Field-of-Study Homogamy

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March 2016 (Updated in Aug 2018)

Abstract

This paper reports evidence on the strong tendency of the college educated to match with partners who graduated in the same field of study—a dimension of assortative matching that has been overlooked thus far. We employ Labor Force Survey data covering most EU countries to measure the extent of field-of-study homogamy in prevailing married and cohabiting couples within several years of college graduation. We find that field-of-study homogamy increases almost immediately after graduation to reach very high levels, especially for spouses working in the same industry, and that it varies dramatically across countries. Our findings are consistent with the presence of field-of-study homophily, and suggest that meeting opportunities play a quantitatively important role in generating the observed matching patterns.

JEL Codes: I23, J12, J16

Keywords: Field-of-Study Homogamy, College Graduates, Marriage and Cohabitation

Acknowledgements: Jurajda is a Research Fellow at IZA, Bonn. This research has been supported by the Czech Science Foundation (grant P402/12/G130). The paper was initiated while Jurajda was visiting the School of Economics at the University of Edinburgh; the School's hospitality is most gratefully acknowledged. We would also like to thank Dana Hamplová, Nikolas Mittag, and Michael Smith for their comments and suggestions.

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1 Introduction

Positive assortative matching is a central feature of marriage markets and the subject of much research in evolutionary psychology, economics, sociology, and demography.[1] *Educational homogamy*—the tendency to match based on one's level of education—has received particular attention in the literature since it affects household inequality (Fernández et al., 2005; Schwartz, 2013; Greenwood et al., 2014; Qian, 2018; Eika et al., in press) and marriage returns to education (Goldin, 1997; Chiappori et al., 2009; Esteve et al., 2012).[2] Educational homogamy appears particularly strong among college graduates (Schwartz and Mare, 2005).

The burgeoning literature on assortative matching has thus far largely ignored one potentially important dimension: matching on the field of study. This is again particularly relevant for college educated, for whom differences in (causal) wage returns across fields of study can be as large as the college wage premium (Hastings et al., 2014; Kirkebøen et al., 2016; Altonji et al., 2016), and where field-of-study choices have been linked to fertility (van Bavel, 2010). If college graduates tend to match into couples within their field of study, the large differences across these fields in both earnings and in the availability of family-friendly careers could lead to sizeable consequences for household inequality and family formation. Two recent papers provide the first evidence on these effects. Eika et al. (in press) measure the contribution of *field-of-study homogamy* (hereafter FSH) towards household income inequality among college graduates in Norway. Bičáková and Jurajda (2017) study almost all EU countries and conclude that the availability of potential partners in one's field of study in college affects the educational structure of parenthood—the share of parents with the same field of study in college as well as the share of parents with different education levels.

In this paper, we provide the first available systematic cross-country evidence on the

[1] Schwartz (2013) provides a recent survey of the sociology and demography literature. Belot and Francesconi (2013) offer an extensive set of references to the theoretical work in economics on search and matching as well as to the evolutionary psychology literature studying assortative mating preferences.

[2] The rising marriage return to college for women (Ge, 2011; Chiappori et al., 2015) may help to explain why women now represent the majority of college graduates across the developed world (Becker, et al., 2010).

degree to which college graduates of each gender match into marriage and cohabitation across fields of study. We do so for most EU countries, using the European Labor Force Surveys, which since 2003 distinguishes eight broad fields of study for each respondent. The cross-sectional data allow us to document FSH trends for couples in prevailing marriages and cohabitations. Specifically, we observe the entire post-college evolution of FSH for graduation cohorts starting in 2003; for earlier graduation cohorts, we map FSH patterns of prevailing marriages and cohabitations from 2003 to 2013. We focus on the 80% of couples involving a college graduate in which both partners are college-educated.[3]

We uncover a high degree of FSH among couples formed by college graduates in all of the 24 EU countries we study. A randomly picked couple is almost twice as likely to be homogamous than would be predicted from matched marginals under random matching (if fields of study played no role in matching). FSH among college graduates grows rapidly in the first three years after graduation and then plateaus. The tendency to match within one's field of study appears at least as strong as the much studied tendency to match within one's educational attainment level, and it varies dramatically across countries. Using cross-country comparisons, we suggest that a society-wide measure of gender inequality—the Gender Gap Index—is related to how well countries utilize their potential for FSH, which, in turn, is determined by their degree of gender segregation across college fields of study.

While the main purpose of this study is to provide new stylized facts on homogamous matching by field of study across a wide set of countries, we structure our analysis to provide insight into two mechanisms that likely underlie assortative mating: We consider the role of preferences versus the role of meeting opportunities (search costs) for FSH. Most of our analysis employs tools used in the sociology and demography literature, but we also interpret the observed matching patterns using an economics equilibrium matching model, which allows us to bring the extent of unmatched college graduates by field of study into the analysis based on clearly specified behavioral foundations.

[3] Of the couples involving a female (male) college graduate, 80% (83%) are college-college couples.

2 Background and Plan of Analysis

The plan of our analysis of FSH reflects the state of the large literature on educational homogamy. First, this literature employs measurement strategies that acknowledge the mechanical effect of gender shares on homogamy. The share of women among college graduates has experienced a secular increase across the world (Becker et al., 2010) and this would lead to an increase in the share of couples formed by two college graduates even if the underlying tendency towards educational homogamy were constant. Similarly, the distribution of men and women across fields of study has a mechanical effect on the potential for FSH. In a field of study, where women represent only 20% of graduates, FSH cannot reach high levels because most male graduates cannot find a homogamous partner.

In the first part of our analysis, which provides a set of novel facts on FSH, we therefore follow the educational homogamy literature and measure the degree of FSH at the EU level using an index that is independent of the distribution of men and women (in couples) across fields of study. Next, we contrast the strength of FSH across pairs of fields of study using match log odds ratios—the building blocks of log-linear models. This allows us to not only measure FSH at field-pair level, but also to compare the degree of FSH to the magnitude of educational homogamy in our data. We shed light on the evolution of FSH at the EU level by estimating log-linear models, which are widely used to study educational homogamy in both sociology and demography (Schwartz and Mare, 2005; Blossfeld, 2009). Again, an often cited advantage of these models is that they are 'marginal-free', that is invariant to changes in marginal distributions of (matched) graduates across fields of study. Most of the literature concludes that educational homogamy has been increasing thanks to a growing tendency of college graduates to marry each other (e.g., Siow, 2015).[4] By extension, one may therefore expect FSH to also be increasing at the EU level.[5]

[4] Gihleb and Lang (2016) study the US evolution of educational homogamy and reach different conclusions.

[5] Bičáková and Jurajda (2014) show that the extent of gender segregation across fields of study, which drives the potential for FSH, is almost constant at the EU level during the period we analyze here.

We complement this description of FSH patterns by asking whether the supply structure of graduates across fields of study differs significantly from the field-of-study structure of matched graduates, i.e., graduates observed in couples. This is an important check since the entire literature, including the first part of the present study, takes the total number of matches as exogenously given. We also illustrate how the gender segregation across fields of study affects the country-specific potential for FSH. This allows us to study cross-country differences in the utilization of the segregation-implied potential for FSH.

Our analysis includes married as well as cohabiting couples, which reflects the growing importance of cohabitation (see, e.g., Choo and Siow, 2006, or Schwartz, 2010). Naturally, we ask whether FSH among pairs in which both partners are college graduates is similar for married and cohabiting couples. Schwartz (2010) finds a similar degree of educational homogamy among cohabitors and married couples when cohabiting and marital unions begin. Our evidence covers the first few years after graduation and so one may also expect a similar degree of FSH among married and cohabiting couples. It has been suggested that the lower permanence of cohabitation unions and their lower enforceability of implicit contracts should be compensated in prevailing unions by stronger tendency to match to partners with similar educational characteristics and labor market prospects who may also share similar interests and tastes (Schoen and Weinick, 1993; Brines and Joyner, 1999). The alternative theory is that cohabitation serves to generate a pool of potential spouses for eventual marriages and may thus be associated with lower levels of homogamy (Blackwell and Lichter, 2000). These two theories thus correspond to a clear (opposite) ordering of the degree of FSH for married and cohabiting couples, and we assess these predictions using our EU-wide data.

In the second part of our analysis, we consider two prime explanations for the presence of FSH, which have been offered to account for the evidence on educational homogamy (see Schwartz and Mare, 2005, for an overview) and are equally applicable to the case of FSH: We consider the role of preferences and of meeting opportunities (matching technology, search costs). Since observed matching patterns depend on both preferences and the available matching technology, interpreting matching outcomes as corresponding to preferences is difficult in absence of a fully specified matching model (Chiappori and Salanié, 2016; Bailey, et al., 2017). Nonetheless, our data allow us to provide a number of informative comparisons.[6]

One set of mechanisms explored in the educational homogamy literature is based on the structure of search costs on the marriage market. Colleges provide important meeting opportunities, and this may be particularly true for studies in the same field or in the same education program. Similarly, workplace-based meeting opportunities linked to field-of-study choices can also drive the degree of FSH. There is a growing body of research documenting the role of schools in structuring marriage markets and supporting educational homogamy (e.g., Blossfeld and Timm, 2003; Nielsen and Svarer, 2009; Pestel, 2017), even if this work does not focus on fields of study. Kaufmann et al. (2013) and Artmann et al. (2018) find that being quasi-randomly admitted to a particular study program or field of study increases the chances of marrying within that program or field. However, Kaufmann et al. (2013) also imply that the effect on matching that attending a particular university has through social networks that individuals access on the marriage market is quantitatively more important than the study-program effect.

Our FSH measures are based on country-wide groups of graduates in the same field of study and therefore are best thought of as corresponding to the combined channels of meeting potential partners in a study program and in marriage market-wide social and workplace networks linked to one's field of study.[7] In the absence of direct measures of search costs,[8] we offer the following comparisons: First, if meeting opportunities in education programs are important for FSH, homogamous couples ought to be more likely to graduate in the same year

[6] Our data provide the largest available samples of EU couples with field of study information, but they do not cover earnings, so that we cannot assess the importance of matching on earnings for FSH. See, e.g., Ong and Wang (2015) for research on gender-specific preferences on spousal income.

