European Societies

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/reus20

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To cite this article: Julia Leesch, Tomáš Katrňák & Jan Skopek (22 Jan 2024): Structural opportunities or assortative mating? – Decomposing trends and country differences in educational sorting outcomes in marriages, European Societies, DOI: 10.1080/14616696.2023.2290238

To link to this article: https://doi.org/10.1080/14616696.2023.2290238

EUROPEAN SOCIETIES
https://doi.org/10.1080/14616696.2023.2290238

Structural opportunities or assortative mating? – Decomposing trends and country differences in educational sorting outcomes in marriages

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ABSTRACT

This study examines within- and cross-country trends and differences in marital sorting by education in Europe. Unlike previous research on assortative mating, our study focuses on the outcomes of the partner search process. We investigate how variations in (a) structural opportunities (educational composition of potential partners) and (b) assortative mating (non-random matching by education) have shaped trends and differences in educational sorting outcomes. Using vital statistics data on all marriages contracted from 2000 to 2020 in Sweden, the Czech Republic, and Italy, we decompose trends and differences in educational sorting outcomes into these two components. Within countries, trends in educational homogamy and hypogamy have been stable or increasing while hypergamy has declined. However, the drivers of these trends varied across countries. For example, in Sweden, shifts in assortative mating and structural opportunities led to more marriages between equally educated spouses, while in Italy, the rise in homogamy stems solely from changes in assortative mating. Within each year, homogamy and heterogamy levels varied between countries. Our findings demonstrate that these cross-country differences can be primarily attributed to variations in assortative mating rather than in opportunity structures. This study adds to recent research studying the structural causes of trends in sorting outcomes.

ARTICLE HISTORY Received 15 May 2023; Accepted 21 November 2023

EDITED BY Patrick Präg

KEYWORDS Assortative mating; homogamy; partner market; marital sorting; educational expansion

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/14616696.2023.2290238.

This article has been corrected with minor changes. These changes do not impact the academic content of the article.

1. Introduction

In recent decades, the homogamy rate – the percentage of opposite-sex couples in which women and men have the same educational level – has increased in many countries (Katrňák and Manea 2020; Nomes and Van Bavel 2017; Permanyer *et al.* 2019). Moreover, among couples in which women and men have different educational levels, hypergamy (he is more educated than she) has decreased and hypogamy (she is more educated than he) has increased (Erát 2021; Esteve *et al.* 2016).[1] However, despite similar *trends* in homogamy, hypergamy, and hypogamy rates, these educational sorting outcomes vary considerably *across countries* (Domański and Przybysz 2007).

It is crucial to understand why educational sorting outcomes – such as homogamy, hypogamy, and hypergamy rates – vary over time and across countries, because these outcomes indicate how educational resources are distributed between wives and husbands. Because education is an indicator for earnings potential, differences in wives' and husbands' education could influence gender inequalities, for example, by affecting the gendered division of labor within couples (García Román 2021). Moreover, 'who marries whom' in terms of education may affect inequalities between couples. For instance, high proportions of low- and high-educated homogamous couples may indicate high levels of educational inequality and earnings inequality between couples (Blossfeld and Timm 2003; Breen and Andersen 2012; Schwartz 2013).

Despite the potential implications of educational sorting outcomes for social inequalities, our knowledge of why these outcomes have changed over time and differ across countries is incomplete. Instead of investigating educational sorting outcomes, research typically applied log-linear models to examine patterns of *assortative mating*, which is the degree of non-randomness by which available women and men form couples (e.g. Kalmijn 1991; Schwartz and Mare 2005; Smits 2003). However, these studies do not reveal *to what extent* trends and differences in assortative mating shape educational sorting outcomes, such as the homogamy rate. Moreover, log-linear models control for structural opportunities, which is the availability of women and men with different educational levels on the partner market. Therefore, the relationship between changing structural opportunities and educational sorting outcomes is under-researched.

[1]Katrňák and Manea (2020) analyzed data on marriages. Permanyer *et al.* (2019), Erát (2021) and Esteve *et al.* (2016) examined a pooled sample of married and unmarried cohabiting couples.

