effect, Costa and Kahn (2000) compare the location choice of power couples with that of low-power couples (households in which neither spouse has a college education), and difference out the marriage market effects for singles. Their work suggests that large cities will continue to attract highly educated couples, and such migration will contribute to the matching in labor markets as well as the city growth. Building upon their work, this paper highlights the differential marriage market effects for foreign-born versus US-born. Moreover, I focus on the migration of Ph.D.-trained individuals instead of the college-educated workers. If the local marriage market does affect the location choices of new-arrival foreign-born PhDs, it will provide an important margin to adjust the innovative activities across U.S. cities.[49] Especially for struggling cities like Cleveland, in order to reinvent cities and achieve urban growth, it would be appealing for policymakers to invite the foreign-born Ph.D. workers to local areas by using some policy instruments.

3. Location Choices of Ph.D. Workers

This section first models how Ph.D. workers choose among different city size categories. Then a multinomial logit model is estimated to predict Ph.D. workers' probabilities of living in large, middle and small size MSAs for the survey years 1990, 2000, and 2010, conditional on their gender, ethnicity (US-born, Chinese or Indian), and household type (Super-Power Couples or Super-Power Singles). At the end of this section, the year-specific tendencies of location choices are documented for each gender-ethnicity-household group. All of the estimations are

[49] Kerr (2010) points outs that spatial adjustments of innovation are highly associated with the mobility of the scientists and engineers that develop the technology. Kerr (2010) finds that patenting migrates faster for technologies that employ immigrant inventors intensively.

conducted using U.S. Census data from the Integrated Public-Use Microdata Series (IPUMS, Ruggles et al., 2010).[50]

Consider a Ph.D.-trained individual *i* has preferences over available city size *s* (e.g., *s* can be chosen from small MSAs, midsize MSAs, and large MSAs). It can be described by a utility function as follows:

$$U_{is} = \beta' X_i + \varepsilon_{is}, \quad (1)$$

where X_i denotes a vector of individual specific characteristics (e.g., age, age squared, English speaking ability, in a STEM occupation or not, etc.), β is the coefficient, and error term ε_{is} allows for different evaluations on living in city size *s*.

Individuals choose to live in the city size *s* that maximizes their expected utilities. If the errors term ε_{is} is independent and identically distributed draws from a Type I extreme value distribution, then the probability that individual i chooses city size *s* is:

$$P(Y_i = s) = \exp\{\beta' X_i + \varepsilon_{is}\} / \sum_s \exp\{\beta' X_i + \varepsilon_{is}\} . \quad (2)$$

Doing some transformation on equation (2) yields the estimating equation as follows:

$$\log(P_s / P_{small}) = \beta' X_i + \varepsilon_{is}, \quad (3)$$

where P_{small} is the probability that individual *i* chooses to live in a small MSA, which has been set up as the baseline group in the multinomial logit model.

Then I introduce how to estimate equation (3) to obtain the average tendency to live in city size *s* for each gender-ethnicity-household group: **Probability (Live in city size *s* | gender, ethnicity, household type)**. For each survey year *t* (1990, 2000 or 2010), conditional on gender and household type, I first run equation (3) separately for foreign-born and US-born to get the

[50] Data for 1990 and 2000 are based on 5 percent samples of the underlying Census population while data for 2010 are from the 1 percent sample from American Community Surveys (ACS).

coefficient estimates $\hat{\beta}$. Then I fix the age at 35 years old and calculate the average standardized probabilities of living in city size *s* in year *t*, denoted as $\hat{P}_{s,t}$, for Ph.D. workers in a specific gender-ethnicity-household group.

Take single, US-born male Ph.D. workers as an example to illustrate the procedure. To calculate their propensity to live in large, midsize, and small MSAs in 2010, denoted as $\hat{P}_{large,2010}$, $\hat{P}_{midsize,2010}$, and $\hat{P}_{small,2010}$, I use a sample consisting of 9,203 US-born single male workers that had a Ph.D. or master equivalent education level and aged between 25 and 50. Equation (3) is estimated in which I control for age, age squared, English language ability, in a STEM occupation or not, self-employed or not, Ph.D. holder or not, race is white or not, and whether this household is linguistically isolated.[51] Once the coefficient estimates $\hat{\beta}$ are obtained, I fix the age at 35 and calculate the average standardized probabilities among all the single, US-born male Ph.D. workers whose race is white. It yields the propensities to live in different city sizes: $\hat{P}_{large,2010}$, $\hat{P}_{midsize,2010}$, and $\hat{P}_{small,2010}$.

Table 3-1 and 3-2 report Ph.D. workers' tendency to living in large, midsize, and small MSAs in 1990, 2000 and 2010, where the city size categories are classified based on the MSA's total population for those aged 15 above.[52] Table 3-1 is for single Ph.D. workers (Super-Power Singles) and Table 3-2 for married Ph.D. workers who have an own-ethnic Ph.D.-holding spouse (Super-Power Couples). It should be noted here that all Ph.D. workers, regardless of their gender, ethnicity, and household type, increasingly concentrate in large MSAs from 1990 to 2010. Moreover, for each survey year, conditional on gender and household type, Chinese and

[51] Households are linguistically isolated if either no person age 14+ speaks only English at home, or no person age 14+ who speaks a language other than English at home speaks English "very well".

[52] Following Costa and Kahn (2000), I define large MSAs as metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. For other classifications of city size categories in the second and third tier models, see the yearly tendency of location choices in Appendix 4-1, 4-2, 5-1 and 5-2.

Indian PhDs display a greater tendency to live in large MSAs relative to their US-born counterparts.

Table 3-1 shows single Ph.D. workers that are from China and India are on average more likely to be located in large MSAs relative to their US-born counterparts. Their probabilities to live in large MSAs are 31% to 38% in 1990, 40% to 43% in 2000, and 44% to 50% in 2010, larger than those of their US-born counterparts — roughly 26% in 1990, 34% in 2000, and 37% to 41% in 2010. This disparity is also present in Table 3-2 among married Ph.D. workers in Super-Power Couples (SPC). In 2010, the average probability to live in large MSAs is roughly 50% for Chinese and Indian Super-Power Couples, larger than just 33% for comparable US-born Super-Power Couples. In particular, married Chinese female Ph.D. workers that have a Chinese Ph.D. husband display the most increasing tendency to live in large cities: their probability of being large MSAs increases by roughly 11 percentage points from the year 1990 to 2000, and then further rises by 12 percentage points from 2000 to 2010.

4. Hypotheses and Identification Strategy

What factors would explain the increasing tendency of Ph.D. workers to live in large cities? To what extent is such migration trend driven by social factors relative to the concern for job opportunities? In order to answer these questions, this section first considers the benefits of being in large MSAs for Ph.D. workers. Then the identification strategy is outlined (Table 4) to investigate the degree to which the local marriage markets affect the location choices of foreign-born Ph.D. workers differently compared to their domestic-born counterparts.

Large cities appeal to Ph.D. workers because they have higher returns to education and better urban amenities such as access to cultural activities. Moreover, for Super-Power Couples

(SPC), large cities are more likely to offer high-quality jobs for both spouses in the family to solve their co-location problems. While for Super-Power Singles (SPS), large cities may provide better access to an active dating environment as such cities often have more educated young people within their ethnicity. Following this analysis, Ph.D. workers' increasing tendency to live in large cities may be caused by the increasing returns to city size, the rising valuations on urban amenities, a rising pressure for job co-location, or a strong desire to access a better marriage market.

As outlined in Table 4, a differencing strategy is adopted to identify the role of local marriage market in driving the location choices of Ph.D.-trained workers. For simplicity, I use Chinese as an example here to represent an ethnic group that is not US-born. Briefly, this method first compares the trend estimates of Chinese Ph.D. workers to live in a given city type to that of US-born Ph.D. workers within the household type (Row 3 and Row 6), and then the double differencing estimators obtained are compared across household types (Row 7). The rest of this section will describe the differencing strategy in details and clarify the underlying assumptions.

The first assumption is as follows. There is no discrimination on immigrants in the Ph.D. labor markets. Within gender group, returns to education in a given city type are same for all Ph.D.-trained workers, both foreign-born and domestic-born.

Given the first assumption, within the household type, the effect from returns to education can be differenced out when the trend estimators of living in a given city size are compared across ethnicities. For example, in Row 3 for married Ph.D. workers in Super-Power Couples (SPC), subtracting the trend estimator of US-born SPC (Row 2) from that of Chinese SPC (Row 1) yields the double-differencing estimator for Super-Power Couples between Chinese and US-born, ($\mathrm{SPC}^{Ch} - \mathrm{SPC}^{US}$). This double-differencing estimator indicates the

combined effects of their different valuations on urban amenities ($A^{Ch} - A^{US}$), plus their differential pressure from job co-location ($C^{Ch} - C^{US}$). Similarly, in Row 6, the double-differencing estimator for single Ph.D. workers between Chinese and US-born, ($SPS^{Ch} - SPS^{US}$), reveals their different valuations on urban amenities ($A^{Ch} - A^{US}$) and local marriage markets ($M^{Ch} - M^{US}$).

Once the double-differencing estimators for SPC (Row 3) and SPS (Row 6) are obtained, I difference them across the household type to generate the triple-differencing estimator, as indicated in Row 7. In doing so, the underlying Assumption 2 is made as follows. Chinese and US-born Ph.D. workers may have different tastes for urban amenities, but such disparity in their valuation on urban amenities ($A^{Ch} - A^{US}$) remains the same for both Super-Power Couples and Super-Power Singles.[53] Given this assumption, the impact of different tastes on urban amenities ($A^{Ch} - A^{US}$) can be ruled out when the triple differencing is conducted across these two household types. As a result, in Table 4 Row 7, the triple-differencing estimator between Chinese and US-born indicate the difference between two effects: the differential marriage market effects and the differential job co-location effects, that is, $(M^{Ch} - M^{US}) - (C^{Ch} - C^{US})$.

To predict the sign of the triple-differencing estimator, the following discussion analyzes the signs of two terms, $(M^{Ch} - M^{US})$ and $(C^{Ch} - C^{US})$. First, it should be noted that the marriage market effect in large cities is expected to be stronger for Chinese than that for their US-born counterparts, that is, $(M^{Ch} - M^{US}) > 0$. That is because Chinese and Indian single PhDs, as shown in the marriage patterns of Table 1, prefer to a find a spouse with a college or

[53] This assumption should hold if the valuation on urban amenity for married Ph.D. workers relative to single Ph.D. workers stays the same across ethnicities. For example, if Chines married PhDs care about the school quality in local areas as US-born married PhDs do, while single PhDs, both Chinese and US-born, do not have concern for the school quality, the valuation on school quality should be differenced out.

higher level of education and within their ethnicity. Moreover, there are few MSAs in the U.S. with scores of single, foreign-born college-educated workers but many more MSAs with sizable numbers of domestic-born college-educated singles. For these reasons, single, foreign-born Ph.D. workers often face thin marriage markets compared to their US-born counterparts, and large cities with better marriage markets may be more attractive to them.

Regarding the sign of $(C^{Ch} - C^{US})$, it is important to recognize that a given city type may have different depth of Ph.D. labor markets between foreign-born and domestic-born, and whether $(C^{Ch} - C^{US})$ equals to zero depends on the standard that is used to classify city size categories. For example, if the MSA's total population is a good proxy for the size of the Ph.D. labor market in the local area, regardless of the Ph.D. workers' ethnicities, $(C^{Ch} - C^{US}) = 0$ is expected to be held when the city size categories are classified based on the MSA's total population. In contrast, this condition may not hold if Chinese PhDs are heavily concentrated in selected industries and occupations as previous studies (Mandorff, 2007) has pointed out, and these sorts of jobs are only available in a few numbers of large cities.[54] In this circumstance, Chinese Super-Power Couples may put higher weights on large cities to solve their co-location problems compared to their US-born counterparts; In other words, I expect $(C^{Ch} - C^{US}) > 0$.

Given the analysis above, the interpretation of the triple-differencing estimator is sensitive to the way I classify the city size categories. When $(C^{Ch} - C^{US}) = 0$ holds, the triple-differencing estimator should yield the differential marriage markets effects between Chinese and US-born Ph.D. workers. For a given city size, the estimator is expected to be positive if Chinese Ph.D. workers put higher weights on having access to an active local marriage market

[54] Another possible reason why large cities are more important for immigrants to solve their colocation problem is that large cities may have more companies that will effectively sponsor the immigrant Ph.D. workers for H-1B visas and green cards.

than their US-born counterparts. If $(C^{Ch} - C^{US}) > 0$ holds, the triple-differencing estimator should indicate the relative importance of differential marriage market effects over the differential co-location effects between Chinese and US-born Ph.D. workers. Under this circumstance, a positive triple-differencing estimator suggests that the marriage market effects dominate the co-location effects, while a negative one indicates the other way around.