[7] In related work, Mansour and McKinnish (2014) and McClendon et al. (2014) uncover a significant role of occupation-based matching for marriage market outcomes.

[8] Direct measures of matching technology are obviously crucial for a better understanding of the patterns we uncover. For example, Rosenfeld and Thomas (2012) suggest the Internet has largely freed matching in the US of the constraints of search opportunities and costs.

compared to non-homogamous couples. Next, to the extent that one expects workplace-based interactions to gradually dominate social networks built during college studies as a source of FSH, we expect the degree of FSH to be higher among couples working in the same industry and the gradient of FSH in years since graduation to be more rapid for the 'same-industry' couples.

The second key explanation for homogamy considered in the educational homogamy literature is based on preferences for similar partners. There is direct evidence that college graduates prefer matching to a partner with a similar level of education (e.g., Bellot and Francesconi, 2013). By extension, graduates in the same field of study may be particularly likely to share similar interests and tastes. The evidence on same-education-level preferences comes mainly from on-line dating, as partner search costs are minimized in such settings. Currently, there appears to be no research eliciting FSH preferences (field-of-study homophily) in such environments. To shed light on the presence of FSH preferences, we argue that matches composed of a college graduate and a high school graduate,[9] in which the spouses work in different industries, are unlikely to be formed thanks to meeting opportunities (low search costs) in workplace or school. Specifically, we measure FSH for the pairs formed by a college graduate and a high school graduate using those high school graduates who did not attend 'field-less' general academic secondary programs, which frequently lead to college studies. These couples are thus unlikely to have met in school, thanks to meeting opportunities, so that the presence of FSH among these couples would suggest the presence of FSH preferences.

To shed further light on the nature of FSH preferences we explore cross-country comparisons based on the notion that converging gender roles, as reflected in decreasing society-wide gender inequality, bring about converging (increasingly symmetrical) partner preferences. If college graduates increasingly prefer similar partners (as discussed in, e.g., Schwartz and Mare, 2005), this would imply preference for those who graduated from the same field of study. We thus ask whether FSH and the utilization of FSH potential is particularly high in

[9] In our EU data, most high-school graduates report a field of study, i.e., their high-school's technical or vocational specialization.

countries featuring a lower degree of society-wide gender inequality.[10] Given the relatively short time period our data cover, we abstain from relating FSH to time-changing correlates such as the degree of development or cultural factors (as Smits et al., 1998, do for educational homogamy). The country-level link between field-of-study choices of men and women and their marriage market preferences is yet to be explored. There is a large literature on field-of-study (major) choices (e.g., Beffy et al., 2012; Wiswall and Zafar, 2015; Ochsenfeld, 2016), but it does not consider the linkages between field-of-study choices and the marriage market. We provide one summary measure of such links.

In the third and final part of our analysis, we interpret the observed matching patterns using an equilibrium matching model. Specifically, we employ the Choo and Siow (2006) model (hereafter, the CS model), which empirically implements Becker's (1973) transferable utility model of a friction-less competitive marriage market—the current benchmark model of the marriage market in economics. The primary purpose of the CS marriage matching function is to describe how match patterns respond to supply changes. Similar to a saturated log-linear matching model, it is nonparametric. Unlike the log-linear matching model, the CS model does not abstract from unmatched individuals. Further, unlike the Schoen's (1981) harmonic mean matching model, which does link matching to supply structure, the CS model allows for substitution elasticities across types of individuals, i.e., spillovers across fields of study. The model's central concept is that of gains from matching—systematic gains to being matched relative to remaining single. These (unmeasured) gains correspond to a utility function based on the McFadden (1974) extreme-value random utility model; they thus correspond to income gains, within-household transfers, and to gains in terms of shared interests and lifestyles. In the equilibrium of the CS model, marital output is allocated between matched spouses in a manner that ensures that they prefer their match to being matched to someone else or remaining unmatched. The matching function derived by Choo

[10]The interpretation of these comparisons as being related to FSH preferences is based on the strong assumption of no cross-country relationship between gender inequality and the extent of meeting opportunities in school- and workplace-based networks. Relaxing this assumption is an important avenue for future research.

and Siow (2006) maps population supplies to who marries whom based on clearly specified behavioral foundations. Importantly, the CS model allows us to consider not only matched, but also unmatched graduates.[11] On the other hand, the model does not allow us to explore the role of search costs. It provides a view of the matching patterns that is complementary to that based on the standard tools used in the sociology and demography literature.

3 Data

Our analysis is based on the EU Labour Force Survey (LFS), which provides information on college graduates and their marriage/cohabitation status in 24 EU countries.[12] We employ the 2014 release of the EU LFS covering reference years 2003 to 2013, when information on field of study is available in the data, and focus on individuals with ISCED 1997 education levels 5 and 6 who graduated between the ages of 20 and 44. We restrict our attention to matching outcomes of the 360,072 female and 321,069 male college graduates from 252 country-reference year LFS samples who graduated between 1993 and 2013. For each such college graduate we also observe the year of graduation, education level, and field-of-study of their partner, if they have one.[13]

We study couples sharing the same household. The EU LFS data record the presence of "spouses or cohabiting partners in the same household" and we refer to such couples as 'marriage/cohabitation' matches. Next, we use a separate LFS question about the marital status of respondents to divide these couples into either married or cohabiting. In total, we observe 128,040 marriage/cohabitation couples formed by two college graduates, of which

[11]The model can be used to decompose changes in assortative matching patterns due to "who marries whom" from changes driven by "who remains single" (Dupuy and Weber, 2018).

[12]The focus on graduates, dictated by the data we use, reflects gender differences in both initial choices of field of study and in completion rates (Alon and Gelbgiser, 2011).

[13]The share of sampled individuals with missing education level or field generally does not exceed 5% in any of the country-year data cells. The Data Appendix provides details on our data sources.

95,497 (75%) are married.[14] There are an additional 58,412 marriage/cohabitation couples in our data formed by a college graduate and a high school graduate; in 32,593 of these it is the woman who holds a college degree. Hence, of the college graduates of either gender in marriage/cohabitation couples in our recent EU data, about 80% are in 'college-college' pairs, corresponding to the high degree of educational homogamy explored extensively in the existing literature. Our analysis of FSH focuses on these 'college-college' couples. We classify them as homogamous or not depending on whether both partners graduated from the same broad field of study. The LFS data recognize eight fields of study—Education, Humanities, Social Sciences, Science, Engineering, Agriculture, Health, and Services.[15]

The data cover the complete post-college matching pattern for cohorts of graduates from 2003 onward. For earlier graduation cohorts, we observe prevailing matching outcomes as of one to ten years after graduation. It is possible that some of the couples we observe were formed prior to their choice of field of study in college. To a degree, this could correspond to same-field-of-study matching preferences. However, it could also be that randomly formed pre-college matches lead to both partners choosing the same field of study. In the absence of longitudinal information, we cannot disentangle these mechanisms.

The Data Appendix Table shows for each country and gender the number of sampled college graduates in the data together with the number of college-college matches, the number of matches formed by a college graduate and by a less educated partner, and the number of unmatched. Sample sizes vary widely across countries; we employ LFS sampling weights

[14] Under 5% of college graduates who report being married do not share their household with their spouse. We count them as single. We also omit from the analysis those couples where a college graduate who fulfils our sample criteria is matched to another college graduate who graduated before 1993 or graduated outside of the 20-44 age range. Including this group in the data does not affect the measured aggregate level of FSH.

[15] Bičáková and Jurajda (2014) use UNESCO population statistics on the gender structure of graduates by field of study to show that the LFS coding of fields of study is consistent with administrative data: The correlation of the UNESCO population shares of women in each graduation year-country-field cell with those measured with sampling error in the EU LFS is 0.97.

(corresponding to the female in each couple) in all of our analysis.[16]

Ours appears to be the first available European panel on marriage/cohabitation patterns of college graduates by field of study, but it shares similar features with datasets employed in recent analyses of matching markets. Similar to Chiappori et al. (2018), we rely on cross-sectional surveys (the US CPS in their case, the EU LFS in ours) to study bidimensional matching in the marriage market when census data do not cover one of the important matching dimensions (smoking in their case, field of study in ours). Our analysis is based on country-wide groups of graduates in the same field of study. In this regard, our approach is similar to that of McClendon et al. (2014), who rely on US-wide measures of occupation-specific education levels to contrast marriage market outcomes across occupations that differ in their share of college graduates. Finally, similar to Schwartz and Mare (2005), who study educational homogamy, we map matching patterns in prevailing matches (as opposed to doing so for newlyweds). As argued in detail in Schwartz and Mare (2005), prevailing matches are relevant for analyzing household-level inequality and for considering child environments.[17]

4 Measuring Field-of-Study Homogamy

4.1 Overall Degree of FSH

We begin our analysis by mapping the field-of-study structure of matches formed between two college graduates at the EU level. 36.4% of the 128,040 marriage/cohabitation couples formed

[16] The EU LFS is a random sample survey covering the population in private households. The primary purpose of the EU LFS is to provide comparable national labor market statistics for EU countries. The survey is conducted by the country-specific National Statistical Institutes and is centrally processed by Eurostat. The sampling units are dwellings, households, or individuals depending on the country-specific sampling frames. The sampling weights we employ reflect the survey-specific sampling design and ensure representativeness. In our regression analysis below, we further condition on survey-year fixed effects.

[17] Prevailing matches reflect the structure of newlyweds combined with separation and re-match patterns. Schwartz and Mare (2012) and Schwartz and Han (2014) study marriage separations by educational homogamy. We know of no work on separations and FSH.

by two college graduates in our LFS sample are homogamous, i.e., formed by graduates from the same field of study. Since it is not clear to what extent this high share is driven by assortative matching on the field of study and to what extent it corresponds to the field-of-study composition of men and women (field marginal distributions), we contrast the pattern of matches against the natural benchmark of random (independent) matching in Figure 1, which offers a visualization of EU-wide FSH. The figure shows a field-by-field (8x8) matrix of match types; men's fields of study correspond to columns of the match matrix, women's to rows. The elements of the match matrix give the difference between two match distributions: the share of all matches of a given match type minus the benchmark share predicted under the assumption of independent matching using the marginal distributions of formed matches across fields of study. The counterfactual assumption (the benchmark comparison) is thus that fields of study play no role in match formation.