Although some research has explored the relationship between structural opportunities and educational sorting outcomes these studies typically did not control for assortative mating (Corti and Scherer 2021; Erát 2021; Esteve *et al.* 2016). Furthermore, Katrňák and Manea (2020) showed that observed trends in educational sorting outcomes correlate with those that would have emerged if husbands and wives had been matched randomly. However, to our knowledge, only two studies have attempted to disentangle the separate influence of *changes* in assortative mating and structural opportunities on trends in educational sorting outcomes (Leesch and Skopek 2023; Permanyer *et al.* 2019). These studies found that trends in homogamy and heterogamy are primarily linked to changing structural opportunities. However, the existing evidence remains fragmented because previous research either investigated comparatively short periods, used rough measures for education (college versus no-college education), or analyzed trends in educational sorting only in one country. Moreover, previous research has not examined the role of assortative mating and structural opportunities in explaining cross-country differences in educational sorting outcomes.

Our study addresses these knowledge gaps by analyzing the extent to which cross-national and cross-temporal variation in educational sorting outcomes of opposite-sex marriages (i.e. homogamy, hypogamy, and hypergamy rates) can be attributed to trends and differences in structural opportunities and assortative mating. For this purpose, we use a decomposition approach that compares observed educational sorting outcomes with hypothetical outcomes that would have occurred if the assortative mating patterns or structural opportunities of another year or country had been in place (Leesch and Skopek 2023).

The analysis exploits unique population data on all marriages contracted in Sweden, the Czech Republic, and Italy from 2000 to 2020. These cases are theoretically interesting as they differ substantially in their structural opportunities due to variations in the start and speed of the expansion of higher education. Furthermore, they display economic and cultural differences, and belong to different welfare regimes, which could influence partner search behavior.

Our study makes several contributions to the literature. In contrast to the majority of research that analyzed assortative mating, our study focuses on educational sorting outcomes in marriages. While a few studies have explored trends in educational sorting outcomes (Leesch and Skopek 2023; Permanyer *et al.* 2019), we advance this perspective by studying not only trends but also cross-country differences in these

outcomes. Moreover, rather than examining the prevalence of unions or marriages (stock of marriages), we investigate the incidence of marriages (contracted marriages in a given year). This is a preferable measure because women's and men's education in the stock of marriages can change due to educational upgrading and assortative divorce and mortality. In addition, our study examines trends in educational sorting in marriages over the past 20 years following the start of the Bologna process in 1999, updating the literature with evidence on recent trends in assortative mating and educational sorting outcomes.

2. Theoretical background

2.1. The partner search framework

Partner search theory (England and Farkas 1986; Oppenheimer 1988) assumes that the outcome of the partner search process depends on three factors: women's and men's preferences for candidates with specific traits, the availability of preferred candidates on the partner market, and partner search behavior. The macrostructural availability of preferred candidates and partner search behavior influences 'who meets whom'. For example, extending the duration of the partner search can increase the chances of meeting preferred candidates. Moreover, the distribution of preferred candidates across space (e.g. regions or neighborhoods) and social contexts (e.g. workplaces or sports clubs) may affect meeting opportunities too (Feld 1981; Van Bavel 2021). Furthermore, since union formation is not an individual but a mutual decision that requires both parties' agreement, women's and men's preferences, and two-sided matching mechanisms influence educational sorting outcomes in the final stage of the partner search process (Van Bavel 2021).

Several concepts of this framework, such as partner preferences or search behavior, have proved difficult to measure because data are usually only available on existing unions. Therefore, a large body of research studies variation in educational assortative mating, the degree of non-randomness in educational sorting outcomes. As these studies control only for structural opportunities on the macro level, all other mechanisms in the partner search process (e.g. partner preferences, the spatial distribution of candidates, and two-sided matching) shape assortative mating patterns. To allow comparability with this framework, we discuss why structural opportunities and assortative mating might vary over time and across countries, and how these variations could have influenced educational sorting outcomes.