5. Results

This section begins with estimating a three-tiered model in which the triple differencing strategy outlined in section 4 is conducted under different classifications of city size categories. The discussion mainly focuses on results of the period from 1990 to 2000, while the results of the period 1990-2010 are also documented. In particular, from 1990 to 2000, high trained individuals from China and India dramatically increase in the United States; moreover, the number of new-arrival Chinese and Indian PhDs that work in the STEM fields more than doubled.[55] In the first-tier model, the MSA's total population for those aged 15 above is used to classify MSAs into large, middle and small sizes. The second-tier model uses the size of the own-ethnic population present in the MSA instead of the total population. The third-tier model, which is the preferred one, combines the criteria applied in the first two models to controls for the size of Ph.D. labor and marriage markets in a given city type, and also, to some extent, capture the density of potential dates in the local area.

[55] For example, in 1990, the number of new-arrival Chinese Ph.D. workers that have been in U.S. no more than ten years is 3,818, and this figure increases by more than four-folds to 20,905 in 2000 and reaches 33,111 in 2010.The number of new-arrival Indian STEM Ph.D. workers is 3,711 in 1990, 9,641 in 2000, and 14,937 in 2010. Person weights are used to calculate these numbers. Regarding the total count of Chinese STEM Ph.D. workers in the U.S., it is 13,169 in 1990, 45,873 in 2000, and 81,972 in 2010. The total number of Indian STEM Ph.D. workers is 10,106 in 1990, 24,868 in 2000, and 39,947 in 2010.

One concern for the triple differencing approach is that some Ph.D. workers chose to live in an MSA with an active dating scene when they were single, and they may stay in the same MSA after they have been married. In this case, the triple differencing approach may underestimate the marriage market effect, for the concentration of these sorts of couples should be attributable to the marriage market effect but it has been mistreated as job collocation effect. To address this concern, I conduct a robustness check by estimating a linear probability model for a sample of young Ph.D. workers that include both marriage and single. The goal of this check is to compare the migration decisions of young single Ph.D. workers to those comparable married Ph.D. workers who made their moving decisions after they have being married. Moreover, observations in this sample also include other foreign-born Ph.D. workers beyond Chinese and Indian PhDs. Briefly summarizing the findings, improving the local dating environment decrease the probability of single foreign-born PhDs to move while no such effect arises for married Ph.D. workers or domestic-born singles.

5.1.City Size Categories Based On the Total Population

Following Cost and Kahn (2000), the first-tier model categorizes MSAs into large, middle, and small size based on the total population size. Table 5-1 shows Ph.D. workers' trend in the propensity to live in large, middle and small size MSAs from 1990 to 2000. For each gender-ethnicity-household group, such first-differencing estimates are obtained by differencing their tendencies of location choices across two survey years 2000 and 1990, which have been documented in Table 3-1 and 3-2. Table 5-2 reports the double-differencing estimates — the differential trends between Chinese (or Indian) and US-born from 1990 to 2000, conditional on gender and household type. Table 5-3 shows the triple-differencing estimates by gender.

Table 5-1 reveals that all Ph.D. workers, regardless of their gender, ethnicity, and household type, display an increasing tendency to live in large MSAs from the year 1990 to 2000. Among single Ph.D. workers in Column 1 and 3, the trend estimates of the propensity to live in the large MSAs range from 0.06 to 0.09. Such increasing tendency of Super-Power Singles (SPS) to being in large MSAs may be caused by the increasing returns to Ph.D. education, the rising valuation on urban amenities, and the appealing local marriage markets that large MSAs can provide. Among Super-Power Couples (SPC), as indicated by Column 2, the probabilities of being in large MSAs increases by roughly 0.04 for US-born married Ph.D. women, smaller than those of Chinese and Indian women, 0.11 and 0.06, respectively. Such disparity is also present among married male PhDs in Super-Power Couples in Column 4, with smaller magnitudes for the increasing trends across all ethnicities. The increasing tendency for Super-Power Couples to be located in large cities, as indicated in Section 4, may result from the increasing returns to Ph.D. education, the rising valuation on urban amenities, and the increasing pressure for job co-location.

Table 5-2 presents the estimates of the differential trends between foreign-born and US-born, and different patterns occur for Super-Power Singles versus Super-Power Couples. Among single Ph.D. workers in both Panel A and B, the trends of the foreign-born relative to the US-born are positive for living in midsize MSAs. These estimates suggest that from 1990 to 2000, the Chinese and Indian single Ph.D. workers' greater valuation on urban amenities and local marriage markets explain their greater increasing tendency relative to their US-born counterparts to live in midsize MSAs. While regarding the trend of foreign-born single PhDs to be located in large MSAs relative to their US-born counterparts, most estimates are non-positive except for the Indian single male PhDs in Column 3. In contrast, for both male and female married Ph.D.

workers in Super-Power Couples, the trends of Chinese and Indian in the propensity to live in large MSAs is significantly greater than those of their US-born counterparts. These estimates, compared with those of Super Power Singles, potentially suggest that large cities are especially attractive to foreign-born Ph.D. couples by enabling them to solve their job co-location problems.

When further differencing these estimate in Table 5-2 across the household types, the resulting triple-differencing estimates for the period 1990-2000 are positive for being midsize MSAs but negative for being large MSAs, as reported in the first two columns of Table 5-3. As analyzed in Section 4, these estimates indicate that compared to their US-born counterparts, the impact of local marriage markets for immigrant single Ph.D. workers are relatively weak in large MSAs but strong in midsize MSAs. Why do the local marriage markets in large MSAs appear to be less attractive to Chinese and Indian single Ph.D. workers relative to their US-born counterparts? One possible explanation is that the first–tier model uses the total population to categorize city sizes, but this measure may not be good enough to capture the thickness of local marriage markets for immigrant single Ph.D. workers — because foreign-born Ph.D. workers disproportionately marry within their own ethnicity, as indicated by marriage patterns in Table 1.

Also, it should be noted that the triple-differencing estimates in Table 5-3 may reveal the differential pressure for job co-location between the foreign-born and US-born Super-Power Couples. As mentioned in Section 4, foreign-born Ph.D. workers often concentrate in selected industries and occupations, which cause them to have more restriction in choosing where to live. Large MSAs, usually with a mix of diverse industries, provide more high-quality job opportunities for these foreign-born Super-Power Couples that face thinner labor markets. This argument is also consistent with the double-differencing estimates in Table 5-2. For these

reasons, the negative triple-differencing estimates for being large MSAs may suggest that the impact of job co-location dominates the effect of the marriage market in explaining the greater increasing trend of Chinese and Indian Ph.D. workers to live in large cities relative to their US-born counterparts.

5.2.City Size Categories Based On the Size of the Own-Ethnic Population

This section estimates the second-tier model in which for each person, all MSAs are reclassified into three city size categories based on the own-ethnic population for those aged 15 above and present in that MSA.[56] Compared to the first-tier model, this model does a better job in capturing the size of the local marriage market for both foreign-born and US-born PhDs. On the other hand, the city size in terms of the own-ethnic population does not necessarily control for the size of Ph.D. labor markets in the local areas. Therefore, a differential effect of job co-location may be present for a given city size between foreign-born and US-born Super-Power Couples. For these reasons, the triple-differencing estimates of the second-tier model in Table 6, as indicated earlier in Section 4, potentially reveal the relative importance of the marriage market effect versus the pressure for job co-location in driving the Ph.D. workers' location choices.

Specifically, city size categories in the second-tier model are defined as follows. For a given person, large own-ethnic MSAs are metropolitan areas in which his/her own ethnic population rank within top 15 among all U.S. MSAs, midsize own-ethnic MSAs as those that rank outside top 15 but have at least 1,000 people within the ethnicity of this person (the cutoff number is 250,000 for the US-born) present in the local areas, and the rest of MSAs are all classified as small own-ethnic MSAs. Based on such classification of city size categories,

[56] Table A6-1 and A6-2 show the predicted probabilities of being in different city sizes for Super-Power Singles and Super-Power Couples, respectively.

Appendix Table A4-1 and A4-2 document the year-specific location choices of Super-Power Singles and Super-Power Couples, respectively.

As shown in Appendix Table A4-1 and A4-2, Chinese and Indian Ph.D. workers, both single and married, are more likely to concentrate in MSAs that have a large size of the own-ethnic population compared to their US-born counterparts. Moreover, such disparity is increasing from 1990 to 2000. For example, the average probabilities of living in large own-ethnic MSAs increase by 0.08 — from 0.53 to 0.61— for Chinese single female PhDs, while the corresponding probabilities stay at 0.32 for their US-born counterparts.[57] Such discrepancy in location trend is also present among Super Power Couples in Appendix Table 4-2. In particular, during the period of 1990 to 2000, the probabilities of being in large own-ethnic MSAs significantly increase by roughly 0.06 and 0.09 for Chinese and Indian Super-Power Couples, respectively, while it decreases by approximately 0.02 for US-born Super-Power Couples.

Table 6 presents the triple-differencing estimates of the second-tier model, which provide evidence that marriage market opportunities are the driving force that causes Ph.D. women to live in cities with a large population of their own ethnicity. Column 1 shows that from 1990 to 2000, the marriage market effect dominates the job co-location effect in explaining Indian Ph.D. women's greater increasing tendency to live in large own-ethnic MSAs relative to their US-born counterparts, and the magnitude is approximately 3 percentage points. While for Chinese Ph.D. women relative to their US-born counterparts in Panel A, the estimate is positive but not statistically different from zero. Conversely, among male Ph.D. workers in Table 6 Column 2, the triple-differencing estimates for the period 1990-2000 are negative for living in large own-

[57] Such disparity in geographic sorting also exists among single male Ph.D. workers. The estimate for the tendency to live in large own-ethnic MSAs stays at roughly 0.49 for Chinese single men during the 1990-2000 period, and it increases from 0.39 to 0.47 for Indian single men, but decreases from 0.32 to 0.30 for US-born single men.

ethnic MSAs. It suggests that in explaining foreign-born Ph.D. men's greater increasing tendency to live in large own-ethnic MSAs relative to those comparable US-born Ph.D. men, the impact of the differential concerns for job co-location is larger than that of the differential marriage markets, by roughly 0.06 and 0.03 for Chinese and Indian, respectively. The disparity between Ph.D.-trained men and women seems to be consistent with the traditional view that men, in general, may be more likely to put job opportunities into priority concern than women.

5.3.City Size Categories Considering the Density of Potential Dates

This section presents results for the third-tier model in which city sizes are classified based on the size of the total population aged 15 above and the size of the own-ethnic population for those that have at least a four-year college education level (OECoAbv) in the MSA. As mentioned earlier, this model is the preferred one because it takes into account the size of the local Ph.D. labor and marriage markets. Moreover, controlling for these two populations – the total population and the own-ethnic highly-educated population – at the same time will shed light on the density of potential dates in the local area, which may provide a better proxy for the quality of the local dating environment. For these reasons, based on such city size classification, the job co-location effect in a given city type is expected to be the same for both foreign-born and US-born Super-Power Couples. As indicated in Section 4, the triple-differencing estimates in Table 7-3 can be interpreted as the differential marriage market effects between foreign-born and domestic-born Ph.D. workers. The discussion below first introduces the city size classification in details and the trends of Ph.D. workers' location choices are documented in Table 7-1 and 7-2, and then Table 7-3 shows the triple-differencing estimates of the third-tier model.

The third-tier model first classifies MSAs into large, middle, and small sizes based on the size of the total population as the first-tier model does, and the baseline group is still small MSAs. Meanwhile, for each person, large and midsize MSAs are further categorized into those with or without a large size of the own-ethnic population whose education level is at least a four-year college (OECoAbv). A large or midsize MSA is defined as having large OECoAbv if the size of the own-ethnic college-above population present in that MSA rank within top 15 among all U.S. MSAs in a given year; otherwise that MSA is classified as having small OECoAbv. For example, in the year 1990, Boston, MA is a large MSA with large OECoAbv for Chinese workers, and a large MSA with small OECoAbv for Indian workers. In contrast, Detroit, MI in 1990 is a large MSA with large OECoAbv for Indians but with small OECoAbv for Chinese.

Table 7-1 and 7-2 present the trend estimates of location choices for single and married Ph.D. workers, respectively.[58] Table 7-1 shows that from 1990 to 2000, single PhDs generally display an increasing tendency to live in large MSAs. Moreover, Chinese and Indian single Ph.D. workers display a further strong tendency to live in midsize cities that have a relatively high density of potential dates. During this period, the probabilities of living in midsize MSAs with a large size of the own-ethnic college-above population (OECoAbv) increase by 0.01 to 0.03 for Chinese and Indian single PhDs and decrease by 0.02 to 0.03 for their US-born counterparts. Conversely, among Super-Power Couples in Table 7-2, only Indian married Ph.D. men increasingly concentrate in midsize MSAs with large OECoAbv. Instead, all Super-Power Couples increasingly concentrate in large MSAs, regardless of the size of the local potential dating pool. These estimates may suggest that the size of the total population play a more

[58] Appendix Table A5-1 and A5-2, for single and married Ph.D. workers, respectively, document the year-specific average probabilities of choosing among these five city size categories.

important role than the size of the own-ethnic population to capture the quality of the local labor market for Super-Power Couples.