More formally, let μ_{ij} denote the match frequency of couples formed from men of type i and women of type j, where $i, j = 1, ..., K$ corresponds to fields-of-study groups so that $K = 8$ in our case. Let $T = \sum_{i=1}^{K} \sum_{j=1}^{K} \mu_{ij} = \sum_{i=1}^{K} \mu_{i\cdot} = \sum_{j=1}^{K} \mu_{\cdot j}$ denote the total number of formed matches. The 'marginal-free' measure then equals $\overline{\mu}_{ij} = \mu_{ij}/T - \left(\mu_{i\cdot}\mu_{\cdot j}/T^2\right)$.[18]

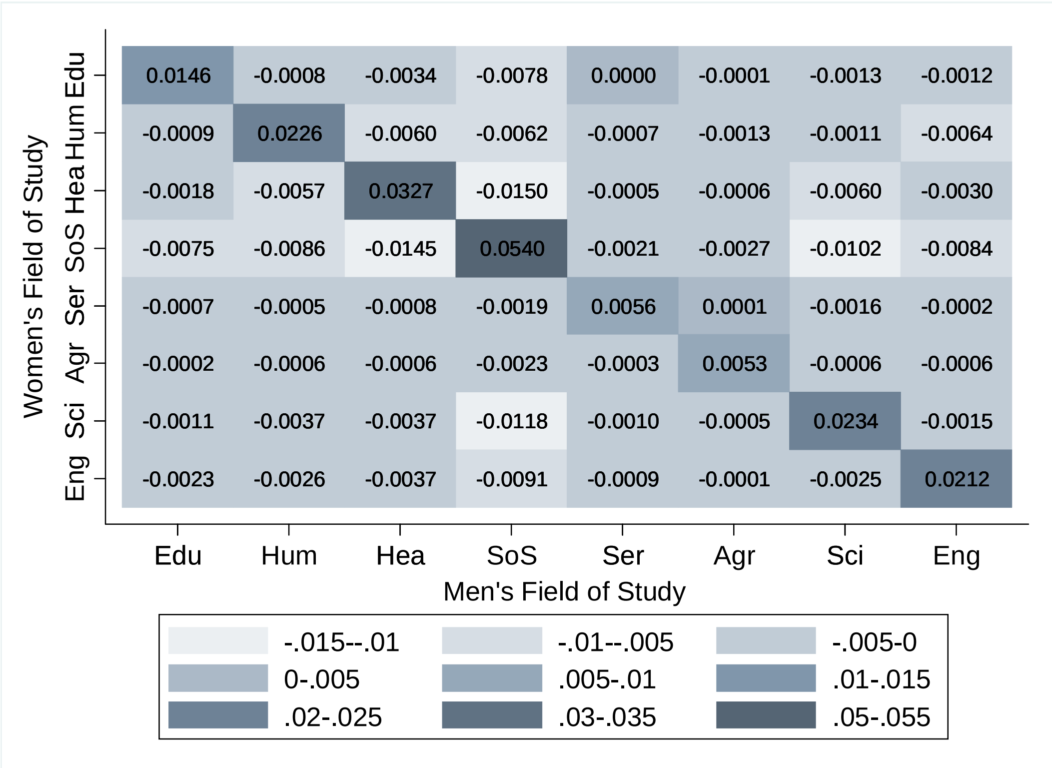
The shading of the match matrix elements in Figure 1, which corresponds to the size of each cell (the EU-wide $\overline{\mu}_{ij}$ value), clearly shows strong FSH on the diagonal of the match matrix, with weaker FSH among graduates in Services and Agriculture and particularly high degree of FSH in Social Sciences and also in Health. The least likely matches, relative to the benchmark of random matching, are to be found between graduates in Health and Social Sciences.

A natural summary of the degree of FSH across the entire matching market is provided by the ratio of the actual share of homogamous matches and the share of homogamous matches

[18] Throughout the paper, we present EU-wide matching statistics aggregated from country-specific matching markets. For example, the EU-wide $\overline{\mu}_{ij}$ values presented in Figure 1 correspond to averages of country-specific values weighted by country total match counts. We also calculated all of the presented matching statistics based on the EU-wide sample of matches and the results were practically identical.

Figure 1: College-to-College Match Distribution against the Benchmark of Independent Matching; All EU-LFS Couples Observed from 2003 to 2013.

Note: Weighted by LFS sample weights. Fields of study: Education (Edu), Humanities (Hum), Social Sciences (SoS), Science (Sci), Engineering (Eng), Agriculture (Agr), Health (Hea), and Services (Ser).



one would expect under the random matching assumption (employed as a benchmark in Figure 1). The ratio of the two diagonal shares, a 'marginal-free' homogamy measure H, allows us to compare the degree of FSH across broad groups of graduates:

$$H = \frac{\sum_{i=1}^{K} \mu_{ii}/T}{\sum_{i=1}^{K} (\mu_{i\cdot}\mu_{\cdot i}/T^2)}. \tag{1}$$

Throughout the paper, we discuss the levels of the FSH index H expressed in percentage points, as $100(H-1)$, with 0 corresponding to no tendency towards FSH.[19]

[19] One could alternatively measure the marginal-free 'global' extent of FSH using the ratio of the geometric means of diagonal and off-diagonal matches. However, such measure, which in a 2x2 case corresponds to

The EU-wide H value corresponding to Figure 1 is 98.8% with a boot-strapped 95% confidence interval of 96.2 to 101.4. Hence, in our EU-LFS data, a randomly picked couple is almost twice as likely to be homogamous than would be predicted from matched marginals under random matching. The homogamous and non-homogamous couples (formed by two college graduates) do not differ in their gender-specific mean age—a basic match characteristic—which is 35 for men and 33 for women.

To shed light on whether FSH is a phenomena affecting only college-college matches, we calculate the H index value corresponding to marriage/cohabitation couples formed by a college graduate and a high school graduate who reports his or her field of study in the EU LFS. There are 58,412 marriage/cohabitation couples in our data between a college graduate and a less educated partner; in 85% (49,716) of these couples, the partner of the college graduate is a high school graduate who reports a field of study.[20] The value of H for the 'high school-college' couples with field of study reported is 25.6% (25.8%) for the 27,664 (22,052) couples where the college graduate is a woman (man).[21] That we find significant FSH in couples formed between high school graduates and college graduates is perhaps surprising given the likely differences in field-of-study content and given the potential field-of-study coding differences between secondary and tertiary education programs. This finding underscores the strong tendency towards FSH uncovered above for 'college-college' couples. In Section 5, we return to the 'high school-college' couples in an attempt to shed light on the sources of FSH.

An important question is whether FSH among 'college-college' couples corresponds primarily to married couples, which represent 75% of our 128,040 marriage/cohabitation matches.

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the 'local' log odds ratio, is sensitive to the distribution of matches among the off-diagonal match cells when $K > 2$, which makes it less attractive.

[20]The other high-school graduates matched to a college graduate attended general secondary programs with no specific field of study.

[21]Both of these measures are statistically significantly above 0 based on bootstrapped standard errors of 3.45 and 2.90 for women and men, respectively.

The answer is clearly no. The H value corresponding to the 95,497 married couples is 100.3% while the H based on the 32,543 cohabiting couples is almost identical at 98.7%. Furthermore, the match matrices corresponding to Figure 1 are almost identical for these two groups: The correlation of the 64 $\overline{\mu}_{ij}$ values across the two matrices is 0.99. This finding is reminiscent of Schwartz (2010) who finds a similar degree of educational homogamy among cohabitors and married couples when cohabiting and marital unions begin. That we find no ordering of FSH between cohabiting and married couples is at odds with theories of cohabitation that predict a stronger dis-similarity between partners in cohabiting couples (in comparison to married couples) in response to the lower enforceability of implicit contracts or the partner-search nature of cohabitation (Schoen and Weinick, 1993; Brines and Joyner, 1999; Blackwell and Lichter, 2000). The similarity of FSH for married and cohabiting couples motivates the joint analysis of both couple types in the rest of our analysis.

4.2 Field-Specific FSH

How does the degree of positive assortative matching vary across pairs of fields of study? We answer this question using the local log odds ratios of match counts for pairs of fields, $\ln\left(\frac{\mu_{ii}\mu_{jj}}{\mu_{ij}\mu_{ji}}\right)$, which represent a standard measure of positive assortative matching in the demography and sociology literature. These building blocks of log-linear models (estimated in the next section) are invariant to changes in marginal distributions (are 'marginal-free').[22]

The 28 local log odds ratios corresponding to all pairwise comparisons of our eight fields of study are (sorted and) presented in Table 1. All of the values are much above 0, statistically significantly so (with p values below 0.001 based on bootstrapped standard errors), suggesting strong positive assortative matching. The lowest log odds ratio is between Social Sciences and Engineering, while the maximum occurs for the combination of Humanities and Agriculture. The table suggests that graduates in Social Sciences are relatively 'open' to matching with

[22]They also correspond to the degree of complementarity of marital output within the matching model of Choo and Siow (2006), which thus provides a behavioral justification for measuring the ratios. We return to the discussion of the local log odds ratios within the CS model in Section 6.

graduates from other fields of study and/or have relatively abundant cross-field meeting opportunities. Similarly, Science and Engineering are also highly compatible. On the other hand, within-field meeting opportunities strongly dominate cross-field interactions and/or matching within one's field is very attractive when the alternative is a non-homogamous match between a graduate in Humanities and one in Agriculture. To provide a deeper understanding of these patterns, future research can elicit FSH preferences, personality traits, and marriage-market expectations of college graduates by field of study.