2.2. Structural opportunities

According to Blau's structural theory, the relative *size of a group* in a population determines the probability of meeting members of this group (Blau 1977; Blau *et al.* 1982). That means the likelihood of meeting and marrying someone with a specific educational level depends on the relative size of that educational group in the population. For example, if few people were highly educated, the probability of meeting and marrying a highly educated person would be low.

The relative sizes of educational groups on the partner market changed profoundly in recent decades due to the global expansion of higher education (Schofer and Meyer 2005). Blau's structural theory suggests high chances of matches between equally educated individuals when there is a large pool of equally educated candidates on the partner market. This occurs in the early and late stages of the process of educational expansion when most people are either low-educated or highly educated (Katrňák and Manea 2020; Michielutte 1972).

Although nearly all countries have experienced an expansion of higher education, they differ in the starting point and speed of this process (OECD 2022b). As a result, in a given year, countries display different partner market compositions. We expect higher homogamy rates in countries with a higher proportion of equally educated candidates in the partner market. In conclusion, when analyzing trends and cross-country differences in educational sorting outcomes, we anticipate a positive relationship between the share of equally educated candidates on the partner market and the homogamy rate.

In addition, *gender gaps in education*, meaning the ratios of women and men within educational levels, shape structural opportunities. Generally, we expect a greater similarity in women's and men's education to be associated with higher chances of meeting and marrying equally educated candidates. However, in most Western countries, the gender gap in tertiary education reversed in recent decades (De Hauw *et al.* 2017; DiPrete and Buchmann 2013; Esteve *et al.* 2016). This improved, ceteris paribus, structural meeting opportunities between tertiary educated women and less educated men.[2] In addition, country differences in gender gaps in education could explain why educational sorting

[2]Our perspective focuses only on structural meeting opportunities. Scholars also assumed that individuals have preferences for equally or more educated candidates. Then, the reversal of the gender gap in education creates an education specific mating squeeze that can push men and women in hypogamous unions due to a lack of preferred candidates (Van Bavel 2012).

outcomes vary between countries. When analyzing trends and cross-country differences in educational sorting outcomes, we therefore assume that gender gaps in higher education favoring women are associated with higher hypogamy and lower hypergamy rates.

To conclude, we expect not only a relationship between the share of equally educated candidates and the homogamy rate, but also a link between women's educational advantage and hypogamy and hypergamy rates. However, the effects of trends and differences in educational expansion and gender gaps in education could have offset or reinforced each other since they coincided empirically.

2.3. Assortative mating

Many studies have demonstrated the non-random nature of marital sorting along various socio-demographic and socio-cultural characteristics, including educational attainment (Kalmijn 1991, 1998; Schwartz and Mare 2005; Smits *et al.* 2000). We briefly discuss four mechanisms that could explain trends and country differences in assortative mating in the first two decades of this millennium.

First, the rising popularity of *online dating* (Potarca 2020; Rosenfeld *et al.* 2019; Rosenfeld and Thomas 2012) changed the social contexts in which women and men meet each other. Online dating provides diverse contexts where opportunities for meeting candidates with different educational levels are high. However, it also reduces search costs and provides information about the available candidates on the partner market, which could contribute to rising homogamy rates (Schwartz 2013). The available evidence suggests that even though online dating does not produce random couples, it tends to act as a social mixer leading to more diverse couple sorting compared to traditional modes of partner search (Potarca 2017, 2020; Thomas 2020).

Second, rising *gender equality*, especially women's rising employment rates, may have led to converging partner preferences since men started benefiting from having highly educated partners with higher earnings prospects (Mare 1991). Although women continue to benefit from a partner with high education and earnings, their growing economic independence allows them to choose partners based on desirable traits unrelated to economic success (Han 2022; Oppenheimer 1994; Schwartz 2013). This could have contributed to a decline in hypergamy and rising homogamy and hypogamy.