The discussion below focuses on the triple-differencing estimates of the third-tier model presented in Table 7-3. First, consider the estimates of being in midsize MSAs with large own-ethnic college-above population – a city size category that probably has the most denser potential dates. In Table 7-3 Column 1, the estimates for Chinese and Indian Ph.D. women relative to US-born Ph.D. women are roughly 0.07 (Panel A) and 0.04 (Panel B), respectively. These triple-differencing estimates indicate that from 1990 to 2000, the stronger marriage market effect for Chinese and Indian Ph.D. women explains their greater increasing tendency to live in midsize MSAs that also have a large size of the own-ethnic college-above population. Such effect is still present for Chinese Ph.D. men in Column 2, but with a smaller magnitude 0.02, while for Indian Ph.D. men, the estimate turns out to be negative. This gender disparity seems to be consistent with the thinner marriage markets faced by immigrant Ph.D. women as compared to Ph.D. men of their ethnicity, for it is more common for men to marry less educated women than the reverse situation.

Secondly, we look at the estimate of living in large MSAs with a large size of the own-ethnic college-above population. From 1990 to 2000, the triple-differencing estimates are positive for Indian PhDs (Panel B) but negative for Chinese PhDs (Panel A). It suggests that the stronger marriage market effect for Indian Ph.D. workers relative to their US-born counterparts explain their greater tendency to live in these areas by approximately 0.01 to 0.02, while it is the other way around for Chinese Ph.D. workers relative to their US-born counterparts. Comparing these estimates to those analyzed in the last paragraph, it suggests that regarding the

opportunities for foreign-born Ph.D.-trained singles to find an ideal spouse, the absolute number of potential dates matters, but not as important as the density of potential dates in a local area.

The importance of the density of the local marriage market is also evident among triple-differencing estimates for the period 1990-2010 in Column 3 and 4 of Table 7-3. Compared to those of the period 1990-2000, the estimates of a longer horizon reveals that the smaller cities with denser potential dates present in local areas have increasingly become feasible marriage markets for immigrant Ph.D. workers. Regarding choosing midsize MSAs with a small size of own-ethnic college-above population, most estimates in Column 3 and 4 are 0.07 to 0.19 (except for Indian Ph.D. women), much larger as compared to those in Column 1 and 2. Moreover, for Ph.D. women to live in small MSAs, the triple-differencing estimates of the period 1990-2000 are not statistically different from zero, while they become significantly positive in the longer time horizon. These changes are consistent with the massive inflow of highly educated Chinese and Indian across U.S. MSAs from 2000 to 2010, which makes marriage markets more geographically expansive for Chinese and Indian Ph.D. workers.[59] For example, during this decade, the mean of Indian college-above population in small MSAs rises from 377 to 801, and in midsize MSAs from 1,986 to 3,226. The new emerging marriage markets in smaller cities may have a potential to attract Chinese and Indian Ph.D. workers to these areas beyond the job opportunities.

[59] During this period, the total count of college-above workers nearly doubles for Indian group, from 566,533 to 1,055,009, and for Chinese group this number increases by nearly 50% from 465,949 to 671,514. This large inflow increases the size as well as the density of potential dates for the Chinese and Indian Ph.D. workers at smaller cities.

5.4.Robustness Check

This section further compares the migration decision of single to that of married for young Ph.D. workers by estimating a linear probability model. The previous triple differencing approach, as pointed out by Compton and Pollak (2007), may have underestimated the marriage market effect because some single Ph.D. workers chose to live in an MSA with an active dating scene, and they stay in the same MSA after marriage.[60] This location lock will tend to occur when moving costs are higher than the benefits from relocating the household. To address this concern, I restrict married PhDs to those young (age 25 to 44), full-time workers who made their moving decisions after they have being married, and I pool this subsample with young, single Ph.D. workers to conduct a comparison. The key hypothesis I test here is that increasing the size of the local potential dating pool will reduce the probability of single Ph.D. workers, especially for those foreign-born, to move to another MSA, while no such effect is expected to arise for married Ph.D. workers.

The linear probability model is as follows.

$$Move_i = \alpha_1 M_{e,c,t} + \alpha_2 ForeignBorn + \alpha_3 Single + \alpha_4 M_{e,c,t} \times Single + \alpha_5 M_{e,c,t} \times Single \times ForeignBorn + X_i\beta + A_{c,t}\gamma + \delta_c + \eta_j + \mu_t + \varepsilon_{i,j,e,c,t} \quad (4)$$

where *i* denotes individual, *j* is for industry, *e* for ethnic group, *c* for the previous residential MSA, and *t* for year. The dependent variable is whether a given Ph.D. worker *i* moved to a different MSA between year *t* and *t+1*: coded as one if that person moved and zero if stayed in the same MSA. The key regressor is individual *i*'s local marriage market, denoted as $M_{e,c,t}$, which is measured by the number of singles of the opposite gender with a college or higher level

[60] Compton and Pollak (2007) revisit the job market co-location effect put forward by Costa and Kahn (2000), and they argue that the rising concentration of highly educated couples in large cities has more to do with the greater opportunity for highly educated singles to meet in large urban centers.

of education and within individual *i*'s ethnic group *e*, at MSA *c*, for year *t*. The coefficient of interest is α_5 on the triple interaction term — $M_{e,c,t}$ interacted with the indicator of being foreign born and the indicator of being single in marital status. As discussed earlier, the sign of α_5 is expected to be negative.

The estimating equation controls for a vector of individual *i*'s demographic and socioeconomic attributes X_i,[61] as well as location-specific attributes $A_{c,t}$ of the previous residential MSA c for year *t*.[62] MSA fixed effects δ_c are included to capture the time-invariant location attributes like sunshine, river, mountains, air quality, distance to the country border, coastal proximity, the number of universities, and the cost of living, etc. Industry fixed effects η_j are also included to capture the time-invariant attributes for a specific industry such as its ethnic concentration, gender density, average skill levels. Year fixed effects μ_t control for the national-wide shock in a particular year and ε_i is the classical error term.

Table 8 presents results for this linear probability model. In Column 1 among young female Ph.D. workers, locating in the previous MSA with 1,000 more single men of their own ethnicity and with a college or higher level of education — the likely dating pool — decreases the probability of foreign-born single women to move to another MSA by 3.3 percentage point. While no significant impact arises for married Ph.D. women, nor for single Ph.D. women that are

[61] For example, X_i includes age, age squared, having own children at home, English speaking ability, occupation's median earned income, residing in the U.S. no more than ten years, in a STEM occupation, Hispanic origin, black race, living in the home state. In particular, I use the variable ("ERSCOR90") constructed by IPUMS to measure occupation's median earned income. This variable reports the percentage of persons in occupations having lower standardized median earnings than the respondent's occupation. For more details, see https://usa.ipums.org/usa-action/variables/ERSCOR90#description_section.

[62] To capture the job opportunities at the MSA *c* for year *t*, I control for the total population, the number of workers in own industry *j*, and average working age and average earnings among all workers in the MSA. To rule out the effect from being close to family and friends, I also include the number of own-ethnic workers that are present in the MSA *c* but are not the potential dates for individual *i*.

domestic-born. Male Ph.D. workers in Column 2 obtain similar estimates. Increasing the size of the local marriage market has no significant impact for married Ph.D. men, nor for US-born single Ph.D. men, while it reduces the probability of moving for single foreign-born Ph.D. men by 3.3 percent. As the first two columns show, the presence of children at home reduces the Ph.D. workers' possibilities of moving by roughly 8 percentage points. Since married PhDs, as the summary statistics suggest, are more likely to have children at home than comparable single PhDs, Column 3 and 4 further restrict the sample to households with no child at home to rule out the influence of children. As shown in the last two columns of Table 8, among no-kid households, the marriage market effect grows to 3.8 percentage points for single foreign-born Ph.D. women while it remains at 3.4 percentage points for single foreign-born Ph.D. men. Again, no such effect is present for other demographic groups in the last two columns.

6. Policy Implications

This paper has implications for the geographic distribution of Ph.D. workers across U.S. cities, which has a potential to affect the innovation productivity and economic growth in local areas. First, it implies that large cities will continuingly appeal to Ph.D.-trained couples by providing better opportunities for both spouses in the household to find a high-quality job that is also within a reasonable commute from their home. It is worth noting that the number of Super-Power Couples is highly likely to grow in the STEM fields. In part, that is because more Ph.D.-trained women enter the STEM fields. The female share of Ph.D. STEM workers rises from 24% in 1990 to 31% in 2000 and 40% in 2010. Moreover, Ph.D. women, display a strong tendency to find a Ph.D.-holding spouse.[63] The resulting growth of Super-Power Couples and severity of job

[63] Foreign-born Ph.D. workers are highly likely to form Super-Power Couples (SPC) within their own ethnic group. Beyond their strong tendency to marry a highly educated spouse within ethnic group, the marriage rates among

co-location problems may cause increasing concentration of married Ph.D. STEM workers in large cities. This suggests that large cities may continue to be more thriving in innovative activities versus smaller towns.[64]

Secondly, this paper implies that as ever-growing skilled immigrants arrive in the U.S., cities with a historically large ethnic population and those with denser educated ethnic population are highly likely to experience a large-scale increase in human capital. That is because such cities with appealing local marriage markets will attract the new-arrival highly trained singles that are eager to find a life partner with similar education and ethnic backgrounds. This increase of human capital might open great opportunities for such cities to develop innovative activities. San Jose, CA, for example, in 1990 was a midsize MSA with a large size of Chinese and Indian college-above population. Since then it has become one of the top destination for Chinese and Indian Ph.D. workers in the U.S and experienced a tremendous amount of new product innovation.[65]

Thirdly, this paper has provocative and controversial policy implications for declining cities like Cleveland. To reinvent cities and achieve urban growth, policymakers in struggling cities may find it appealing to invite highly trained immigrants by subsidizing Indian and Chinese STEM workers with a tax credit for several years. At a certain point, these cities on their own will start to attract new-arrival Ph.D.-trained individuals with similar ethnic backgrounds for the active dating environment. The self-reinforcing growth of the highly educated ethnic community may attract the firms that intensively use skilled workers to local areas, possibly

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foreign-born PhDs, especially for Chines and Indian PhDs in STEM occupations, are quite high. In Census 2000, 90% of Chinese Ph.D. STEM workers are married, 83% for Indian, 72% for the US-born and 64% for West European.

[64] This is consistent with the stylized fact documented by Kerr (2010): three large cities account for 25% of U.S. domestic patenting for 1995-2004: San Francisco 12%, New York 7%, and Los Angeles 6%.

[65] See more details in Appendix Table A6, which documents the MSA's Chinese and Indian population in 1990 among the top 20 MSAs that create the largest number of patents in 2001.

generating agglomeration economies. However, this plan is also controversial because such policies seem to be unfair to some immigrant groups like the Hispanic, who are more likely to have the low education attainments.

7. Conclusions

Ph.D.-trained individuals, especially those that are not born in the U.S., increasingly concentrate in large metropolitan areas from 1990 to 2010. This paper investigates the degree to which the local marriage market and job co-location pressure affect the location choices of foreign-born Ph.D. singles and couples differently compared to their US-born counterparts. This work is important because Ph.D.-trained STEM workers account for a significant share of innovation in the United States, and a sizable proportion of such Ph.D. workers are foreign born. Moreover, foreign-born Ph.D. workers face with thin marriage markets compared to their U.S-born counterparts. The contributing reason is that foreign-born PhDs, and especially those from China and India, display a strong tendency to marry highly educated individuals within their own ethnicity. This narrows the dating pool and summary measures confirm that there are relatively few MSAs in the U.S. that offer active dating environment for these sorts of workers. For these reasons, single, foreign-born Ph.D. workers may prefer to live in MSAs that can provide better marriage markets.

Two key findings are as follows. First, marriage market opportunities attract immigrant Ph.D.-trained singles to cities with denser potential dates. Chinese and Indian single Ph.D. workers display a strong tendency to live in MSAs that have a large population of their own ethnicity. The stronger desire to access an active dating environment explains Chinese and Indian Ph.D. workers' greater tendency relative to their US-born counterparts to live in midsize MSAs

with large sizes of own-ethnic college-above population. The marriage market effect is 4 to 7 percentage points for the female group, larger than that for the male group, roughly 2 percentage points. This gender disparity is consistent with the asymmetry of marriage markets between Ph.D.-trained men and women – it is more common for Ph.D.-trained men to marry less-educated women than the reverse situation. Secondly, immigrant married Ph.D. workers that have an own-ethnic Ph.D. spouse display a stronger tendency relative to their US-born counterparts to live in large MSAs, regardless of the size of the local own-ethnic population. That is mainly because large cities with better labor markets often enable both spouses in the Super-Power Couples to find a job that is well matched to their training and within a reasonable commute from their home. Such a job co-location effect seems to dominate the marriage market effect in explaining foreign-born PhDs' greater increasing trend to live in large cities.