Table 1: 'Local' Log Odds Ratios

Field Pair		log odds	Field Pair		log odds	Field Pair		log odds
SoS	Eng	1.84	Eng	Ser	3.00	Ser	Sci	3.69
SoS	Hum	2.20	Eng	Hum	3.06	Hum	Hea	3.79
Sci	Eng	2.24	Eng	Edu	3.17	Agr	Eng	3.89
SoS	Sci	2.34	Eng	Hea	3.17	Agr	Edu	4.19
SoS	Ser	2.55	Sci	Hum	3.19	Ser	Edu	4.30
SoS	Edu	2.65	Hea	Edu	3.39	Agr	SoS	4.33
SoS	Hea	2.73	Hea	Sci	3.44	Agr	Sci	4.93
Edu	Hum	2.98	Hea	Ser	3.53	Agr	Ser	5.43
Edu	Sci	2.99	Ser	Hum	3.68	Agr	Hea	5.45
						Agr	Hum	5.86

Notes: Each entry shows the value of the log odds ratio for a given pair of fields of study calculated using college-to-college matches observed in the 2003-2013 EU-LFS, weighted by LFS sample weights. Fields of study: Education (Edu), Humanities (Hum), Social Sciences (SoS), Science (Sci), Engineering (Eng), Agriculture (Agr), Health (Hea), and Services (Ser).

For comparison with the values presented in Table 1, the log odds ratio corresponding to the education-*level* 2x2 match matrix considering only the level of education, i.e., college vs. less than college, is 1.83. All of our pairwise field comparisons thus display a stronger tendency towards positive assortative matching than the much studied educational dimension of homogamy.

4.3 Decomposing FSH Trends

A natural inquiry is whether FSH changes over time. Our data provide only limited time coverage, but it is tempting to plot the aggregate evolution of H. However, such changes may be due to several distinct potential sources: H can change over time thanks to marriage-market-wide shocks to FSH affecting all market participants, thanks to a changing propensity towards FSH across successive graduation cohorts, or, possibly, thanks to a changing composition of our sample over time with respect to the years since graduation when matched couples are observed. To provide an informative view of the EU-wide trends in FSH, we thus estimate log-linear (Poisson) regressions to decompose trends in FSH to aggregate year, graduation-cohort year, and years-since-graduation effects.

Specifically, the analysis distinguishes several types of ij couples (where $i, j = 1, ..., K$ denotes fields-of-study groups) corresponding to additional indices we now introduce: t for the calendar year when a given matched couple is observed, y for graduation year of the matched college graduate, and s for the years since graduation ($s = t - y$). Our FSH trend analysis is performed separately from the perspective of either gender, but we omit the gender subscript here for the sake of the exposition.[23] We consider separately two balanced 'data windows' in terms of years since graduation: $s = 0, 1, ..., 5$ and $s = 6, 7, ..., 10$. This allows us to separately track FSH trends early vs. late after college graduation. The full $0 \leq s \leq 5$ window is observed (in the 2003-2013 LFS samples) for graduation cohorts $y = 2003, ..., 2008$; the $5 < s \leq 10$ window is observed for graduation cohorts $y = 1998, ..., 2003$.

We follow the literature (e.g., Schwartz and Mare, 2005), and focus on FSH trends by conditioning on a set of fully saturated time-constant fixed effects λ_{ij}, which corresponds to the average tendency to match across fields of study. The matches corresponding to the ij (8x8) match matrices observed across the available ty combinations are explained as follows:

[23] When two members of a college-educated couple graduated in different years, the y index (as well as the s index) will differ for this couple depending on whether we measure FSH from the perspective of male or female college graduates.

$$\ln \mu_{ijyt} = \lambda + \lambda_{ij} + \sum_{l=t,y,s} (\lambda_{il} + \lambda_{jl}) + \gamma_y^D + \gamma_t^D + \gamma_s^D, \tag{2}$$

where λ_{it} and λ_{jt} denote a set of time-changing (marginal) fixed effects, and where γ_t^D denotes a calendar-time homogamy fixed effect, which corresponds to diagonal elements of the match matrix. This traditional list of controls is expanded by also allowing for graduation-cohort effects in order to focus on the role of colleges in structuring matching markets for college graduates. Specifically, λ_{iy} and λ_{jy} capture the cohort-specific marginal distributions by gender, and γ_y^D, which again corresponds to diagonal elements of the match matrix, tracks the evolution of homogamy across successive graduation cohorts. Finally, we parametrize the evolution of FSH by years s since graduation in a similar fashion using γ_s^D. The γ_t^D parameter captures the aggregate market-wide evolution of FSH conditional on the cohort structure of the matching market captured by the γ_y^D and γ_s^D parameters. The often-cited feature of this approach is that the γ parameters are estimated whilst conditioning on own-type marginals, i.e., that they are 'marginal-free' (similar to the H index and the log odds ratios).

Specifications based on equation 2 were estimated for the EU-wide sample of respondents.[24] In none of our estimated specifications do the γ_y^D or the γ_t^D coefficients reach conventional levels of statistical significance, individually or jointly; they also all remain small. We thus detect no evidence of EU-wide time or graduation-cohort trends.

However, in the $0 \leq s \leq 5$ window we find that FSH increases rapidly after the year of graduation (year 0) with no further gradient detected in the $5 < s \leq 10$ window. Table 2 shows estimated γ_s^D coefficients for the $0 \leq s \leq 5$ window. The first column, based on all female respondents, implies that FSH increases immediately after graduation and is relatively flat afterwards. We return to the interpretation of this pattern (and to the second and third column of Table 2) in Section 5 where we discuss the potential mechanisms underlying FSH.

[24] We insert the $\mu = 1$ value into the logarithm of match counts for match-matrix cells with no observed matched couples. Robustness checks are discussed in the Appendix Section 8.

Table 2: FSH Trends in Log-Linear Regressions

Year-since-graduation effects (relative to year 0)			
γ_1^D	**0.523**	**0.796**	0.239
γ_2^D	**0.458**	**0.924**	**0.517**
γ_3^D	**0.656**	**1.022**	**0.717**
γ_4^D	**0.629**	**0.888**	**0.709**
γ_5^D	0.517	**0.954**	0.453
Same industry	n.a.	Yes	No
Number of match cells		1,280	

Notes: Each entry shows a homogamy γ_s^D coefficient from regression specifications based on equation 3. The LFS sampling weights are employed. Bolded coefficients are statistically significant at the 10% level.

4.4 FSH and Supply Structure

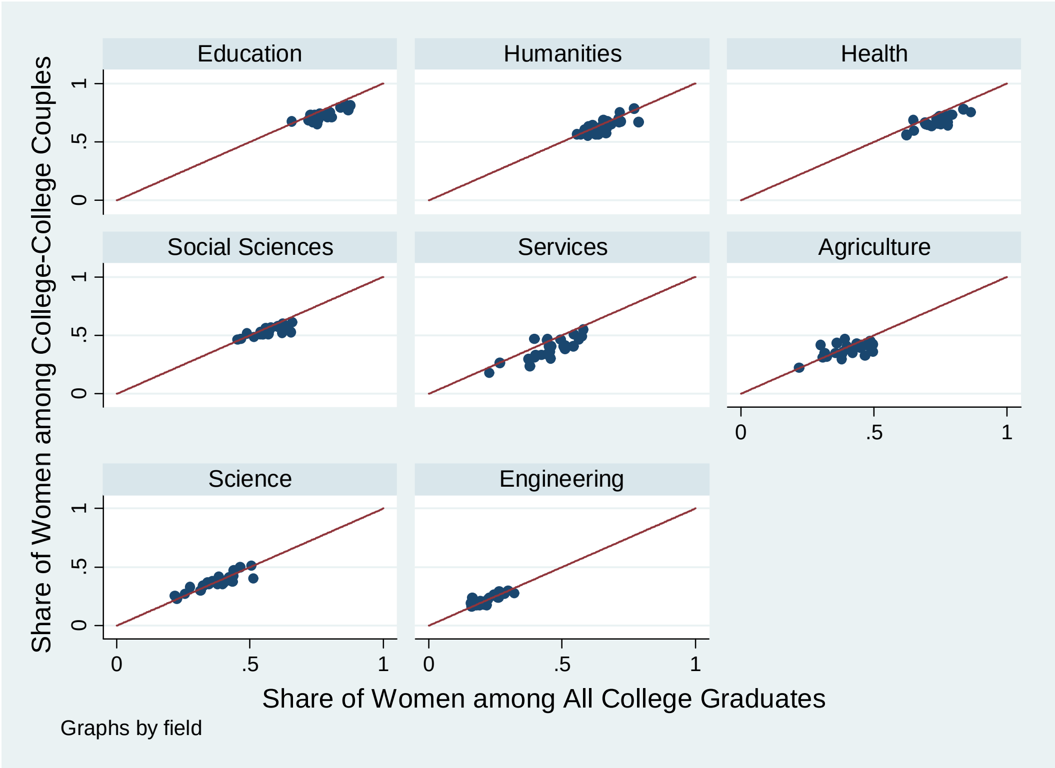
In the descriptive analysis provided above, we followed the literature in that we took the total number of matched graduates (by type) as exogenously given when calculating our FSH indices. However, in any market equilibrium setting, matched marginals are likely to be influenced by the marginal distributions of potential partners—by supply structure.[25] In Figure 2, we thus compare the gender structure of supply and matched marginals. The shares of women among available graduates, 24 for each field of study corresponding to the 24 EU countries in our data, are shown on the horizontal axis. Each graph then compares (against the 45-degree line) this share of women on all college graduates to the corresponding field-specific share of (matched) women on 'college-college' couples.

Conditioning on being matched to another college graduate does not result in a gender structure that differs markedly from that of the entire matching market of college graduates. Figure 2 thus suggests that differences between supply and matched marginals may be

[25] In terms of the notation introduced in Section 4.1 the supply marginals $\widetilde{\mu}_{i\cdot}$ and $\widetilde{\mu}_{\cdot j}$ correspond to the men in field i and women in field j, respectively, who could form homogamous matches. By accounting identity $\widetilde{\mu}_{i\cdot} = \sum_{j=1}^{K} \mu_{ij} + \mu_{i0} = \mu_{i\cdot} + \mu_{i0}$, where μ_{i0} is the number of unmatched men of type i. Similarly, $\widetilde{\mu}_{\cdot j} = \mu_{\cdot j} + \mu_{j0}$.