Third, *economic inequalities* between educational groups may affect assortative mating because they indicate how much someone might lose when marrying 'down' in education (Fernandez *et al.* 2005; Schwartz 2013). When marrying someone less educated is less affordable, homogamous matching might become more likely, as individuals may prioritize education over other attributes when choosing partners.

Fourth, *welfare regimes* could influence assortative mating (Domański and Przybysz 2007). In social-democratic welfare states like Sweden, generous social benefits largely decouple welfare from the market and family (Esping-Andersen 1999). In such contexts, status attainment might be less critical for choosing a partner, potentially weakening the association between husbands' and wives' education. Italy, as a Mediterranean welfare state, features a dualized protection system and limited policies supporting mothers' employment (e.g. public childcare for young children) (Del Boca and Vuri 2007; Naldini and Saraceno 2008). Therefore, men's socioeconomic position might be more important than women's in the partner search process. Similar to other post-communist welfare states, the Czech Republic experienced a retrenchment of benefits and a process of re-familization in the late 1990s and 2000s (e.g. by reducing spending for public childcare) (Saxonberg and Sirovátka 2009; Saxonberg and Szelewa 2007). The retrenchment of benefits suggests that women's and men's socioeconomic resources increasingly govern the partner search process, while re-familization may suggest that men's resources carry more weight than women's.

Taken together, assortative mating is shaped by multiple, jointly operating mechanisms of partner search and choice. Theoretical arguments from above would let us expect to observe both (a) change in assortative mating over time within countries and (b) differences between countries in patterns of assortative mating. Our study investigates the role of within-country trends and between-country differences in assortative mating and structural opportunities for trends and differences in educational sorting outcomes.

2.4. Structural opportunities and assortative mating in Sweden, the Czech Republic, and Italy

During the first 20 years of this millennium, Sweden, the Czech Republic, and Italy have experienced an expansion of higher education that

profoundly changed structural opportunities on the partner market.[3] An early expansion of higher education characterizes Sweden. In 2000, already 33.6% of 25- to 34-year-olds attained tertiary education. In the subsequent 20 years, tertiary education continued to increase up to 49.1%, suggesting a rising concentration of individuals at the highest educational level (OECD 2022b). In the Czech Republic and Italy, the overall educational attainment of 25- to 34-year-old men and women was comparatively low in 2000. In the Czech Republic, tertiary education increased rapidly from 11.2% in 2000 to 33.0% in 2020, and in Italy, tertiary education grew from 10.4% in 2000 to 28.9% in 2020 (OECD 2022b). In all three countries, women's educational attainment has been rising faster than men's, leading to a reversal of the gender gap in higher education (De Hauw *et al.* 2017).

Moreover, partner choice and matching mechanisms may vary between the three countries, as each country represents different cultural, socioeconomic, and welfare contexts. In Sweden, several factors suggest that the odds of homogamy will be smaller than in other European societies. Sweden's social-democratic welfare state fosters individualism and gender equality, contributing to a high female employment rate (OECD 2022a). Furthermore, income inequality is relatively low (OECD 2020), and high levels of interpersonal trust could make heterogamous matches more likely (Domański and Przybysz 2007; Inglehart 1999). For the other countries, the expectations are less straightforward. In Italy, high levels of income inequality (OECD 2020) provide incentives for homogamous matching. However, family-provided welfare and care, along with a low female employment rate of about 50% (OECD 2022a) may promote hypergamous matching. In the Czech Republic, women's employment rate is high (OECD 2022a), despite the reduction in public spending for childcare. Additionally, income inequality is low (OECD 2020), even though returns to education tend to be high (Montenegro and Patrinos 2014), which may shape the perceived costs of marrying 'down' in education.

Empirically, assortative mating was found to be substantially lower in Sweden than in the Czech Republic and Italy (Domański and Przybysz 2007; Katrňák and Manea 2020). However, only few studies investigated trends in educational assortative mating in Sweden, the Czech Republic, and Italy. The available evidence suggests that, in these countries,

[3]For more information about the educational systems of Sweden, the Czech Republic, and Italy see Hörner *et al.* (2007).

assortative mating declined among the tertiary educated and increased for less educated husbands and wives (Katrňák and Manea 2020). Ultimately, structural opportunities and assortative mating vary over time and across countries. Thus, they can both affect trends and cross-country differences in educational sorting outcomes.