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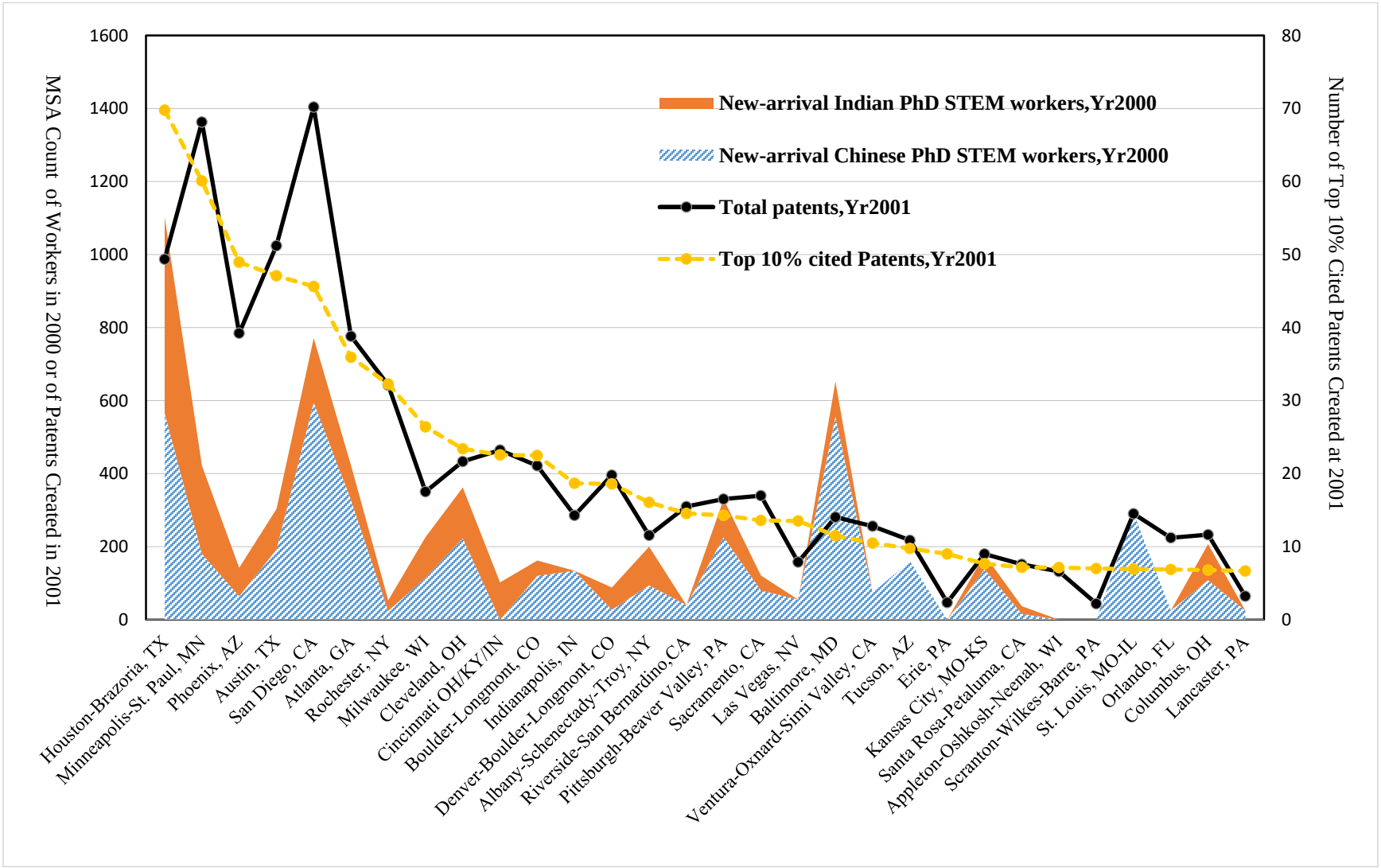
Figure 1: New-Arrival Ph.D. STEM Workers at Top 30 MSAs in Terms of High-quality Patents Creation at Year 2001



[a] New-Arrival refers to those foreign-born that have been in US less or equal to ten years. In this figure, San Jose, CA is excluded for visual clarity. In 2000, San Jose has 1,143 Chinese and 335 Indian New-Arrival Ph.D. workers in STEM Occupations. In 2001, 4,734 patents were created in San Jose, CA, and 276 are top 10% cited patents.

Table 1: Marriage Patterns for Ph.D. Holders by Birth Region (BR), Census Year 2000 [a]

Panel A: Marriage Patterns for Male Ph.D. Holders, Age 25 to 65

	Frequency of Wife's Education Level and Birth Region (BR) (Numbers Are in Percentage Points)					
Male PhDs' Birth Region [b]	(1) Same-BR Wife	(2) US-Born Wife	(3) Wife with a Ph.D. Degree	(4) Wife with Col+ Education	(5) Same-BR Wife with a Ph.D. Degree	(6) Same-BR Wife with Col+ Education
US-Born	92.8	92.8	12.3	77.1	10.8	71.5
Foreign-born	71.6	19.6	15.1	80.7	10.0	57.5
China	95.1	2.4	13.6	84.7	12.8	80.6
India	83.9	10.4	14.9	86.9	12.0	72.6
Korea	94.7	3.6	8.6	85.8	7.9	81.8
Philippines	71.8	21.4	16.9	82.2	14.1	64.9
Eastern Europe	78.6	13.8	22.1	86.7	17.5	70.0
Western Europe	41.2	42.3	16.1	81.7	6.7	31.9

Panel B: Marriage Patterns for Female Ph.D. Holders, Age 25 to 65

	Frequency of Husband's Education and Birth Region (BR) (Numbers Are in Percentage Points)					
Female PhDs' Birth Region [b]	(1) Same-BR Husband	(2) US-Born Husband	(3) Husband with a Ph.D. Degree	(4) Husband with Col+ Education	(5) Same-BR Husband with a Ph.D. Degree	(6) Same-BR Husband with Col+ Education
US-Born	93.1	93.1	31.6	83.9	28.2	77.9
Foreign-born	59.7	29.9	48.0	89.8	30.2	53.6
China	78.5	15.2	56.2	96.3	44.1	75.8
India	83.6	12.2	51.6	96.3	44.9	81.1
Korea	66.2	24.7	54.8	90.1	33.7	60.5
Philippines	51.4	40.0	27.0	76.0	14.3	42.1
Eastern Europe	70.6	18.9	54.8	90.7	42.1	65.2
Western Europe	29.8	56.7	46.6	94.3	17.6	29.2

[a] Data are 5% sample decennial census 2000 extracted from IPUMS (Ruggles et al, 2010). This table is confined to married Ph.D. holders who are living in married-couple households in which both spouses are present and have reported their education levels, nativities and places of birth.

[b] US-Born is defined as born in the U.S.A. or those born abroad with American Parent(s) and all the others are defined as foreign-born. I group countries into 22 regions mostly based on United Nations Statistics Division.

[c] Col+ (College-above) education refers to having received at least 4-year college education attainment.

Table 2-1: Top 25 MSAs with Largest Population of New-arrival Ph.D. Workers from China, Year 2010

		Count of New-Arrival Chinese Ph.D. Workers			Count of New-Arrival Chinese Ph.D. Workers in STEM Occupations				
Rank	MSA Name	Total	Male	Female	Total	Married Male	Married Female	Single Male	Single Female
1	Washington, DC/MD/VA	3106	2092	1014	2798	1679	924	195	0
2	Boston, MA	2484	1362	1122	1833	832	658	343	0
3	Houston-Brazoria, TX	2088	1701	387	1201	864	262	75	0
4	New York-Northeastern NJ	1796	1347	449	1108	666	341	101	0
5	Chicago-Gary-Lake, IL	1774	934	840	1409	828	486	0	95
6	San Jose, CA	1751	1334	417	1413	1005	362	46	0
7	Philadelphia, PA/NJ	1427	273	1154	955	0	817	0	0
8	Oakland, CA	1395	945	450	1030	547	217	266	0
9	Baltimore, MD	1248	834	414	738	271	0	270	197
10	Atlanta, GA	1208	665	543	926	480	446	0	0
11	Raleigh-Durham, NC	1188	792	396	707	512	0	0	195
12	Los Angeles-Long Beach, CA	1170	677	493	888	477	142	200	69
13	Dallas-Fort Worth, TX	962	803	159	881	573	78	230	0
14	Seattle-Everett, WA	914	496	418	506	425	81	0	0
15	Newark, NJ	863	636	227	608	400	115	93	0
16	Detroit, MI	750	522	228	574	181	121	70	0
17	San Francisco-Oakland-Vallejo, CA	718	291	427	718	194	354	97	73
18	Riverside-San Bernardino, CA	698	400	298	469	241	177	0	51
19	San Diego, CA	695	487	208	391	264	57	0	70
20	Miami-Hialeah, FL	623	484	139	464	308	83	73	0
21	Cleveland, OH	621	511	110	451	386	0	65	0
22	Ann Arbor, MI	519	350	169	430	261	169	0	0
23	Birmingham, AL	502	224	278	224	224	0	0	0
24	Austin, TX	497	392	105	260	199	0	0	0
25	Cincinnati OH/KY/IN	485	393	92	196	104	92	0	0

a Data are 1% sample from American Community Surveys 2010, extracted from IPUMS (Ruggles et al, 2010). New-arrival Ph.D. workers from China are immigrants who hold a Ph.D. degree, born in China, aged 25 and above, employed at the survey year, and had been in the U.S. less or equal to ten years. Person weights are used to calculate these numbers.

b STEM Occupations are classified based on Census code list for STEM and STEM-related occupation, which is available at www.bls.gov/soc.

Table 2-2: Top 25 MSAs with Largest Population of New-arrival Ph.D. Workers from India, Year 2010

		Count of New-Arrival Indian Ph.D. Workers			Count of New-Arrival Indian Ph.D. Workers in STEM Occupations				
Rank	MSA Name	Total	Male	Female	Total	Married Male	Married Female	Single Male	Single Female
1	Chicago-Gary-Lake, IL	1296	666	630	476	208	0	0	268
2	Boston, MA	1276	1055	221	896	666	0	230	0
3	Los Angeles-Long Beach, CA	1239	650	589	882	276	334	272	0
4	Philadelphia, PA/NJ	1207	965	242	769	457	80	135	97
5	Minneapolis-St. Paul, MN	976	582	394	133	0	133	0	0
6	State College, PA	845	845	0	845	0	0	845	0
7	San Diego, CA	777	530	247	530	429	0	101	0
8	Houston-Brazoria, TX	725	487	238	164	164	0	0	0
9	St. Louis, MO-IL	695	417	278	550	272	278	0	0
10	Oakland, CA	616	462	154	514	78	154	282	0
11	Dayton-Springfield, OH	603	603	0	0	0	0	0	0
12	Washington, DC/MD/VA	577	521	56	304	248	56	0	0
13	Atlanta, GA	567	420	147	500	270	147	83	0
14	New York-Northeastern NJ	543	305	238	344	0	116	106	122
15	San Jose, CA	531	468	63	383	320	63	0	0
16	Portland-Vancouver, OR	466	466	0	466	466	0	0	0
17	Trenton, NJ	450	236	214	249	141	108	0	0
18	Baltimore, MD	435	61	374	61	61	0	0	0
19	Cleveland, OH	430	381	49	430	166	49	215	0
20	Austin, TX	411	316	95	54	54	0	0	0
21	Charlottesville, VA	405	0	405	405	0	135	0	270
22	Seattle-Everett, WA	390	309	81	321	132	81	108	0
23	Mobile, AL	364	364	0	364	364	0	0	0
24	Lowell, MA/NH	348	348	0	0	0	0	0	0
25	Dallas-Fort Worth, TX	339	339	0	196	196	0	0	0

[a] Data are 1% sample from American Community Surveys 2010, extracted from IPUMS (Ruggles et al, 2010). New-arrival Ph.D. workers from India are immigrants who hold a Ph.D. degree, born in India, aged 25 and above, employed at the survey year, and had been in U.S. less or equal to ten years. Person weights are used to calculate these numbers.

[b] STEM Occupations are classified based on Census code list for STEM and STEM-related occupation, which is available at www.bls.gov/soc.