Figure 2: Country-Specific Percentages of Women in College Graduates by Field

Note: For each EU country, the graphs show the share of women by field of all college graduates vs. the corresponding share of graduates who are matched to another college graduate. LFS weights are employed.



small,[26] but this is clearly an important avenue for future research. The Figure also illustrates the limited extent of cross-country variation in the share of female graduates by field of study: Engineering (Education) is the most 'male' ('female') field in almost all countries.

[26]This is consistent with the highly gender-unbalanced supply structure by field of study having only a limited effect on the ability of college graduates to form 'college-college' couples. See Bičáková and Jurajda (2017) for a similar conclusion with respect to fertility of college graduates based on a difference-in-differences analysis.

4.5 FSH Potential Across Fields

The fact that women continue to be unevenly represented across college fields of study (e.g., Charles and Bradley, 2009; van de Werfhorst, 2017) implies dramatic cross-field differences in the potential for FSH. The field-of-study gender supply structure has a direct, mechanical effect on the maximum degree of FSH. Consider the most 'male' field of study, engineering, where men represent about 80% of graduates. Most male engineering graduates will not be able to find a female partner within their field of study. On the other hand, women, who form about 20% of all engineering graduates in our data, face an abundant supply of male peers (potential partners) in their field of study. It is therefore not surprising that among the marriage/cohabitation matches involving female college graduates in engineering and male college graduates in any field, 60.5% of couples are homogamous. For comparison, in services, the most gender-balanced field of study, the corresponding share is only 22.3%.

Table 3: The Share of Homogamous Couples on All 'College-College' Couples

	Women	Men
Highly 'male' fields of study	0.56	0.15
Balanced fields of study	0.37	0.44
Highly 'female' fields of study	0.19	0.50

Notes: Each entry shows the share of homogamous couples on marriage/cohabitation couples formed by two college graduates in a given group of fields. The LFS sampling weights are employed. Balanced fields of study are those with shares of women between 25 and 75%. The gender structure of each field of study corresponds to the average (taken across all available cohorts) of the share of women on all college graduates by country.

Table 3 provides a more general statement of these tendencies: It shows the shares of FSH couples of all couples formed by two college graduates in our EU LFS sample separately for gender-balanced and unbalanced fields of study. Clearly, the choice of study field has substantial consequences in terms of one's ability to form homogamous matches, i.e., with respect to the structure of marriage-market returns. Given the strong tendency towards FSH, the relationship of field-of-study choice to FSH potential, i.e., the endogeneity of the supply marginals with respect to FSH, is an important area for future research.

4.6 FSH Potential Across Countries

We now employ the understanding of how the supply structure affects the potential for FSH to study cross-country differences in the degree of FSH, which are large in our data: H values corresponding to all 'college-college' couples range from 56% in Latvia to 142% in Slovakia, with a simple cross-country average of 96.6%.[27] There is a number of potential determinants of country levels of FSH[28] and only 24 country observations in our data; this makes it difficult to provide a comprehensive understanding of these cross-country differences in marginal-free homogamy. In the next section, we focus on one cross-country dimension that may help us understand the sources of FSH. In this section, we continue exploring the relationship between FSH and the gender composition of fields of study: We ask how well (how efficiently) countries utilize the potential for FSH implied by the supply structure as reflected in the marginal distributions of formed matches.

As illustrated in the previous section, a more gender segregated composition of fields of study implies a lower potential for FSH. The maximum potential share of homogamous matches under a given marginal distribution of matches, denoted P, is given by[29]

$$P = \sum_{i=1}^{K} \widehat{\mu_i}/T \text{ where } \widehat{\mu_i} = \min[\mu_{i\cdot}, \mu_{\cdot i}]. \tag{3}$$

[27]The country-specific number of 'college-college' couples available in the EU LFS (shown in the Appendix Table 5) ranges from 542 for Estonia to 18,798 for Germany, and it averages at 5,335 per country. Therefore, sampling error will affect H values in small samples. The differences in H values, however, are almost equally large within the subset of countries where the number of observations is above 5,335: Here, H ranges from 61% in the Netherlands to 133% in Germany, with bootstrapped standard errors of 2.15 and 3.77, respectively.

[28]Among the possible country-level determinants of FSH (and of the potential for FSH) are the extent of gender stereotypes in occupational choice, gender wage gaps and labor-force participation gaps by field of study, the degree to which highly 'female' fields of study are linked to family-friendly career paths, and the intergenerational transmission of FSH (as suggested in Mare, 2016, for educational homogamy).

[29]Note that P equals 1 minus the Duncan index (Duncan and Duncan, 1955), which measures the extent of gender segregation across fields of study.

Achieving this maximum potential would result in the following value of the H index:

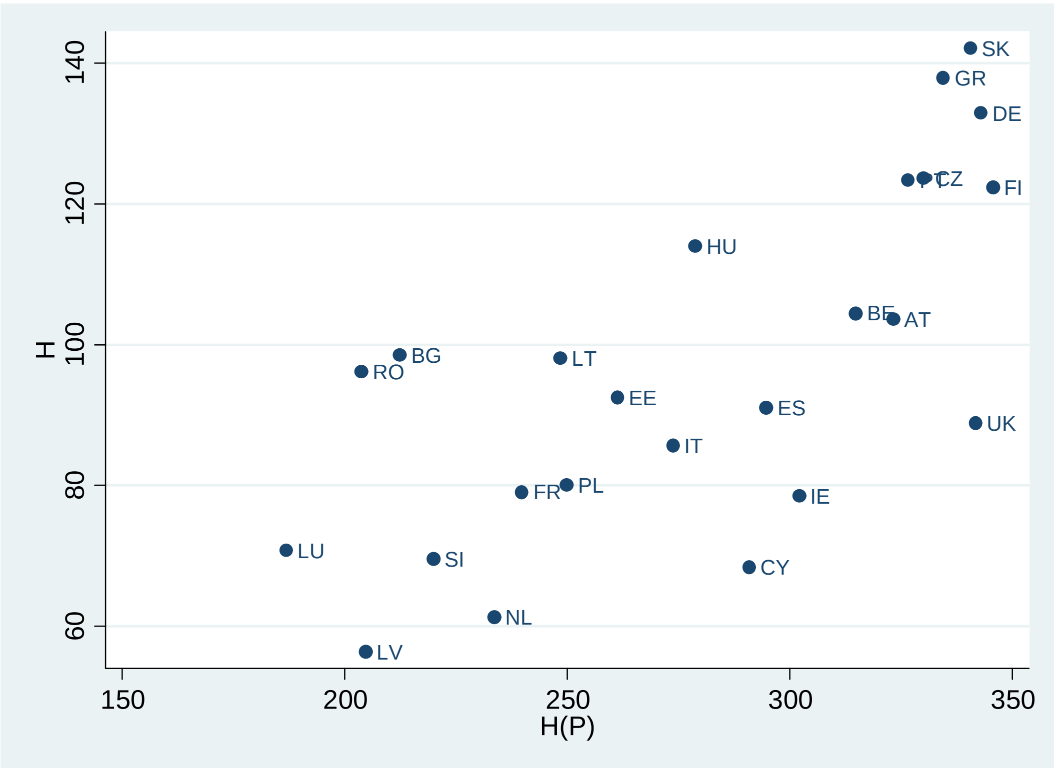
$$H(P) = \frac{P}{\sum_{i=1}^{K} (\mu_{i\cdot}\mu_{\cdot i}/T^2)}. \tag{4}$$

Similar to the H index, we discuss the level of the $H(P)$ index expressed in percentage points, i.e., as $100(H(P) - 1)$.

The EU-wide value of $H(P)$ is 298%. Recall that the EU-wide H value (estimated in Section 4.1) is 98.8%. Hence, at the EU level about a third of the FSH matching potential is used. Figure 3 contrasts the country-specific values of $H(P)$, the marginal-implied potential for FSH, with the corresponding actual degree of FSH, i.e., the country-specific H value. Since both indices are normalized by the same random-match counterfactual benchmark $\sum_{i=1}^{K} (\mu_{i\cdot}\mu_{\cdot i}/T^2)$, it is not surprising that they are correlated.

Figure 3: Homogamy Potential $H(P)$ and Actual Extent of Homogamy H

Note: Weighted by LFS sample weights. Country codes are provided in the Data Appendix.



In Figure 3, groups of countries differ in the degree to which they utilize their FSH potential: Romania, Bulgaria, Hungary, Greece, and Slovakia use more than 40% of their FSH potential while Latvia, the Netherlands, Cyprus, Ireland, and the UK use as little as 25% of their FSH potential. Both of these groups span the entire range of FSH potential values, suggesting that varying degrees of gender segregation of field of study in college are consistent with both high and low degree of utilization of FSH potential and that the utilization rates are driven by country-level structural factors.[30]

The denominator of the H index is the the random-match benchmark degree of homogamy, which is correlated with the extent of gender segregation across fields of study P. The FSH-potential utilization ratio $H/H(P) = P^{-1} \sum_{i=1}^{K} \mu_{ii}/T$ is thus analogous to the FSH index H in that it contrasts the observed degree of homogamy $\sum_{i=1}^{K} \mu_{ii}/T$ with a segregation measure. While H uses the benchmark of no homogamy, $H/H(P)$ uses the alternative benchmark of maximum homogamy. We study the cross-country differences in $H/H(P)$ values in the next section, where we discuss potential mechanisms underlying FSH.

5 FSH Mechanisms

In the first part of our analysis, we document a high degree of FSH among college graduates in the EU and a smaller, but still significant degree of FSH among couples composed of a high school graduate and a college graduate. Using three 'marginal-free' measurement approaches, we find that the tendency to match to partners from the same field of study varies both across fields and across countries, and that it rises quickly after graduation and then plateaus. In this section, we explore comparisons available in our data that shed light on the two key mechanisms generating FSH introduced in Section 2: preferences for FSH

[30] For example, Figure 3 is consistent with college students in the UK or Ireland (as opposed to Romania or Bulgaria) spending a significant share of their studies in classrooms with students from other fields of study thanks to electives in more 'liberal' education systems. We are not aware of any work classifying national tertiary education systems according to this degree of overlap, i.e., meeting opportunity.

and meeting opportunities related to networks formed in school and/or workplace.