3. Method

3.1. Data

Our data contains information on all marriages that were contracted in Sweden, the Czech Republic, and Italy in even years from 2000 to 2020 (2000, 2002, … , 2020).[4] This includes first and higher-order marriages. Table A1 in the Appendix shows the absolute numbers of contracted marriages by year and country. In total, we analyzed 3,285,848 marriages.

The data provide precise measures of the incidence of marriage. In contrast to prevalence measures (stock of marriages) featured by much of previous research, incidence measures (newly established marriages) are unaffected by changes after marriage, such as educational upgrades or assortative divorce. Incidence measures are therefore advantageous to study change in marital sorting. Furthermore, the data do not suffer from sampling bias as they include information on all contracted marriages.

However, cross-country differences and changes in the prevalence of unmarried cohabitation may question the appropriateness of focusing only on married couples (Kiernan 2001; Prioux 2006). For example, in Sweden cohabitation is more common than in other European countries (Kiernan 2001). Furthermore, less educated individuals tend to live in cohabiting unions more often than more educated women and men (Bumpass and Lu 2000; Schwartz 2010). Trends and cross-country differences in the education-specific selectivity into cohabiting unions could affect our results by shaping the educational compositions of married women and men. For instance, if less educated women increasingly choose cohabitation over marriage, this shift could lead to a decrease in hypergamy rates among those who eventually marry. Research also suggests that assortative mating patterns differ between cohabitors and married couples (Blackwell and Lichter 2000; Esteve *et al.* 2013; Schoen and Weinick 1993). If these differences shift over time or vary across countries, they could also affect our findings. However, empirically, it

[4]We thank the Statistical Offices of Italy, Sweden, and the Czech Republic for providing the data and making this research possible.

remains an open question to what extent trends and cross-country differences in educational sorting outcomes in marriages have been influenced by these mechanisms. Despite this potential limitation, our study focuses on marriages because reliable incidence measures for cohabiting unions are not readily available, while the incidence of marriages is clearly defined and recorded by national statistical offices.

In all analyzed countries, the number of contracted marriages dropped considerably in 2020, which is most likely linked to restrictions that were imposed on weddings during the early phases of the COVID-19 pandemic, such as limiting the number of guests. From 2018 to 2020, the number of contracted marriages halved in Italy and declined by more than 20% in the Czech Republic and Sweden. Moreover, in 2008, the Czech Republic introduced the option not to identify husbands' and wives' education. Because this has been increasingly applied in subsequent years, the number of contracted marriages has declined in our sample. When interpreting the results, this needs to be considered as educational attainment could influence whether individuals report their educational level.

3.2. Measurement

Educational sorting outcomes. To measure the joint distribution of husbands' and wives' education, we distinguished four levels of education: low, lower intermediate, upper intermediate, and high. While these levels are not strictly comparable across countries in terms of years of education, they do reflect meaningful country-specific differences in the educational systems coded by the countries' statistical offices. In the Appendix, we provide detailed information on the comparability of the measure. Furthermore, Tables B1 to B3 in the Appendix show all marriage tables (contingency tables depicting husbands' and wives' education). To achieve a measure of educational sorting outcomes that allows for an intuitive interpretation, we collapsed these outcomes into three categories that distinguish between homogamy (wife and husband equally educated), hypogamy (wife more educated than husband), and hypergamy (wife less educated than husband).