Table 3-1: Location Choices for Single Ph.D. Workers by Year,

Classify City Sizes Based on MSA's Total Population

City Size Categories Based on ***MSA's Total Population***	**Single Ph.D. Workers (SPS)** Predicted Probabilities to Live in Different City Sizes		
	(1)	(2)	(3)
	Year 1990	Year 2000	Year 2010
Panel A: Single, US-born White Male PhDs			
Large MSAs	0.2644 (.00014)	0.3316 (.00012)	0.4126 (.00035)
Midsize MSAs	0.4584 (.00044)	0.4289 (.00044)	0.3714 (.00084)
Small MSAs	0.2772 (.00037)	0.2395 (.00035)	0.2160 (.00069)
Panel B: Single, US-born White Female PhDs			
Large MSAs	0.2678 (.00026)	0.3480 (.00017)	0.3721 (.00031)
Midsize MSAs	0.4355 (.00048)	0.4117 (.00028)	0.4080 (.00050)
Small MSAs	0.2967 (.00064)	0.2403 (.00029)	0.2199 (.00041)
Panel C: Single, Chinese Male PhDs			
Large MSAs	0.3238 (.00400)	0.3917 (.00277)	0.4977 (.00598)
Midsize MSAs	0.4673 (.00408)	0.4445 (.00259)	0.3783 (.00424)
Small MSAs	0.2089 (.00609)	0.1638 (.00363)	0.1240 (.00324)
Panel D: Single, Chinese Female PhDs			
Large MSAs	0.3751 (.00796)	0.4326 (.00317)	0.4693 (.01038)
Midsize MSAs	0.4490 (.00893)	0.4399 (.00207)	0.3411 (.00763)
Small MSAs	0.1759 (.00834)	0.1275 (.00419)	0.1896 (.00868)
Panel E: Single, Indian Male PhDs			
Large MSAs	0.3106 (.00322)	0.3991 (.00228)	0.4365 (.00564)
Midsize MSAs	0.4359 (.00360)	0.4628 (.00248)	0.4489 (.00411)
Small MSAs	0.2535 (.00577)	0.1381 (.00264)	0.1146 (.00272)
Panel F: Single, Indian Female PhDs			
Large MSAs	0.3376 (.00831)	0.4020 (.00400)	0.4365 (.00778)
Midsize MSAs	0.4123 (.01133)	0.4333 (.00258)	0.3568 (.00499)
Small MSAs	0.2501 (.01313)	0.1647 (.00591)	0.2167 (.01140)

a City size categories are based on the size of MSA's total population for those who are aged 15 above. Large MSAs are Metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. Standard errors are in parentheses.

b Data for 1990 and 2000 are 5% sample from decennial census, and for 2010 are 1% sample from ACS. For each year, the probabilities should sum to one within panel. Standard errors are in parentheses.

Table 3-2: Location Choices for Married Ph.D. Workers in Super-Power Couples (SPC)

Classify City Sizes Based on MSA's Total Population

City Size Categories Based on ***MSA's Total Population***	**Married Ph.D. Workers (SPC)** Predicted Probabilities to Live in Different City Sizes		
	(1) Year 1990	(2) Year 2000	(3) Year 2010
Panel A: Married, US-born White Male PhDs			
Large MSAs	0.2729 (.00024)	0.3011 (.00037)	0.3329 (.00093)
Midsize MSAs	0.4241 (.00067)	0.4321 (.00058)	0.3944 (.00103)
Small MSAs	0.3030 (.00075)	0.2668 (.00054)	0.2727 (.00090)
Panel B: Married, US-born White Female PhDs			
Large MSAs	0.2575 (.00056)	0.3010 (.00031)	0.3331 (.00065)
Midsize MSAs	0.4389 (.00082)	0.4395 (.00069)	0.3895 (.00136)
Small MSAs	0.3036 (.00130)	0.2595 (.00082)	0.2774 (.00154)
Panel C: Married, Chinese Male PhDs			
Large MSAs	0.3029 (.00499)	0.3703 (.00183)	0.4937 (.00273)
Midsize MSAs	0.5229 (.00407)	0.4957 (.00105)	0.3392 (.00141)
Small MSAs	0.1742 (.00656)	0.1340 (.00183)	0.1671 (.00186)
Panel D: Married, Chinese Female PhDs			
Large MSAs	0.2649 (.00505)	0.3737 (.00166)	0.4893 (.00327)
Midsize MSAs	0.5878 (.00592)	0.5076 (.00168)	0.3482 (.00252)
Small MSAs	0.1473 (.00547)	0.1187 (.00170)	0.1625 (.00244)
Panel E: Married, Indian Male PhDs			
Large MSAs	0.2897 (.00375)	0.3312 (.00239)	0.4507 (.00573)
Midsize MSAs	0.4981 (.00319)	0.5206 (.00174)	0.3881 (.00310)
Small MSAs	0.2122 (.00499)	0.1482 (.00274)	0.1612 (.00342)
Panel F: Married, Indian Female PhDs			
Large MSAs	0.2716 (.00283)	0.3326 (.00246)	0.4242 (.00406)
Midsize MSAs	0.4940 (.00486)	0.5022 (.00228)	0.3815 (.00412)
Small MSAs	0.2344 (.00622)	0.1652 (.00278)	0.1943 (.00378)

a City size categories are based on the size of MSA's total population for those who are aged 15 above. Large MSAs are Metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. For each year, the probabilities should sum to one within panel. Standard errors are in parentheses.

b Data for 1990 and 2000 are 5% sample from decennial census, and for 2010 are 1% sample from ACS. Predicted Probabilities are averaged among married Ph.D. workers that have a Ph.D.-holding spouse within their own ethnicity.

Table 4: Differencing Strategy to Identify the Marriage Market and Job Co-Location Effects:

Using Chinese as an Example

	Household Type [a]	Label	Benefits of living in a large city [b]
1	Chinese Super-Power Couples (SPC)	SPC^{Ch}	Job Co-Location C^{Ch}, Urban Amenities A^{Ch}, Returns to Education
2	US-born Super-Power Couples	SPC^{US}	Job Co-Location C^{US}, Urban Amenities A^{US}, Returns to Education
3	Double Difference: Row1- Row2	$\text{SPC}^{Ch} - \text{SPC}^{US}$	Urban Amenities $\left(A^{Ch} - A^{US}\right) +$ Job Co-Location $(C^{Ch} - C^{US})$
4	Chinese Super-Power Singles (SPS)	SPS^{Ch}	Marriage Markets M^{Ch}, Urban Amenities A^{Ch}, Returns to Education
5	US-born Super-Power Singles	SPS^{US}	Marriage Markets M^{US}, Urban Amenities A^{US}, Returns to Education
6	Double Difference: Row4 - Row5	$\text{SPS}^{Ch} - \text{SPS}^{US}$	Urban amenities $(A^{Ch} - A^{US}) +$ Marriage Markets $(M^{Ch} - M^{US})$
7	Triple Difference: Row6 - Row3	$(\text{SPS}^{Ch} - \text{SPS}^{US}) - (\text{SPC}^{Ch} - \text{SPC}^{US})$	Marriage Markets $(M^{Ch} - M^{US})$ – Job Co-Location $(C^{Ch} - C^{US})$

[a] "Super-Power" Couples: married couple households where both spouses in the family have a Ph.D. degree. "Super-Power" Singles (SPS): Ph.D. workers who report their marital status as never married, divorced or widowed.

[b] Within the gender group, returns to education for Ph.D. holders in a given city type are assumed same between Chinese and US born, regardless of the marital status. Chinese and US-born Ph.D. workers may have different tastes for urban amenities (like access to cultural activities), but the difference between their valuations on urban amenity $(A^{ch} - A^{US})$ are assumed to stay the same across household types.

Table 5-1: Trends in Propensity to Live in Different City Sizes, Year 1990 to 2000,

Classify City Sizes Based on MSA's Total Population

City Size Category Based on ***MSA's Total Population***	**Female Ph.D. Workers**		**Male Ph.D. Workers**	
	(1) Single Ph.D. Workers (SPS)	(2) Married Ph.D. Workers in SPC	(3) Single Ph.D. Workers (SPS)	(4) Married Ph.D. Workers in SPC
Panel A: US-born				
	SPS^{US}	SPC^{US}	SPS^{US}	SPC^{US}
Large MSAs	0.0802***	0.0435***	0.0672***	0.0282***
	(.00031)	(.00064)	(.00018)	(.00044)
Midsize MSAs	-0.0239***	0.0006	-0.0295***	0.0080***
	(.00055)	(.00107)	(.00063)	(.00088)
Small MSAs	-0.0563***	-0.0441***	-0.0377***	-0.0362***
	(.00070)	(.00154)	(.00051)	(.00092)
Panel B: Chinese				
	SPS^{Ch}	SPC^{Ch}	SPS^{Ch}	SPC^{Ch}
Large MSAs	0.0575***	0.1088***	0.0679***	0.0674***
	(.00856)	(.00457)	(.00487)	(.00539)
Midsize MSAs	-0.0092	-0.0802***	-0.0228***	-0.0272***
	(.00917)	(.00616)	(.00480)	(.00421)
Small MSAs	-0.0483***	-0.0286***	-0.0451***	-0.0402***
	(.00899)	(.00573)	(.00686)	(.00560)
Panel C: Indian				
	SPS^{In}	SPC^{In}	SPS^{In}	SPC^{In}
Large MSAs	0.0644***	0.0610***	0.0885***	0.0415***
	(.00933)	(.00375)	(.00386)	(.00427)
Midsize MSAs	0.0210*	0.0082	0.0269***	0.0225***
	(.01162)	(.00537)	(.00425)	(.00364)
Small MSAs	-0.0854***	-0.0692***	-0.1154***	-0.0640***
	(.01395)	(.00681)	(.00634)	(.00569)

a City size categories are based on the size of MSA's total population for those who are aged 15 above. Large MSAs are metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

b The first difference estimators for Single Ph.D. workers (SPS) are obtained by subtracting Column 1 from Column 2 in Table 3-1. Similarly, subtracting Column 1 from Column 2 in Table 3-2 obtained the first-differencing estimators for Super-Power Couples.

Table 5-2: DOUBLE DIFFERENCE Estimators by Gender, Year 1990 to 2000,

Classify City Sizes Based on MSA's Total Population

Panel A: Differential Trends Between Chinese and US-born

City Size Category Based on ***MSA's Total Population***	**Female Ph.D. Workers**		**Male Ph.D. Workers**	
	(1) Single PhDs ($SPS^{Ch} - SPS^{US}$)	(2) Married PhDs ($SPC^{Ch} - SPC^{US}$)	(3) Single PhDs ($SPS^{Ch} - SPS^{US}$)	(4) Married PhDs ($SPC^{Ch} - SPC^{US}$)
Large MSAs	-0.0227***	0.0653***	0.0007	0.0392***
	(.00726)	(.00305)	(.00419)	(.00225)
Midsize MSAs	0.0147***	-0.0808***	0.0067***	-0.0352***
	(.00439)	(.00628)	(.00217)	(.00414)
Small MSAs	0.0080*	0.0155***	-0.0074**	-0.0040**
	(.00426)	(.00450)	(.00348)	(.00202)

Panel B: Differential Trends Between Indian and US-born

City Size Category Based on ***MSA's Total Population***	**Female Ph.D. Workers**		**Male Ph.D. Workers**	
	(1) Single PhDs ($SPS^{In} - SPS^{US}$)	(2) Married PhDs ($SPC^{In} - SPC^{US}$)	(3) Single PhDs ($SPS^{In} - SPS^{US}$)	(4) Married PhDs ($SPC^{In} - SPC^{US}$)
Large MSAs	-0.0158***	0.0175***	0.0213***	0.0133***
	(.00469)	(.00353)	(.00353)	(.00260)
Midsize MSAs	0.0449***	0.0076**	0.0564***	0.0145***
	(.00599)	(.00351)	(.00210)	(.00244)
Small MSAs	-0.0291***	-0.0251***	-0.0777***	-0.0278***
	(.00661)	(.00579)	(.00650)	(.00470)

a City size categories are based on MSA's total population for those who are aged 15 above. Large MSAs are Metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. Standard errors are in parentheses.

b The double difference estimators are obtained by differencing trends in propensity to Live in a given city size between foreign and domestic born Ph.D. workers, conditional on gender and household type. Standard errors are in parentheses. And ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level. For each panel and within each column, the probabilities should sum to zero.

Table 5-3: TRIPLE DIFFERENCE Estimators by Gender,

City Sizes Based on MSA's Total Population

City Size Category Based on ***MSA's Total Population***	**Triple Difference, Marriage Markets Effects Relative to Colocation Effects**			
	Year 1990 to 2000		**Year 1990 to 2010**	
	(1) **Female Ph.D. Workers**	(2) **Male Ph.D. Workers**	(3) **Female Ph.D. Workers**	(4) **Male Ph.D. Workers**
Panel A: Chinese Relative to US-born $(\text{SPS}^{Ch} - \text{SPS}^{US}) - (\text{SPC}^{Ch} - \text{SPC}^{US})$				
Large MSAs	-0.0881***	-0.0385***	-0.1588***	-0.1052***
	(.00234)	(.00355)	(.00841)	(.00859)
Midsize MSAs	0.0955***	0.0419***	0.1098***	0.1520***
	(.00498)	(.00058)	(.00837)	(.00866)
Small MSAs	-0.0075	-0.0034	0.0490***	-0.0468
	(.00735)	(.00217)	(.00271)	(.00373)
Panel B: Indian Relative to US-born $(SPS^{In} - SPS^{US}) - (SPC^{In} - SPC^{US})$				
Large MSAs	-0.0333***	0.0079	-0.0924***	-0.1232***
	(.00268)	(.00285)	(.00560)	(.00793)
Midsize MSAs	0.0373***	0.0419***	0.0351***	0.1801***
	(.00065)	(.00058)	(.00771)	(.00590)
Small MSAs	-0.0040	-0.0498***	0.0573***	-0.0569***
	(.00439)	(.00434)	(.00772)	(.00519)

[a] City size categories are based on the MSA's total population for those who are aged 15 above. Large MSAs are Metropolitan areas in which the total population for those who are aged 15 above is at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas.

[b] Each cell is obtained by differencing the double-differencing estimators across household type, within gender group. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level. Within each panel and for a given column, the probabilities should sum to zero.