5.1 Meeting Opportunities

What kind of evidence would suggest that meeting opportunities are an important source of FSH? In line with the notion that schools structure the marriage market for college graduates, we find that members of homogamous 'college-college' couples are somewhat closer in age to each other than members of non-homogamous couples: The average gap between partners in year of graduation is 3.4 for non-homogamous couples and only 2.6 for homogamous couples. Further, the share of homogamous couples who have graduated from college in the same year is higher, at 25%, compared to the corresponding share of non-homogamous couples, which stands at 14%.[31] Again, this likely corresponds to couple formation being driven by social networks related to college studies.

Homogamous matches can additionally be initiated within workplace interactions to the extent that workplaces are segregated across fields of study (i.e., hospitals vs. IT companies). To assess this possibility, we calculate H values for couples working in the same industry, which approximates shared networks linked to one's workplace. The EU LFS data distinguish 1-digit NACE industries; we use the industry of the current employer for respondents who are employed at the time of the survey and the industry of the previous employment for jobless respondents. Of the 128,040 'college-college' couples in our data, 30,041 couples share the same industry of employment and 91,614 couples work in different industries.[32] The overall H value for the same-industry group is very high at 204.8%, while the H value corresponding to the different-industry group is much lower at 58.5%.[33] This suggests that

[31] Of the 128,040 marriage/cohabitation couples in our data composed of two college graduates, 97% graduated from college within 10 years of each other.

[32] The remaining group consisting of couples where at least one spouse does not have labor market experience was too small to generate reliable inference.

[33] This gap is systematic: Almost all of the country-specific values of H for the 'different-industry' couples remain between 40% and 80%. Similarly, the H values corresponding to the 'same-industry' couples are

workplace-based interactions are a quantitatively important source of FSH. Indeed, the share of 'same-industry' couples on all homogamous 'college-college' couples is particularly high for graduates in Education and in Health, where the link between study field and industry of employment is also particularly strong. Only in these two fields are there more 'same-industry' homogamous couples than there are 'different-industry' homogamous couples.

The pattern of FSH with respect to years since graduation can also be informative about the importance of school- and workplace-based meeting opportunities. Matches effectively formed during study years (in an education program or in social networks related to one's field of study) are likely to lead to observable common households (matches) with some delay after graduation, but one would expect this type of FSH gradient to plateau within a few years of graduation. In contrast, homogamous matching initiated within workplace-based interactions is likely to grow in importance with years since graduation as the effect of social networks formed while in school fades away. To assess these patterns, we estimate the γ parameters of the log-linear model introduced in Section 4.3 for the subset of couples sharing the same industry and for those working in different industries.[34] The second and third columns of Table 2 contrast the estimated FSH year-since-graduation trends for these two types of couples. We find that the gradient of FSH in terms of years since graduation s is both more rapid within the first five years after graduation and reaches higher levels for the same-industry group.[35] Similar to the comparison of H levels, the evolution of FSH with respect to years since graduation is thus consistent with quantitatively important meeting opportunities driven by one's place of work.[36]

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above 150% for almost all of the 24 EU countries we study.

[34] This is only a first-step approximation of the workplace-as-meeting-place matching channel. Respondents who currently work in different industries could have worked in the same industry at the time of the initial match formation; similarly, those who met while working in different industries may have joined the same industry after matching. Homogamous couples formed in school could also be more likely to work in the same industry. Future work on this issue requires the use of longitudinal data.

[35] We again do not detect any gradient in the $5 < s \leq 10$ window.

[36] In related work, Svarer (2007) and McKinnish (2007) study the marriage market consequences of the

5.2 FSH Preferences

What evidence can we provide to asses the presence of FSH preferences? The ideal test for FSH preferences would be based on an environment where search costs (differences in meeting opportunities) play no role. We can approximate such approach by focusing on couples working in different industries and formed by a college graduate and a high school graduate. In comparison to college-college matches, couples formed by a high school graduate and a college graduate are less likely to be based on interactions anchored by one's school attendance,[37] leaving workplace-related interactions and FSH preferences as the main plausible mechanisms. We lower the importance of workplace-based matching by focusing on 'different-industry' couples.[38] The value of H for the 'high school-college' couples (with field of study reported) working in different industries is 11.3% (7.6%) for the 23,267 (17,384) couples where the college graduate is a woman (man). These H values are much below the roughly 25% level reported in Section 4.1 for all 'high school-college' couples, but they are still statistically significantly above zero (at the 5% level) based on bootstrapped standard errors, and suggest the presence of field-of-study homophily. On the other hand, the quantitative importance of these preferences appears low relative to that of the industry-of-employment-based meeting opportunities. The H level is about 75% (for both men and women) for 'high school-college' couples who do share their industry of employment.

Finally, we return to cross-country comparisons to provide indirect suggestive evidence on FSH preferences based on the notion that converging gender roles, as reflected in decreasing society-wide gender inequality, bring about converging (increasingly symmetrical) partner

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gender composition of the workplace.

[37]Recall that graduates of general (typically academic) secondary programs with no specific field of study, who are likely to have interacted with future college graduates in their secondary programs, are not included in our FSH measures.

[38]The share of homogamous couples where both partners work in the same 1-digit NACE industry is under 30% for homogamous couples formed by a high school graduate and a college graduate and it is 37% for the 'college-college' homogamous couples.

preferences. We approximate society-wide gender inequality using the 2010 Gender Gap Index (GGI), which reflects economic and political opportunities, education, and well-being for women.[39] To the extent that declining society-wide gender inequality corresponds to both converging gender roles and symmetrical partner tastes, one would expect the GGI index to be positively related to FSH. We assess the strength of the GGI-FSH relationship across the 24 countries in our data using regressions that are robust against high-leverage data points.[40]

We find no statistically or economically significant relationship between the GGI index and the degree of gender segregation by field of study P, the potential level of homogamy $H(P)$, and the overall homogamy index H. In Figure 4 we ask whether the gender culture of a country, as reflected in the 2010 values of the GGI index, is related to the rate at which its FSH potential is used—the FSH-potential utilization ratio $H/H(P)$. The graph suggests that higher gender equality is associated with lower utilization of the FSH potential. One cannot reject the hypothesis that the slope of the relationship is minus one. If Cyprus is excluded, the negative relationship becomes statistically significant at the 0.01 level; if Finland is also excluded, the slope estimate is -1.05 and the R-squared of the univariate regression with 22 data points is 0.4. Since the GGI index does not have a strong relationship with the extent of gender segregation across fields of study, i.e., with the denominator of $H/H(P)$, the relationship in Figure 4 is primarily due to the share of homogamous matches on all matches declining with GGI. One explanation for this pattern is that the preference for homogamous matching is higher for college graduates in countries with more traditionally defined gender roles. We are able to exclude some of the alternative explanations:

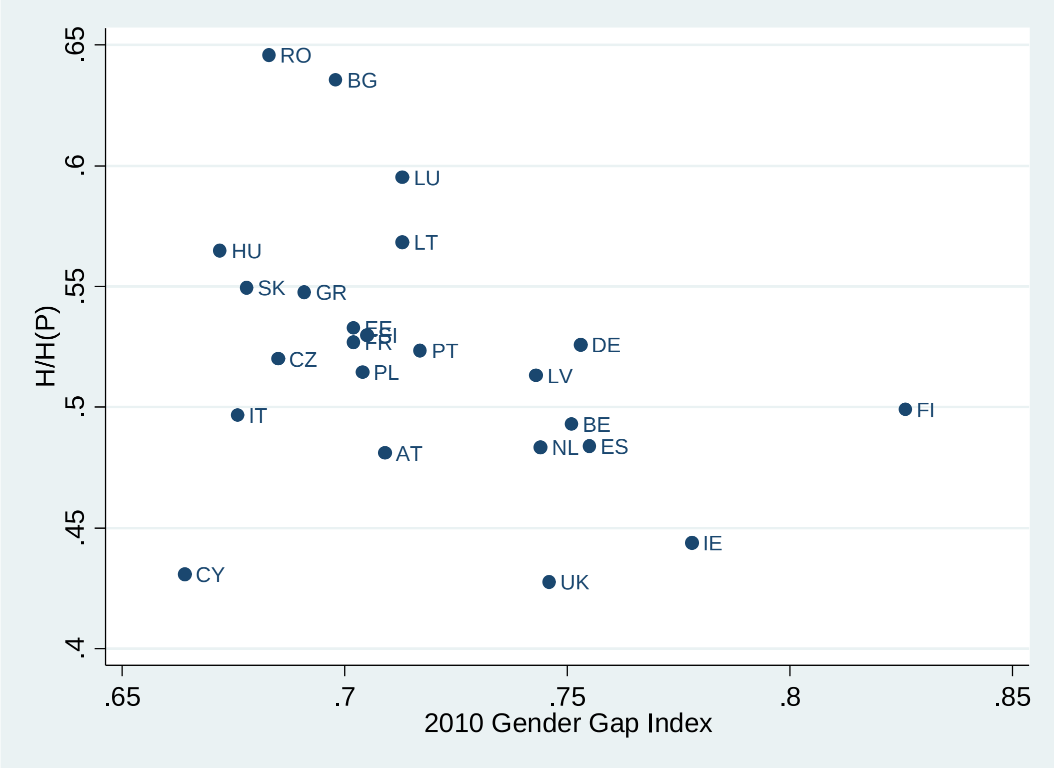
First, the relationship in Figure 4 could be driven by a compositional shift. The degree of

[39] The highest possible score is 1 (equality) and the lowest possible score is 0 (inequality). The index is generated by the World Economic Forum and has been used to study cross-country gender differences in, e.g., Guiso et al. (2008).