Structural opportunities. We used the educational composition of husbands and wives who married in a given year and country to measure structural opportunities. Thus, in a marriage table the marginal distributions reflect structural opportunities. This approximation of structural opportunities has two limitations. First, individuals who do not marry may have been available on the partner market. Therefore, variation in

the educational gradient in marriage across time and space (Bertrand *et al.* 2021; Kalmijn 2013) can affect the measure of structural opportunities. For example, Leesch and Skopek (2023) showed that, in Ireland, a small but non-negligible part of trends in educational sorting outcomes is linked to changes in the educational gradient in union formation. Second, we observe marriages of different cohorts within one period. Thus, the age at which women and men marry – which has been increasing over time (OECD 2019) – influences who marries in a given year. That means our measure of structural opportunities in one period includes individuals of different birth cohorts who possibly belonged to different partner markets. However, by measuring structural opportunities with the marginal distribution, we achieve comparability with the bulk of studies that control for the marginal distributions to study assortative mating (e.g. Mare 1991; Schwartz and Mare 2005).

Assortative mating. In line with previous literature, we employed the odds ratio structure in a marriage table to measure assortative mating. The odds ratios in a marriage table reflect the association between husbands' and wives' education net of structural opportunities.

3.3. Analytical approach

Our analysis involved four steps. First, we examined trends in absolute homogamy, hypogamy, and hypergamy rates in Sweden, the Czech Republic and Italy. Second, we investigated changes in structural opportunities by analyzing trends in wives' and husbands' educational attainment. In the third step, we modeled assortative mating using log-linear models. Lastly, we analyzed the extent to which within-country trends and between-country differences in educational sorting outcomes can be attributed to trends and differences in assortative mating and structural opportunities. For this purpose, we applied a decomposition approach introduced by Leesch and Skopek (2023). The assortative mating models were estimated using the LEM software (Vermunt 1997), while Stata 16 was employed for the remaining analyses.

The decomposition includes two steps. First, we swapped either the odds ratios or the marginal distributions between two marriage tables and determined the cell frequencies that match this counterfactual combination of odds ratios and marginal distributions. Table 1 shows that there are two observed or factual marriage tables and two hypothetical or counterfactual marriage tables. In each table we calculated the required educational sorting outcome, such as the fraction of homogamous unions. Y denotes observed

Table 1. Observed and counterfactual educational marital sorting outcomes.

	Assortative mating	
Structural opportunities	Table 1	Table 2
Table 1	Y_{11}	$\dot{Y}_{12}$
Table 2	$\dot{Y}_{21}$	Y_{22}

or factual sorting outcomes and $\dot{Y}$ stands for hypothetical or counterfactual sorting outcomes. Of course, the sorting outcome derived from the observed Table 1 (e.g. observed in county 1 or at time 1) has the odds ratios and marginal distributions of Table 1 (Y_{11}). The outcomes in Table 2 were obtained through the odds ratios and marginal distributions of Table 2 (Y_{22}). The counterfactual marital sorting outcomes reflect the odds ratios of Table 1 and the marginal distributions of Table 2 ($\dot{Y}_{21}$) or the odds ratios of Table 2 and the marginal distributions of Table 1 ($\dot{Y}_{12}$).

Upon swapping the odds ratios or marginal distributions, we obtained the counterfactual marriage tables by using iterative proportional fitting (IPF) (Deming and Stephan 1940; Lomax and Norman 2016). IPF adjusts the cells in a table alternately to the row and column totals of another table without changing the odds ratio structure of the initial table. The process of rescaling cells to row and column totals continues iteratively until all cells match the predefined odds ratio structure and marginal distributions which results in the required counterfactual table.

In the second step, we used the counterfactual and observed marriage tables to analyze the extent to which differences in educational sorting are attributable to differences in assortative mating and structural opportunities. To investigate the role of structural opportunities for trends and country differences in educational sorting, we compared educational sorting outcomes (e.g. homogamy rate) between both tables after the odds ratios had been fixed at Table 1 ($\dot{Y}_{21} - Y_{11}$) and at Table 2 ($Y_{22} - \dot{Y}_{12}$). In both comparisons, educational sorting outcomes differ only in marginal distributions. We calculated the average marginal distribution component from both marginal distribution components. Correspondingly, the average odds ratio component was obtained from differences in educational sorting after marginal distributions had been fixed at Table 1 ($\dot{Y}_{12} - Y_{11}$) and Table 2 ($Y_{22} - \dot{Y}_{21}$). A formal elaboration of the methodology is provided in the Appendix.