Table 6: City Size Categories Based on MSA's Own-Ethnic Population,

TRIPLE DIFFERENCE Estimators by Gender

City Size Category Based on ***MSA's Own-Ethnic Population***	**Marriage Markets Effects Relative to Colocation Effects**			
	Year 1990 to 2000		**Year 1990 to 2010**	
	(1) **Female Ph.D. Workers**	(2) **Male Ph.D. Workers**	(3) **Female Ph.D. Workers**	(4) **Male Ph.D. Workers**
Panel A: Chinese Relative to US-born $(\text{SPS}^{Ch} - \text{SPS}^{US}) - (\text{SPC}^{Ch} - \text{SPC}^{US})$				
Large Own-Ethnic MSAs	0.0014	-0.0606***	-0.1090***	-0.0844***
	(.00289)	(.00227)	(.00419)	(.00367)
Midsize Own-Ethnic MSAs	-0.0369	0.0336***	0.0311***	0.0802***
	(.00522)	(.00249)	(.00822)	(.00391)
Small Own-Ethnic MSAs	0.0355***	0.0270***	0.0779***	0.0042
	(.00104)	(.00552)	(.00647)	(.00733)
Panel B: Indian Relative to US-born $(SPS^{In} - SPS^{US}) - (SPC^{In} - SPC^{US})$				
Large Own-Ethnic MSAs	0.0279***	-0.0261***	-0.0521***	-0.1504***
	(.00421)	(.00317)	(.00590)	(.00573)
Midsize Own-Ethnic MSAs	-0.1502***	0.0305***	-0.1724***	0.1442***
	(.00420)	(.00361)	(.01313)	(.00827)
Small Own-Ethnic MSAs	0.1223***	-0.0044	0.2245***	0.0062
	(.00854)	(.00555)	(.00903)	(.00879)

a City size categories are based on the size of the own-ethnic population that are aged 15 above and present in that MSA. For a given person, large own-ethnic MSAs are metropolitan areas in which his/her own ethnic population rank within top 15 among all U.S. MSAs, midsize own-ethnic MSAs as those that rank outside top 15 but have at least 1,000 people within the ethnicity of this person (the cutoff number is 250,000 for the US-born) present in the local areas, and the rest of MSAs are classified as small own-ethnic MSAs.

b Within a specific gender-period, for each panel, the probabilities should sum to zero. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 7-1: City Size Categories Based on

MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv),

Trends of Location Choices for Single Ph.D. Workers

City Size Category Based on ***MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv)***	**Year 1990 to 2000**				**Year 1990 to 2010**			
	(1) **Single Female PhDs**		(2) **Single Male PhDs**		(3) **Single Female PhDs**		(4) **Single Male PhDs**	
Panel A: US-born (SPS^{US})								
Large MSAs + Large OECoAbv	0.0385***	(.00286)	0.0243***	(.00020)	0.0268***	(.00043)	0.0668***	(.00033)
Large MSAs + Small OECoAbv	0.0416***	(.00008)	0.0426***	(.00008)	0.0779***	(.00011)	0.0812***	(.00027)
Midsize MSAs + Large OECoAbv	-0.0343***	(.00013)	-0.0241***	(.00011)	-0.0632***	(.00012)	-0.0506***	(.00007)
Midsize MSAs + Small OECoAbv	0.0105***	(.00045)	-0.0051***	(.00052)	0.0353***	(.00063)	-0.0361***	(.00094)
Small MSAs	-0.0563***	(.00070)	-0.0377***	(.00051)	-0.0768***	(.00076)	-0.0613***	(.00078)
Panel B: Chinese (SPS^{Ch})								
Large MSAs + Large OECoAbv	0.0095	(.00784)	0.0207***	(.00463)	0.0001	(.01314)	0.1038***	(.00870)
Large MSAs + Small OECoAbv	0.0454***	(.00121)	0.0483***	(.00113)	0.0830***	(.00343)	0.0712***	(.00373)
Midsize MSAs + Large OECoAbv	0.0226***	(.00696)	0.0153***	(.00443)	-0.1019***	(.00764)	-0.0838***	(.00451)
Midsize MSAs + Small OECoAbv	-0.0273***	(.00444)	-0.0387***	(.00239)	0.0087***	(.00745)	-0.0059	(.00589)
Small MSAs	-0.0502***	(.00920)	-0.0456***	(.00696)	0.0101	(.01240)	-0.0853***	(.00689)
Panel C: Indian (SPS^{In})								
Large MSAs + Large OECoAbv	0.0749***	(.01063)	0.0752***	(.00371)	0.0588***	(.00848)	0.0450***	(.00843)
Large MSAs + Small OECoAbv	-0.0016	(.00360)	0.0121***	(.00141)	0.0404***	(.00556)	0.0824***	(.00422)
Midsize MSAs + Large OECoAbv	0.0278***	(.00385)	0.0078***	(.00272)	0.0004	(.00598)	-0.0524***	(.00346)
Midsize MSAs + Small OECoAbv	-0.0202**	(.00773)	0.0186***	(.00175)	-0.0717***	(.00783)	0.0629***	(.00590)
Small MSAs	-0.0809***	(.01349)	-0.1137***	(.00624)	-0.0279	(.01709)	-0.1379***	(.00616)

a City size categories are based on two indicators :1) the MSA's total population who aged 15 above, and on 2) the size of the own-ethnic population that have at least four-year college education levels (OECoAbv) and are present in that MSA. Large MSAs are metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. For a Ph.D. worker, an MSA is defined as having Large OECoAbv if the size of the own-ethnic college-above population in that MSA rank within top 15 among all U.S. MSAs in a given survey year; otherwise, an MSA is defined as having Small OECoAbv.

b For a gender group in a specific period, the probabilities should sum to zero within each panel. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 7-2: City Size Categories Based on

MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv),

Trends of Location Choices for Married Ph.D. Workers in Super-Power Couples (SPC)

City Size Category Based on ***MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv)***	**Year 1990 to 2000**				**Year 1990 to 2010**			
	(1) **Married Female PhDs in SPC**		(2) **Married Male PhDs in SPC**		(3) **Married Female PhDs in SPC**		(4) **Married Male PhDs in SPC**	
Panel A: US-born (SPC^{US})								
Large MSAs + Large OECoAbv	0.0131***	(.00062)	-0.0001	(.00041)	0.0236***	(.00084)	0.0062***	(.00091)
Large MSAs + Small OECoAbv	0.0301***	(.00007)	0.0288***	(.00008)	0.0526***	(.00019)	0.0537***	(.00027)
Midsize MSAs + Large OECoAbv	-0.0208***	(.00026)	-0.0186***	(.00021)	-0.0565***	(.00015)	-0.0517***	(.00013)
Midsize MSAs + Small OECoAbv	0.0220***	(.00085)	0.0262***	(.00072)	0.0070***	(.00015)	0.0220***	(.00120)
Small MSAs	-0.0444***	(.00154)	-0.0363***	(.00092)	-0.0267***	(.00202)	-0.0302***	(.00117)
Panel B: Chinese (SPC^{Ch})								
Large MSAs + Large OECoAbv	0.0566***	(.00341)	0.0181***	(.00562)	0.1097***	(.00509)	0.0760***	(.00520)
Large MSAs + Small OECoAbv	0.0487***	(.00207)	0.0446***	(.00115)	0.1118***	(.00355)	0.1075***	(.00242)
Midsize MSAs + Large OECoAbv	-0.0322***	(.00666)	-0.0009	(.00574)	-0.1454***	(.00658)	-0.1183***	(.00564)
Midsize MSAs + Small OECoAbv	-0.0415***	(.00459)	-0.0196***	(.00629)	-0.0870***	(.00582)	-0.0541***	(.00642)
Small MSAs	-0.0316***	(.00588)	-0.0422***	(.00564)	0.0109***	(.00533)	-0.0111	(.00671)
Panel C: Indian (SPC^{In})								
Large MSAs + Large OECoAbv	0.0395***	(.00317)	0.0296***	(.00487)	0.0934***	(.00526)	0.0845***	(.00690)
Large MSAs + Small OECoAbv	0.0187***	(.00163)	0.0165***	(.00067)	0.0641***	(.00277)	0.0791***	(.00322)
Midsize MSAs + Large OECoAbv	0.0003	(.00274)	0.0224***	(.00326)	-0.0467***	(.00298)	-0.0462***	(.00318)
Midsize MSAs + Small OECoAbv	0.0105***	(.00336)	-0.0062	(.00474)	-0.0742***	(.00580)	-0.0692***	(.00570)
Small MSAs	-0.0690***	(.00657)	-0.0623***	(.00485)	-0.0366***	(.00708)	-0.0482***	(.00548)

a City size categories are based on two indicators :1) the MSA's total population who aged 15 above, and on 2) the size of the own-ethnic population that have at least four-year college education levels (OECoAbv) and are present in that MSA. Large MSAs are metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. For a Ph.D. worker, an MSA is defined as having Large OECoAbv if the size of the own-ethnic college-above population in that MSA rank within top 15 among all U.S. MSAs in a given survey year; otherwise, an MSA is defined as having Small OECoAbv.

b For a gender group in a specific period, the probabilities should sum to zero within each panel. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 7-3: City Size Categories Based on

MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv),

TRIPLE DIFFERENCE Estimators by Gender

City Size Category Based on ***MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv)***	**Marriage Markets Effects**							
	Year 1990 to 2000				**Year 1990 to 2010**			
	(1)		(2)		(3)		(4)	
	Female Ph.D. Workers		**Male Ph.D. Workers**		**Female Ph.D. Workers**		**Male Ph.D. Workers**	
Panel A: Chinese Relative to US-born $(\text{SPS}^{Ch} - \text{SPS}^{US}) - (\text{SPC}^{Ch} - \text{SPC}^{US})$								
Large MSAs + Large OECoAbv	-0.0725***	(.00256)	-0.0219***	(.00141)	-0.1128***	(.00450)	-0.0328***	(.00448)
Large MSAs + Small OECoAbv	-0.0149***	(.00112)	-0.0101***	(.00155)	-0.0541***	(.00741)	-0.0637***	(.00518)
Midsize MSAs + Large OECoAbv	0.0684***	(.00293)	0.0217***	(.00235)	0.0502***	(.00691)	0.0334***	(.00486)
Midsize MSAs + Small OECoAbv	0.0257***	(.00192)	0.0123***	(.00053)	0.0673***	(.00434)	0.1063***	(.00482)
Small MSAs	-0.0067	(.00736)	-0.0020	(.00218)	0.0494***	(.00264)	-0.0432***	(.00373)
Panel B: Indian Relative to US-born $(SPS^{In} - SPS^{US}) - (SPC^{In} - SPC^{US})$								
Large MSAs + Large OECoAbv	0.0100***	(.00296)	0.0211***	(.00174)	-0.0378***	(.00505)	-0.1001***	(.00573)
Large MSAs + Small OECoAbv	-0.0319***	(.00473)	-0.0182***	(.00232)	-0.0490***	(.00290)	-0.0240***	(.00668)
Midsize MSAs + Large OECoAbv	0.0411***	(.00242)	-0.0091***	(.00185)	0.0538***	(.00384)	-0.0074**	(.00325)
Midsize MSAs + Small OECoAbv	-0.0192***	(.00188)	0.0561***	(.00155)	-0.0258***	(.00841)	0.1902***	(.00583)
Small MSAs	4.87e-05	(.00435)	-0.0499***	(.00378)	0.0588***	(.00163)	-0.0587***	(.00516)

[a] City size categories are based on two indicators :1) the MSA's total population who aged 15 above, and on 2) the size of the own-ethnic population that have at least four-year college education levels (OECoAbv) and are present in that MSA. Large MSAs are metropolitan areas in which the total population for those who are aged 15 above was at least 2 million, midsize MSAs as those between 2 million and 250,000, and small MSAs as those less than 250,000 or in rural areas. For a Ph.D. worker, an MSA is defined as having Large OECoAbv if the size of the own-ethnic college-above population in that MSA rank within top 15 among all U.S. MSAs in a given survey year; otherwise, an MSA is defined as having Small OECoAbv.

[b] For a gender group in a specific period, the probabilities should sum to zero within each panel. Standard errors are in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level and * at 10% level.