[40] Specifically, we employ the `rreg` command in `Stata`, which calculates the Cook's D statistic and excludes observations for which $D > 1$. In the regression analysis reported below, this approach leads to excluding one or two countries in most estimated specifications. Finland and/or Cyprus are the most frequent exclusions. The detailed results are available from the authors.

Figure 4: The Gender Gap Index and FSH-Potential Utilization Rate

Note: The highest possible GGI score is 1 (equality) and the lowest possible score is 0 (inequality).



homogamy (H) is about four times higher for couples working in the same industry, and this translates to values of $H/H(P)$ being 2.5 times higher for 'same industry' couples compared to 'different industry' couples. Hence, should the GGI index be negatively correlated with the extent of the 'same-industry' channel generating FSH, this would lower the aggregate $H/H(P)$ measure even in the absence of an underlying relationship between GGI and the FSH utilization measure *within* couples classified by whether or not they work in the same industry. We find no evidence of such a compositional explanation. The share of 'same-industry' couples is not significantly related to the GGI index across countries either statistically (at the 5% level) or economically. Furthermore, we cannot reject the hypothesis that the slopes of the relationship between $H/H(P)$ and the GGI for the 'same-industry' and the 'different-industry' couples are both equal to -1.[41]

Second, we also estimate a similar least-squares slope of -1.01 based on excluding Cyprus and Finland (with the corresponding p value of 0.06) for the relationship between $H/H(P)$ and the GGI for couples formed by a college graduate and a high-school graduate. We expect the role of search costs (meeting opportunities) for homogamy to be strongest among the college-college couples working in the same industry (who could have met via college- or workplace-based networks) and to be weak for couples formed by a high school graduate and a college graduate (who are unlikely to have met in school). Hence, the similarity of the slope of the $H/H(P)$-GGI relationship for these distinct groups suggests that the negative relationship is not driven by cross-country differences in search costs. The mechanism underlying this robust correlation, which rejects the notion that preferences for partners are becoming more symmetrical with respect to field of study as societies lower the overall level of gender inequality, is worth exploring in future work that elicits FSH preferences directly.

6 FSH in a Behavioral Matching Model

In the last part of our analysis, we employ the Choo and Siow (2006) model to take a structured view of the matching patterns that allows for the interpretation of these patterns to reflect the differences between available and matched marginal distributions of graduates. The equilibrium type-specific gains from matching in the CS model are $\ln(\mu_{ij} / \sqrt{\mu_{i0}\, \mu_{0j}})$. This measure contrasts μ_{ij}, the number of realized (college-college) matches of type ij, with the geometric mean of the number of men and women of a given type who remain unmatched (to a college graduate), denoted by μ_{i0} and μ_{0j}, respectively.[42] As discussed in Section 2, the CS model allows for equilibrium effects on μ_{ij} of changing supplies of potential partners of types other than i and j.

[41] Both of the slope coefficients are also highly statistically significantly different from zero.

[42] See note n. 25 for the definition of μ_{i0} and μ_{j0}. In our case, the group of college graduates unmatched to a college graduate includes both single graduates and those matched to a less educated partner.

Within the model, the local log odds ratios, which can be derived from the type-specific gains from matching, correspond to the degree of complementarity of marital output.[43] The model thus provides an interpretation for the values of the local log odds ratios reported in Section 4.1: The sum of matching outputs from homogamous matches exceeds the sum of matching outputs from mixed-field matches in all pairwise field comparisons.[44] The perhaps intuitive interpretation of the log odds ratios reported in Table 1 in terms of the CS model is that the value of matching within one's field of study (relative to a given mixed-field alternative) is particularly high for pairs of fields involving Agriculture and is relatively low for pairs of fields involving Social Sciences (with the exception of the pairing with Agriculture).

Figure 5 visualizes the 8x8 EU-wide map of gains from homogamous matches corresponding to the $\ln(\mu_{ij} \,/ \sqrt{\mu_{i0}\,\mu_{0j}})$ values. Consistent with the high values of local log odds ratios reported in Section 4.1, the highest gains from matching appear on the diagonal of the match matrix in Figure 5. In particular, homogamous-match gains appear highest for graduates in Social Sciences and for those in Health. The gains from mixed-field non-homogamous matches are generally low in Agriculture and also for women in Engineering and in Services.[45] Of the mixed-field matches, matching gains are highest for couples formed by a female Social Sciences graduate and a male Science graduate, as well as for couples formed by a male Social Sciences graduate and a female graduate in Education, Humanities or Health, where they are comparable to the gains from homogamous matches of two Services graduates.

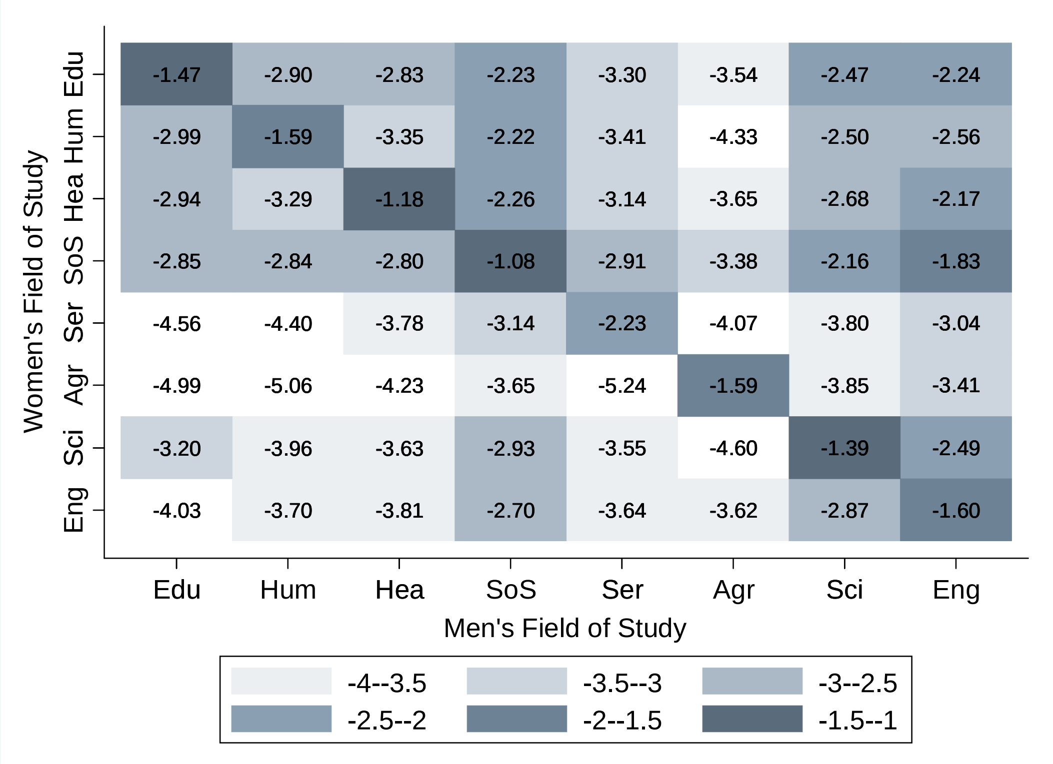
Differences in matching gains across field combinations are related to the field gender composition, i.e., to the supply structure. In Figure 5, fields of study are sorted according to

[43] In the local log odds comparison, denominators of the type-specific measures cancel out, which is why the log odds ratios are 'marginal free', i.e., independent of supply marginals (Siow, 2015).

[44] Siow (2015) derives a test of positive assortative matching across an ordered matching dimension, which asks whether local log odds ratios are above 0 for all 2x2 comparisons along the diagonal of the match matrix. In our unordered match case, this corresponds to asking whether the ratios are above 0 for all pairwise field-of-study comparisons, which they are in Table 1.

[45] In contrast, the lowest values in Figure 1, where only matched marginals are taken into account, appeared for Health-Social Sciences and for Science-Social Sciences couples.

Figure 5: Gains from Matching in the CS Model



the share of women. Almost all of the match gains in the below-diagonal part of the matrix are lower than those in the above-diagonal part. Gains from mixed-field matches are thus generally low for women studying in highly 'male' fields. Matching gains for couples formed by female Engineering graduates (a minority in their field) and male Education or Health graduates (also a minority) are almost 50% lower compared to those for couples formed by male Engineering graduates and female Education or Health graduates (all majority groups). The underlying mechanism is that while there are few unmatched men in Education and unmatched women in Engineering (thanks in large part to the strong FSH of minority groups within highly unbalanced fields; see Section 4.4), lowering the denominator of the CS matching gains measure, there are even fewer male Education graduates matched to women from other fields (or female Engineering graduates matched to men from other fields).[46]

[46] We have also explored the 1,536 country-field combination values of the CS measure of match gains in a

Overall, the CS model implies that graduates in Social Sciences generate large matching gains from homogamous matches, but are not heavily 'penalized' for matching to graduates from other fields. In contrast, for graduates in Agriculture matching gains are much lower in non-homogamous compared to homogamous matches.[47]

7 Conclusions

In this paper, we provide the first systematic evidence of the degree of field-of-study homogamy (FSH) among college graduates covering almost all EU countries. The tendency to match within one's field of study is very strong based on both measures widely used in the sociology/demography literature and based on measures corresponding to the Choo and Siow's (2006) matching model equilibrium. In particular, it is at least as strong as the much discussed tendency to match within one's educational attainment level. FSH among pairs in which both partners are college graduates is similar for married and cohabiting couples and is particularly high for couples working in the same industry. It increases quickly after graduation and is stable afterwards. We find little evidence of EU-wide trends in FSH between 1998 and 2013. The EU countries we study differ dramatically in their strength of FSH.

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regression analysis conditioning on a full set of 64 field-combination fixed effects, 24 country fixed effects, and on the share of women in fields of study from either a male or a female matching perspective. Consistent with the aggregate evidence in Figure 5, we find that the higher the share of women in the field where men study, the lower the CS match gains are off the diagonal of the match matrix. Put simply, those men who graduate from fields with an unusually high proportion of females (where there are unusually good opportunities for meeting a potential partner) and don't find a match there, have lower gains from matching. This effect is stronger in countries with more traditional gender roles as measured by the GGI index.