The method allows pairwise comparisons only. Thus, to analyze trends in educational sorting in marriages within countries, we compared marriage tables of each year with the marriage table of the reference year 2000 (10 comparisons within each country). To decompose of cross-country differences, we compared marriage tables of two countries within the

same year (3 comparisons for each of the 11 time points). Replication files are available at the Open Science Framework via https://doi.org/10.17605/OSF.IO/AYGH5.

4. Results

4.1. Educational sorting outcomes in marriages

Figure 1 shows educational sorting outcomes in marriages in Sweden, the Czech Republic, and Italy. The solid lines depict observed educational sorting outcomes. The dashed lines will be discussed at the end of the next section because they reflect structural opportunities. In each year, in all three countries, most marriages were contracted between equally educated men and women, and hypogamy rates (wives are more educated than husbands) have been higher than hypergamy rates (wives are less educated than husbands). However, educational sorting outcomes differ substantially between countries. Up to 2018, homogamy rates were the lowest in Sweden and the highest in Italy. Hypogamy and hypergamy rates were the highest in Sweden and the lowest in Italy, with the Czech Republic in between.

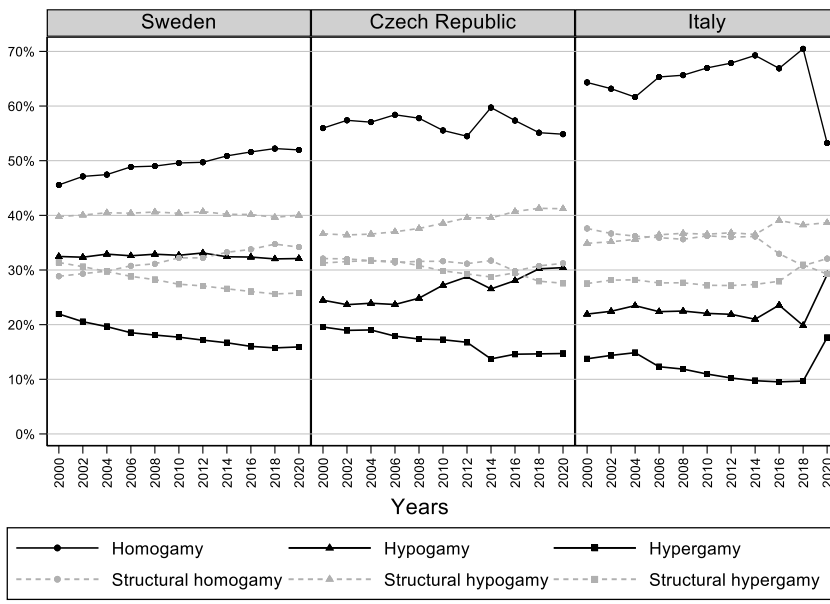

Figure 1. Observed (solid lines) and structural (dashed lines) educational sorting outcomes.

Note: Structural sorting outcomes refer to hypothetical educational sorting outcomes if there were no association between spouses' education

From 2000 to 2020, educational sorting outcomes changed substantially. In Sweden, the homogamy rate increased, hypergamy declined, and the hypogamy rate remained at a constant level of about 32%. In the Czech Republic, homogamy rates fluctuated between 54.5% and 59.7%. Hypogamy increased, and the hypergamy rate declined from 19.6% in 2000 to about 14% in 2014 and has hardly changed since then. In Italy, homogamy increased up to 2018 and dropped considerably in the last year. No clear trends in hypogamy are visible, and the hypergamy rate declined up to 2018, followed by a substantial increase in 2020.

The striking change in educational sorting outcomes in Italy in 2020 could be linked to the outbreak of the COVID-19 pandemic. Italy was the first European country to be heavily affected by the pandemic, and it implemented some of the strictest lockdown measures in the European Union (Plümper and Neumayer 2022). Social distancing measures banned wedding ceremonies in spring 2020 and later transitioned to severely limiting the number of guests. Further research is necessary to understand the profound changes in educational sorting outcomes in Italy in 2020. First evidence suggests that uncertainty about the duration of the COVID-19 pandemic affected marriage intentions (Guetto *et al.* 2021). This uncertainty might influence couples differently, depending on both partners' education, for example, if uncertainty about the duration of the pandemic is linked to employment uncertainty.