Table 8: Influence of Marriage and Children

Migration for Young (Age 25 to 44) Ph.D. Workers

Dependent Variable: 1 if Moved to a Different MSA, 0 if Stayed in the Same MSA.				
	All Single Ph.D. Workers + Married Ph.D. Workers Who Made the Moving Decision Post-Marriage			
	With or Without Children Present at Home		No Child Present at Home	
	(1) Female	(2) Male	(3) Female	(4) Male
Count of Own-Ethnic Col+ Single of the Opposite Gender in 1,000s in the Previous MSA (**M**)	0.002	4.0e-04	0.001	4.2e-04
	(0.002)	(0.001)	(0.002)	(0.001)
Single	-0.284	1.388	0.771	0.115
	(1.497)	(1.192)	(1.809)	(2.735)
Foreign-Born (=1 if the worker is not a US-Born)	0.013	0.021	0.015	0.014
	(0.066)	(0.039)	(0.073)	(0.049)
M × Single	-9.3e-04	-4.2e-04	-6.1e-04	-5.4e-04
	(7.4e-04)	(5.6e-04)	(9.2e-04)	(8.2e-04)
M × Single × Foreign-Born	-0.033*	-0.033***	-0.038*	-0.034***
	(0.018)	(0.009)	(0.021)	(0.009)
Has Own Child in the Household	-0.072**	-0.081**	-	-
	(0.032)	(0.038)	-	-
MSA Fixed Effects	236	252	228	247
Industry Fixed Effects	21	21	21	21
Year Fixed Effects	Yes	Yes	Yes	Yes
Individual Characteristics	Yes	Yes	Yes	Yes
R-squared	0.240	0.193	0.249	0.192
Observations	2,508	3,494	2,141	3,149

[a] Sample is restricted to fulltime Ph.D. workers whose usual hours worked per week ≥ 35hours. I suppress the coefficient estimates on the characteristics of the previous MSA locations, e.g., total population, own-industry employment, number of own-ethnic workers excluding col+ single of the opposite gender, MSA average working age, MSA average annual earnings. I also suppress the coefficient estimates on individual attributes, e.g. age, square of age, occupation's median earned income, Hispanic origin, Black race, English Speaking Ability, years in the U.S.no more than ten, living in birth state, and also those on characteristics of the worker's spouse, e.g. spouse's education level, age, English speaking ability. Standard errors are clustered at MSA level and are reported in parentheses. ***denotes the estimate is significant from zero at 1% level, ** at 5% level.

Appendix

Table A1: Share of Workers Living in Large MSAs by Education Attainment, 1990-2010

Panel A: Workers Holding a Ph.D. Degree

Share of Workers Living in Large MSAs	(1) Year 1990	(2) Year 2000	(3) Year 2010
All Ph.D. Workers	0.252	0.325	0.394
Female Ph.D. Workers:			
All Female PhDs	0.285	0.352	0.407
US-born Female PhDs	0.267	0.329	0.378
Foreign-born Female PhDs	0.380	0.441	0.496
Male Ph.D. Workers:			
All Male PhDs	0.242	0.313	0.385
US-born Male PhDs	0.220	0.281	0.338
Foreign-born Male PhDs	0.329	0.401	0.492

Panel B: Workers Having a College or Master Degree

Share of Workers Living in Large MSAs	(1) Year 1990	(2) Year 2000	(3) Year 2010
All Workers	0.234	0.318	0.371
Female Workers:			
All Female	0.239	0.316	0.368
US-born Female	0.223	0.294	0.341
Foreign-born Female	0.423	0.494	0.535
Male Workers:			
All Male	0.230	0.320	0.375
US-born Male	0.212	0.297	0.347
Foreign-born Male	0.404	0.483	0.531

Panel C: Workers with High School or a Lower Level of Education

Share of Workers Living in Large MSAs	(1) Year 1990	(2) Year 2000	(3) Year 2010
All Workers	0.166	0.232	0.282
Female Workers:			
All Female	0.168	0.231	0.280
US-born Female	0.143	0.198	0.235
Foreign-born Female	0.413	0.479	0.496
Male Workers:			
All Male	0.164	0.233	0.284
US-born Male	0.132	0.188	0.224
Foreign-born Male	0.433	0.491	0.498

Table A2-1: Distribution of Col+ Single Men among U.S. MSAs by Ethnicity (Birth Region):

Number of MSAs in 6 Size Categories, [a]
Size Categories Based on MSA Count of Own-Ethnic Col+ Single Men (*M*)
Year 1990 and Year 2010

	(1)		(2)		(3)		(4)		(5)		(6)	
MSA Size Categories Are Based on *MSA Count of Own-Ethnic Col+ Single Men (M)*	$200 \leq M \leq 499$		$500 \leq M \leq 999$		$1000 \leq M \leq 1999$		$2000 \leq M \leq 3999$		$4000 \leq M \leq 7999$		$M \geq 8000$	
	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010
Ethnicity (Birth Region)												
United States	2[b]	3	18	10	53	34	73	54	47	80	80	116
Canada	10	17	5	15	2	2	0	2	0	0	0	0
Other North America	0	0	0	0	0	0	0	0	0	0	0	0
Central America and Caribbean	16	31	11	16	5	14	0	14	2	4	1	3
Southern America	14	31	4	10	1	8	2	4	1	2	0	1
Northern Europe	16	18	6	14	3	6	1	1	0	1	0	0
Western Europe	13	26	8	10	2	3	1	1	0	1	0	0
Southern Europe	10	21	4	9	1	3	1	0	0	1	0	0
Eastern Europe	15	29	3	10	1	9	2	2	0	1	0	1
China	10	31	6	17	4	5	0	4	2	3	0	2
Japan	7	10	0	2	2	2	0	0	0	0	0	0
Korea	6	19	0	6	1	6	1	0	0	2	0	0
Other East Asia	0	2	0	0	0	0	0	0	0	0	0	0
Philippines	10	20	4	7	4	8	0	6	1	0	0	1
Vietnam	7	12	1	13	3	5	0	3	0	1	0	0
Other Southeast Asia	8	17	1	9	1	3	0	1	0	0	0	0
India	20	34	7	22	4	15	2	13	0	3	0	1
Other South Asia	7	11	6	8	2	2	0	1	1	1	0	0
Middle East	9	19	5	10	0	1	2	3	0	0	0	0
Africa	13	31	6	15	2	7	2	7	0	2	0	0
Oceania	2	5	0	2	0	1	0	0	0	0	0	0
Other	8	0	6	0	1	0	1	0	0	0	0	0

[a] Column (1) to (6) represent six size categories based on the number of single men within their own ethnicity and with a college or higher level of education at the MSA for a given year.

[b] Each cell in the table reports the number of MSAs fall into one size category for a given ethnicity and year. For example, for the US-born, the first column under the year 1990 shows that in 1990, there are 2 MSAs across the U.S. that have a MSA count of US-born col+ single men between 200 and 499.

Table A2-2: Distribution of Col+ Single Women among U.S. MSAs by Ethnicity (Birth Region):

Number of MSAs in 6 Size Categories,[a]
Size Categories Based on MSA Count of Own-Ethnic Co+ Single Women (*W*)
Year 1990 and Year 2010

	(1)		(2)		(3)		(4)		(5)		(6)	
MSA Size Categories Are Based on *MSA Count of Own-Ethnic Col+ Single Women (W)*	$200 \leq W \leq 499$		$500 \leq W \leq 999$		$1000 \leq W \leq 1999$		$2000 \leq W \leq 3999$		$4000 \leq W \leq 7999$		$W \geq 8000$	
	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010	Year 1990	Year 2010
Ethnicity (Birth Region)												
United States	0[b]	0	20	4	54	17	64	55	50	75	85	146
Canada	13	24	2	8	2	3	0	2	0	0	0	0
Other North America	0	2	0	0	0	0	0	0	0	0	0	0
Central America and Caribbean	15	35	11	24	4	14	1	11	1	5	2	4
Southern America	7	26	4	17	2	9	1	5	1	2	0	2
Northern Europe	10	25	7	6	2	4	1	1	0	1	0	0
Western Europe	18	19	4	9	2	4	1	2	0	1	0	0
Southern Europe	5	20	2	7	0	2	1	1	0	0	0	0
Eastern Europe	9	25	2	21	2	9	1	1	0	2	0	2
China	11	32	5	13	1	7	1	3	2	4	0	2
Japan	1	15	2	4	0	1	0	1	0	1	0	0
Korea	6	26	2	7	2	6	0	4	0	2	0	0
Other East Asia	0	2	0	0	0	0	0	0	0	0	0	0
Philippines	8	28	10	10	4	12	3	8	1	4	1	1
Vietnam	5	18	4	9	0	6	0	2	0	1	0	0
Other Southeast Asia	7	17	0	9	1	4	0	1	0	0	0	0
India	11	33	2	17	1	7	0	7	0	1	0	0
Other South Asia	6	13	1	3	1	1	0	2	0	0	0	0
Middle East	2	13	2	5	1	2	0	2	0	0	0	0
Africa	7	20	3	14	1	6	0	2	0	1	0	0
Oceania	2	5	0	4	0	2	0	0	0	0	0	0
Other	8	2	2	0	1	0	1	0	0	0	0	0

[a] Column (1) to (6) represent six size categories based on the number of single women with own ethnicity and with a college or higher level of education at the MSA for a given year.

[b] Each cell in the table reports the number of MSAs fall into one size category for a given ethnicity and year. For example, for the US-born, the first column under year 1990 shows that in 1990, there is no MSA in the U.S that has a MSA count of US-born col+ single women falling between 200 and 499.

Table A3: Number of MSAs in 4 Size Categories Based on MSA Count of Own-Industry Ph.D. Workers (I)

PANEL A: Year 1990

MSA Size Categories Are Based on ***MSA Count of Own-Industry Ph.D. Workers (I)***	$100 \leq I \leq 199$	$200 \leq I \leq 499$	$500 \leq I \leq 999$	$I \geq 1000$
Industry				
Agriculture	9	2	0	0
Mining	2	2	1	1
Construction	13	7	2	0
Manufacturing	36	28	20	21
Transportation, Communication, Electricity and Gas	21	7	5	0
Wholesale	14	10	2	0
Retail	26	8	4	1
FIRE	28	12	8	3
Computer and Data Processing	13	8	2	0
Health Service	48	50	19	23
Legal Service	29	14	3	3
Education	41	66	48	90
Social Service	13	5	1	1
Museum, Art, Zoo	3	1	0	0
Membership Organization	30	17	3	3
Engineering	15	4	4	0
Accounting, Audit	2	1	0	0
R&D, Testing	21	22	12	12
Management and Public Relation	24	23	7	8
Other Services	20	10	3	1
Public Administration	33	31	10	3

PANEL B: Year 2010

MSA Size Categories Are Based on ***MSA Count of Own-Industry Ph.D. Workers (I)***	$100 \leq I \leq 199$	$200 \leq I \leq 499$	$500 \leq I \leq 999$	$I \geq 1000$
Industry				
Agriculture	27	17	2	0
Mining	5	2	0	1
Construction	14	5	2	0
Manufacturing	32	40	26	31
Transportation, Communication, Electricity and Gas	16	17	10	2
Wholesale	15	13	2	0
Retail	47	34	21	9
FIRE	29	25	12	7
Computer and Data Processing	14	13	11	5
Health Service	37	62	58	71
Legal Service	26	38	26	14
Education	41	66	48	90
Social Service	22	26	7	0
Museum, Art, Zoo	6	6	1	0
Membership Organization	33	49	13	8
Engineering	30	20	3	4
Accounting, Audit	7	5	0	0
R&D, Testing	26	41	17	22
Management and Public Relation	41	28	13	9
Other Services	23	19	10	3
Public Administration	38	50	23	10

Table A4-1: City Size Categories Based on MSA's Own-Ethnic Population

Location Choices for Single Ph.D. Workers

City Size Categories Based on ***MSA's Own-Ethnic Population***	Predicted Probabilities					
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	Year 1990	Year 2000	Year 2010	Year 1990	Year 2000	Year 2010
Panel A: US-born						
Large Own-Ethnic MSAs	0.3226	0.3208	0.2896	0.3155	0.3021	0.3104
	(.00028)	(.00008)	(.00037)	(.00011)	(.00013)	(.00038)
Midsize Own-Ethnic MSAs	0.3714	0.4236	0.4783	0.3991	0.4423	0.4633
	(.00045)	(.00026)	(.00062)	(.00039)	(.00039)	(.00105)
Small Own-Ethnic MSAs	0.3060	0.2556	0.2321	0.2854	0.2556	0.2263
	(.00064)	(.00031)	(.00033)	(.00037)	(.00036)	(.00075)
Panel B: Chinese						
Large Own-Ethnic MSAs	0.5262	0.6054	0.4445	0.4842	0.4929	0.4607
	(.00763)	(.00483)	(.01209)	(.00703)	(.00381)	(.00873)
Midsize Own-Ethnic MSAs	0.2948	0.2774	0.3947	0.3097	0.3643	0.4371
	(.00652)	(.00203)	(.01019)	(.00476)	(.00270)	(.00647)
Small Own-Ethnic MSAs	0.1790	0.1172	0.1608	0.2061	0.1428	0.1022
	(.00480)	(.00320)	(.00504)	(.00549)	(.00226)	(.00283)
Panel C: Indian						
Large Own-Ethnic MSAs	0.3507	0.4831	0.3869	0.3936	0.4706	0.3576
	(.00572)	(.00635)	(.00643)	(.00465)	(.00295)	(.00829)
Midsize Own-Ethnic MSAs	0.3639	0.3413	0.3784	0.3161	0.4084	0.5576
	(.00788)	(.00206)	(.00220)	(.00286)	(.00267)	(.00684)
Small Own-Ethnic MSAs	0.2854	0.1756	0.2347	0.2903	0.1210	0.0848
	(.00696)	(.00498)	(.00677)	(.00500)	(.00158)	(.00214)

[a] City size categories are based on the size of the own-ethnic population that are aged 15 above and present in that MSA. For a given person, large own-ethnic MSAs are metropolitan areas in which his/her own ethnic population rank within top 15 among all U.S. MSAs, midsize own-ethnic MSAs as those that rank outside top 15 but have at least 1,000 people within the ethnicity of this person (the cutoff number is 250,000 for the US-born) present in the local areas, and the rest of MSAs are classified as small own-ethnic MSAs.