[47] In Figure 5, college graduates matched to less-than-college educated and single college graduates were treated as equal components of the unmatched frequencies μ_{i0} and μ_{0j}, that is, as not contributing to FSH. Future work can build on existing multi-dimensional matching models (Dupuy and Galichon, 2014; Chiappori et al., 2015; Chiappori et al., 2018) to incorporate in the analysis the matches between college graduates and those high-school graduates who report a field of study, i.e., to consider matching on both education level and field of study.

They also differ in how uneven their representation of women across college fields of study is, which generates dramatic differences in FSH potential across countries. We demonstrate that the gender composition of fields of study, i.e., the supply structure of the matching market of college graduates, is linked to the potential for FSH, to cross-country differences in FSH, as well as to the matching gains implied by the Choo and Siow (2006) model.

Looking across fields of study, we find that graduates in Social Sciences are particularly well positioned in terms of FSH: They feature a strong degree of FSH based on the random-match-benchmark measure of homogamy. Similarly, they display strong gains from homogamous matching based on the Choo and Siow (2006) model; the model also suggests that Social Sciences graduates are highly compatible with graduates from other fields of study. This is perhaps not surprising given that social sciences overlap with both humanities and natural sciences in their objects of interest and/or methodologies.

While we cannot directly disentangle the role of FSH preferences and the role of meeting opportunities in generating these FSH patterns, we provide a number of informative comparisons in an attempt to isolate these two key mechanisms. We find evidence consistent with the presence of FSH preferences, but our data suggest a quantitatively more important role for meeting opportunities, especially those related to one's industry of employment. Our cross-country comparisons are not consistent with the notion that preferences for partners graduating from one's own field of study are stronger in societies featuring a lower overall degree of gender inequality. Future work can utilize longitudinal data on the timing of initial match formation combined with labor market histories to provide a more powerful decomposition of these mechanisms.[48]

Our findings suggest avenues for future research. First, it is important to complete the descriptive map of marriage-market correlates of field-of-study choice. Martín-García, et al.

[48]Such data could also be used to assess the hypothesis of Xie et al. (2015) that homogamy can arise independent of preferences as a structural consequence of the dwindling pool of potential partners over time and to explore the household income inequality consequences of the interplay of FSH with division of paid labor over the life course as Gonalons-Pons and Schwartz (2017) do for educational homogamy.

(2017) measure the relationship between field of study and the transition to first marriage or cohabitation. Oppermann (2014), Bičáková and Jurajda (2017), and Artmann et al. (2018) explore the links between field of study and fertility. Future research can relate field-of-study homogamy of couples to marital stability (as Schwartz and Han, 2014, do for educational homogamy) and other family outcomes such child human capital investment (Artmann et al., 2018). Information on both field-of-study and income, which is not available in our data, is needed to investigate the extent to which FSH is due to similar earnings potential within fields of study. Data covering both field-of-study choices and earnings can also be used to systematically measure the household income inequality consequences of FSH (as Greenwood, et al., 2014, have done for educational homogamy in the US, and as Eika et al., in press, have done for FSH in Norway) and to investigate the sensitivity of household income to labor-market shocks. Such sensitivity may be high for the many homogamous couples working in the same industry, where both partners face common industry- and skill-specific labor demand fluctuations.

Second, future work can also explore gender-specific field-of-study marriage-market expectations among high school graduates (as, e.g., McDaniel, 2010, have for the decision to obtain any type of college degree). Given the increasing marriage returns to college (Chiappori et al., 2015), it is plausible that the choice of field of study is related to marriage prospects, i.e., to the gender composition of the field and the potential for FSH (Wiswall and Zafar, 2016). Alternatively, students could be making uninformed or short-sighted college choices as work cited in Hastings et al. (2014) suggests.[49] If marriage-market prospects are important for field-of-study choices, this would motivate theoretical work endogenizing the field-of-study choice with respect to both labor-market and marriage-market returns.[50]

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[49] Within this line of work, Lavy and Megalokonomou (2015) recently point to the importance of teacher stereotypes in explaining academic aspirations and field-of-study choices. Quadlin (2017) highlights the effect of funding sources on field of study choices.

[50] See Greenwood et al. (2016) and Reijnders (2018) for recent models of marriage, labor markets, educational investment, and educational homogamy (but not FSH).

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8 Log-Linear Model Estimation Appendix

How robust are the log-linear regressions of Section 4.3 to country heterogeneity of FSH patterns? The limited country-specific sample sizes (shown below) imply that estimating the log-linear models for each EU country separately generates excessively noisy estimates based on match-type matrices featuring a large share of empty cells. We have thus estimated EU-wide specifications based on country-specific $ijyt$-type match counts where we allowed for country-specific heterogeneity by including in equation 2 either country fixed effects λ_c or, alternatively, country fixed-effect matrices λ_{ijc}. The estimated EU-wide homogamy trends (allowing for country-specific differences in average match propensities by type) were noisier than those presented in Section 4.3, but painted a consistent picture.

The estimates reported in Table 2 are based on specifications where we parametrized the year effects and the graduation-cohort effects using three-year fixed effects. Such parsimonious parametrization minimizes the extent of empty match cells. We have alternatively estimated specifications where each year and each cohort has its own γ coefficient, and these estimates led to both quantitatively and qualitatively similar conclusions. Finally, results based on defining s using the male vs. the female perspective were also broadly consistent.

Table 4: Fit Statistics for Log-Linear Regressions

$\gamma_y^D + \gamma_t^D + \gamma_s^D$	2893.7	2884.9	2923.7	1009	207
$\gamma_y^D + \gamma_t^D$	2899.0	2899.3	2932.0	1020	202
$\gamma_y^D + \gamma_s^D$	2895.1	2887.9	2925.7	1016	204
$\gamma_t^D + \gamma_s^D$	2894.4	2885.7	2923.8	1012	206
Same industry	n.a.	Yes	No	D.f.	# of parameters

Notes: The presented deviance (D) statistics correspond to log-linear model estimates shown in Table 2. Degrees of freedom and the number of parameters (minus 1) are also provided.

Table 4 shows the deviance (D) fit statistics comparing the models estimated in Table 2 to the fully saturated model.[51] The table presents D together with the number of degrees of freedom and the number of parameters. The models that do not allow for the assortative match pattern to evolve with years since graduation (i.e., models with no γ_s^D) fit data poorly relative to models that do include the γ_s^D parameters.

[51] The D statistics, which are sometimes referred to as G^2, were calculated using the `fitstat` module of `Stata`. Unlike Schwartz and Mare (2005), our samples are not large, so we do not present Bayesian statistics, which lead to identical conclusions in any case.

9 EU LFS Data Appendix

We use the 2014 release of the anonymised EU Labour Force Survey (LFS) for the reference years 2003-2013.[52] More specifically, we use the annual samples ("yearly files") except for Finland, where the annual sample does not contain information about spouses, so we use the specific household data file where this information is available. From the 28 EU member states covered by the EU LFS, we exclude Sweden on account of missing graduation year information, Denmark where a large part of the sample does not report educational attainment, and Croatia and Malta whose samples of college graduates are very small. The analysis-ready data thus cover 24 countries: Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Germany (DE), Estonia (EE), Spain (ES), Finland (FI), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovenia (SI), Slovakia (SK), and United Kingdom (UK). We do not use data from before 2003 since no information about the field of education was asked until then. We also cannot use the following reference years due to missing data on graduation year and/or field of study: CZ 2004 and 2005, AT 2003, BE 2003, ES 2005, IE 2003 and 2007, LT 2003, PL 2003, PT 2003, RO 2003, UK 2003.

The EU LFS is a collection of national labor force surveys from EU countries. While most of the underlying surveys are collected as short rotating panels, the publicly available version of the data does not allow linking of individuals within surveys. In order to ensure that we do not use repeated observations for the same individuals, we use data from a single annual interview wave (wave 1 in all cases when multiple waves are available in the data). The following eight fields of study are recorded in the EU LFS (with their ISCED codes and descriptions):

Education	100	Teacher training and education science
Humanities	200	Humanities, languages, and arts
Social sciences	300	Social sciences, business and law
Science	400	Life and physical sciences, mathematics and computing
Engineering	500	Engineering, manufacturing and construction
Agriculture	600	Agriculture and veterinary
Health	700	Health and social services
Services	800	Personal, transport, environmental, and security services

[52] The Eurostat has no responsibility for the results and conclusions presented in this paper.

Table 5: Sample Size by Country

Country	College Graduates Men	Women	in Coll.-Coll. Couples	in Coll.-High Sch. Couples Men	Women	Unmatched Men	Women
AT	6537	6127	2192	993	707	3352	3228
BE	34630	39831	12066	1134	2190	21430	25575
BG	5163	6478	2121	154	445	2888	3912
CY	2648	3188	1246	63	138	1339	1804
CZ	6510	6969	2502	728	826	3280	3641
DE	52778	46721	18798	8300	4816	25680	23107
EE	1018	1515	542	87	213	389	760
ES	29440	34164	8927	731	1046	19782	24191
FI	16856	20299	11026	2446	4194	3384	5079
FR	21322	23579	10031	1353	2442	9938	11106
GR	9845	10732	2385	532	506	6928	7841
HU	5674	7110	1999	366	708	3309	4403
IE	12224	15096	5621	580	1352	6023	8123
IT	23748	29492	6117	940	1573	16691	21802
LT	3738	5069	1607	192	395	1939	3067
LU	9738	10052	4730	686	751	4322	4571
LV	1415	2445	644	105	281	666	1520
NL	26905	27632	13154	3532	3899	10219	10579
PL	15106	21377	7716	1077	3435	6313	10226
PT	3677	5846	1205	95	331	2377	4310
RO	8767	9429	3550	593	552	4624	5327
SI	3990	5200	1541	231	532	2218	3127
SK	3656	4239	1223	239	350	2194	2666
UK	15684	17482	7097	662	911	7925	9474
Total	321,069	360,072	128,040	25,819	32,593	167,210	199,439

Notes: Each entry shows the number of observed graduates or marriage/cohabitation couples by type. Coll.-coll. couples are formed by two college graduates.