[b] Within a specific gender-period, for each panel, the probabilities should sum to one. Standard errors are in parentheses.

Table A4-2: City Size Categories Based on MSA's Own-Ethnic Population

Location Choices for Married Ph.D. Workers in Super-Power Couples (SPC)

City Size Categories Based on ***MSA's Own-Ethnic Population***	Predicted Probabilities					
	Married Female Ph.D. Workers in SPC			**Married Male Ph.D. Workers in SPC**		
	Year 1990	Year 2000	Year 2010	Year 1990	Year 2000	Year 2010
Panel A: US-born						
Large Own-Ethnic MSAs	0.3124	0.2960	0.2704	0.3222	0.2953	0.2740
	(.00062)	(.00035)	(.00052)	(.00029)	(.00030)	(.00085)
Midsize Own-Ethnic MSAs	0.3741	0.4258	0.4461	0.3642	0.4193	0.4442
	(.00074)	(.00055)	(.00136)	(.00060)	(.00052)	(.00114)
Small Own-Ethnic MSAs	0.3135	0.2782	0.2835	0.3136	0.2854	0.2818
	(.00133)	(.00086)	(.00155)	(.00076)	(.00053)	(.00097)
Panel B: Chinese						
Large Own-Ethnic MSAs	0.4210	0.4841	0.4393	0.4267	0.4825	0.4444
	(.00383)	(.00214)	(.00360)	(.00909)	(.00334)	(.00351)
Midsize Own-Ethnic MSAs	0.3913	0.4104	0.4252	0.3704	0.4033	0.4334
	(.00383)	(.00107)	(.00276)	(.00396)	(.00216)	(.00308)
Small Own-Ethnic MSAs	0.1877	0.1055	0.1355	0.2029	0.1142	0.1222
	(.00592)	(.00132)	(.00300)	(.00683)	(.00153)	(.00196)
Panel C: Indian						
Large Own-Ethnic MSAs	0.3534	0.4433	0.4328	0.3693	0.4590	0.4405
	(.00445)	(.00286)	(.00570)	(.00657)	(.00407)	(.00533)
Midsize Own-Ethnic MSAs	0.2754	0.4026	0.4273	0.3371	0.4108	0.4501
	(.00349)	(.00140)	(.00651)	(.00258)	(.00250)	(.00417)
Small Own-Ethnic MSAs	0.3712	0.1541	0.1399	0.2936	0.1302	0.1094
	(.00668)	(.00195)	(.00507)	(.00600)	(.00216)	(.00327)

[a] City size categories are based on the size of the own-ethnic population that are aged 15 above and present in that MSA. For a given person, large own-ethnic MSAs are metropolitan areas in which his/her own ethnic population rank within top 15 among all U.S. MSAs, midsize own-ethnic MSAs as those that rank outside top 15 but have at least 1,000 people within the ethnicity of this person (the cutoff number is 250,000 for the US-born) present in the local areas, and the rest of MSAs are classified as small own-ethnic MSAs.

[b] Within a specific gender-period, for each panel, the probabilities should sum to one. Standard errors are in parentheses.

Table A5-1: City Size Categories Based on MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv)

Location Choices for Single Ph.D. Workers [a]

City size categories	Predicted Probabilities					
	Single Female Ph.D. Workers			**Single Male Ph.D. Workers**		
	Year 1990	Year 2000	Year 2010	Year 1990	Year 2000	Year 2010
Panel A: US-born						
Large MSAs + Large OECoAbv	0.2678	0.3063	0.2947	0.2645	0.2888	0.3313
	(.00026)	(.00011)	(.00034)	(.00013)	(.00014)	(.00029)
Large MSAs + Small OECoAbv	0.0000	0.0416	0.0779	0.0000	0.0426	0.0812
	(.00000)	(.00008)	(.00011)	(.00000)	(.00008)	(.00027)
Midsize MSAs + Large OECoAbv	0.0632	0.0288	0.0000	0.0506	0.0265	0.0000
	(.00012)	(.00006)	(.00000)	(.00007)	(.00008)	(.00000)
Midsize MSAs + Small OECoAbv	0.3724	0.3829	0.4077	0.4075	0.4024	0.3715
	(.00038)	(.00024)	(.00050)	(.00039)	(.00035)	(.00085)
Small MSAs	0.2966	0.2403	0.2198	0.2774	0.2397	0.2161
	(.00064)	(.00030)	(.00041)	(.00037)	(.00035)	(.00069)
Panel B: Chinese						
Large MSAs + Large OECoAbv	0.3827	0.3922	0.3828	0.3109	0.3316	0.4147
	(.00775)	(.00357)	(.01061)	(.00380)	(.00254)	(.00782)
Large MSAs + Small OECoAbv	0.0053	0.0507	0.0883	0.0148	0.0631	0.0860
	(.00060)	(.00105)	(.00338)	(.00065)	(.00093)	(.00368)
Midsize MSAs + Large OECoAbv	0.1775	0.2000	0.0756	0.1735	0.1888	0.0898
	(.00685)	(.00318)	(.00339)	(.00374)	(.00240)	(.00253)
Midsize MSAs + Small OECoAbv	0.2542	0.2269	0.2629	0.2904	0.2517	0.2845
	(.00422)	(.00137)	(.00614)	(.00188)	(.00133)	(.00559)
Small MSAs	0.1803	0.1301	0.1904	0.2104	0.1647	0.1251
	(.00840)	(.00431)	(.00861)	(.00607)	(.00371)	(.00325)
Panel C: Indian						
Large MSAs + Large OECoAbv	0.2951	0.3700	0.3540	0.2778	0.3530	0.3228
	(.00692)	(.00477)	(.00512)	(.00283)	(.00232)	(.00794)
Large MSAs + Small OECoAbv	0.0308	0.0292	0.0712	0.0323	0.0447	0.1150
	(.00357)	(.00051)	(.00378)	(.00128)	(.00058)	(.00403)
Midsize MSAs + Large OECoAbv	0.0709	0.0987	0.0714	0.1232	0.1310	0.0708
	(.00323)	(.00167)	(.00427)	(.00236)	(.00156)	(.00253)
Midsize MSAs + Small OECoAbv	0.3586	0.3384	0.2868	0.3149	0.3335	0.3778
	(.00761)	(.00134)	(.00183)	(.00120)	(.00128)	(.00578)
Small MSAs	0.2459	0.1637	0.2166	0.2514	0.1377	0.1135
	(.01245)	(.00575)	(.01103)	(.00568)	(.00258)	(.00237)

[a] An MSA has large OECoAbv if its own-ethnic col+ population ranks within top15 among all U.S MSAs; otherwise it has Small OECoAbv. Standard errors are in parentheses.

Table A5-2: City Size Categories Based on MSA's Total Population and Own-Ethnic Col+ Population (OECoAbv)

Location Choices for Married Ph.D. Workers in SPC

City size categories	Predicted Probabilities					
	Married Female Ph.D. Workers in SPC			**Married Male Ph.D. Workers in SPC**		
	Year 1990	Year 2000	Year 2010	Year 1990	Year 2000	Year 2010
Panel A: US-born						
Large MSAs + Large OECoAbv	0.2576	0.2707	0.2812	0.2729	0.2727	0.2791
	(.00056)	(.00027)	(.00062)	(.00024)	(.00034)	(.00088)
Large MSAs + Small OECoAbv	0.0000	0.0301	0.0526	0.0000	0.0288	0.0537
	(.00000)	(.00007)	(.00019)	(.00000)	(.00008)	(.00027)
Midsize MSAs + Large OECoAbv	0.0565	0.0357	0.0000	0.0517	0.0331	0.0000
	(.00015)	(.00021)	(.00000)	(.00013)	(.00016)	(.00000)
Midsize MSAs + Small OECoAbv	0.3823	0.4042	0.3892	0.3724	0.3987	0.3945
	(.00067)	(.00052)	(.00134)	(.00056)	(.00046)	(.00103)
Small MSAs	0.3036	0.2593	0.2770	0.3030	0.2666	0.2727
	(.00130)	(.00083)	(.00154)	(.00075)	(.00054)	(.00090)
Panel B: Chinese						
Large MSAs + Large OECoAbv	0.2509	0.3075	0.3605	0.2950	0.3131	0.3710
	(.00365)	(.00125)	(.00354)	(.00541)	(.00190)	(.00209)
Large MSAs + Small OECoAbv	0.0204	0.0691	0.1322	0.0149	0.0595	0.1224
	(.00223)	(.00075)	(.00276)	(.00083)	(.00040)	(.00227)
Midsize MSAs + Large OECoAbv	0.2208	0.1886	0.0754	0.1893	0.1884	0.0710
	(.00647)	(.00159)	(.00121)	(.00559)	(.00134)	(.00077)
Midsize MSAs + Small OECoAbv	0.3567	0.3151	0.2697	0.3225	0.3029	0.2684
	(.00416)	(.00173)	(.00277)	(.00616)	(.00129)	(.00179)
Small MSAs	0.1513	0.1197	0.1622	0.1783	0.1360	0.1672
	(.00563)	(.00171)	(.00230)	(.00645)	(.00185)	(.00185)
Panel C: Indian						
Large MSAs + Large OECoAbv	0.2461	0.2857	0.3395	0.2688	0.2984	0.3533
	(.00228)	(.00220)	(.00474)	(.00446)	(.00265)	(.00442)
Large MSAs + Small OECoAbv	0.0211	0.0398	0.0852	0.0153	0.0318	0.0943
	(.00154)	(.00054)	(.00248)	(.00061)	(.00028)	(.00317)
Midsize MSAs + Large OECoAbv	0.1304	0.1307	0.0838	0.1221	0.1145	0.0759
	(.00241)	(.00148)	(.00175)	(.00297)	(.00134)	(.00113)
Midsize MSAs + Small OECoAbv	0.3703	0.3808	0.2960	0.3846	0.3784	0.3153
	(.00325)	(.00172)	(.00516)	(.00441)	(.00175)	(.00362)
Small MSAs	0.2320	0.1631	0.1955	0.2093	0.1469	0.1611
	(.00602)	(.00263)	(.00371)	(.00439)	(.00266)	(.00329)

[a] An MSA has large OECoAbv if its own-ethnic col+ population ranks within top15 among all U.S MSAs; otherwise it has Small OECoAbv. Standard errors are in parentheses.

Table A6: Top 20 MSAs of Patent Creation in the Year 2001[a]

MSA Name	Total Patents at Year 2001	Top Cited Patents at Year 2001[b]	Population at Year 1990 (In 1,000s)			College-Above Population at Year 1990 (In 1,000s)	
			All ethnicities	Chinese	Indian	Chinese	Indian
San Jose, CA	4734	276	1173	32.81	13.25	14.46	6.96
San Diego, CA	1404	46	1951	9.15	3.11	3.30	1.14
Minneapolis-Saint Paul, MN	1363	60	1756	3.59	3.90	1.75	1.70
Austin, TX	1024	47	551	3.01	2.60	1.30	1.05
Houston, TX	987	70	2376	15.72	17.32	6.75	7.62
Phoenix, AZ	784	49	1623	4.34	2.99	1.43	1.30
Atlanta, GA	776	36	1870	5.18	6.60	1.99	2.96
Rochester, NY	642	32	745	1.49	1.69	0.71	1.01
Cincinnati, OH-KY-IN	465	23	964	1.07	2.48	0.45	1.36
Cleveland, OH	433	23	1366	2.82	3.87	0.89	2.12
Denver, CO	422	22	179	0.85	0.53	0.30	0.28
Milwaukee, WI	396	19	1197	2.78	1.04	0.89	0.55
Sacramento, CA	350	26	1094	1.67	1.39	0.86	0.66
Pittsburgh, PA	340	14	1128	11.39	3.36	2.22	0.97
Riverside-San Bernardino, CA	330	14	1545	2.62	3.54	1.05	1.88
Raleigh-Durham, NC	310	14	1881	5.62	5.19	1.45	2.28
Saint Louis, MO-IL	290	7	1807	2.13	2.10	0.71	1.36
Indianapolis, IN	286	19	953	0.99	1.50	0.41	0.58
Baltimore, MD	281	11	1834	3.82	5.21	1.16	3.07
Ventura-Oxnard-Simi Valley, CA	256	10	504	2.47	1.51	1.09	0.80

[a] These patents are utility patents with application year in 2001. Data are downloaded from NBER Patent Data Project (PDP) and Harvard Patent Network Dataverse. Patents with multiple inventors are distributed evenly across all inventors' corresponding residing MSAs. Population count is calculated by using decennial census data from IPUMS.

[b] Citation counts are until 2006, and are truncation-adjusted by using the weight Hall et al. (2001) suggested. Patents whose number of received citations among top 10% within its own technology category are regarded as top cited patents.

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