4.2. Structural opportunities

Figure 2 shows trends in the educational attainment of husbands and wives. In all countries, higher education has expanded considerably. The Czech Republic recorded a rapid increase in higher education, especially for wives – from approximately 10% in 2000–40.4% in 2020. In Sweden and Italy, the growth in higher education has been somewhat slower. In Sweden, higher education was already widespread in 2000 (40.4% for wives and 35.7% for husbands), while in Italy, only a minority (around 10%) was highly educated. Upper intermediate education has risen in all countries among husbands, but remained stable or declined for wives. Lower intermediate education has decreased markedly among husbands and wives in all countries, and those with a low level of education formed the smallest groups in all years and countries.

Despite the main trends in educational attainment being similar in all three countries, they do not necessarily shape trends in structural opportunities in the same way. In a low-educated context, educational

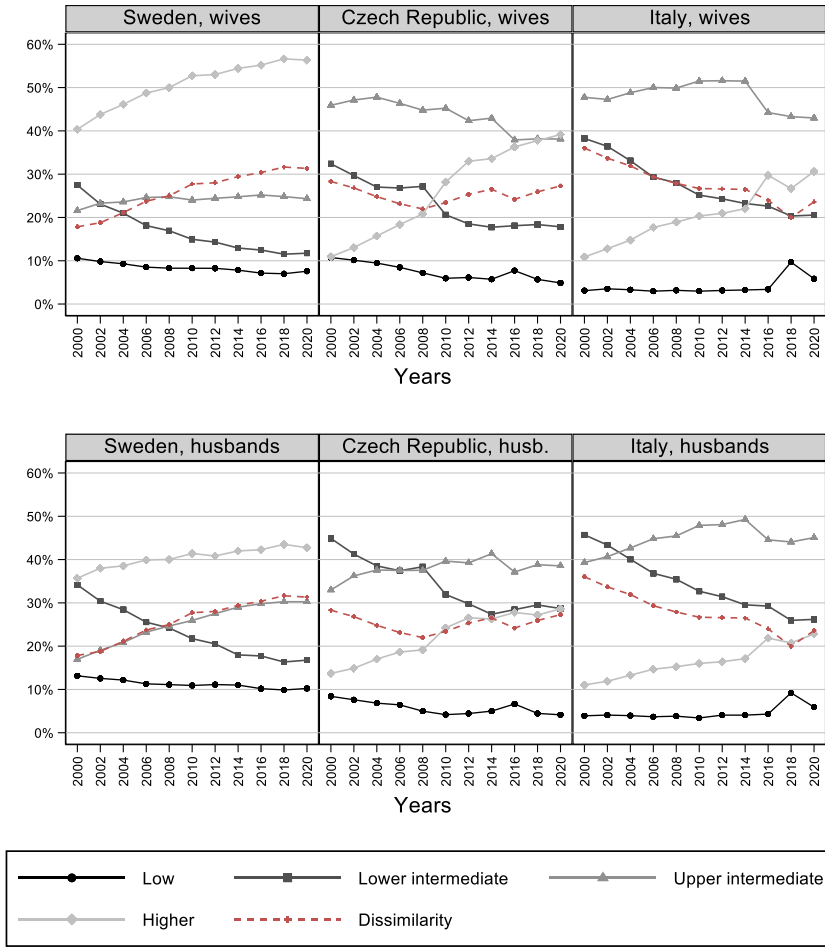

Figure 2. Trends in husbands' and wives' educational attainment and trends in the dissimilarity index.

expansion typically leads to more variation in educational levels. In highly educated contexts, educational expansion is linked to a growing concentration of individuals to few educational levels. To demonstrate this, the dissimilarity index in Figure 2 displays the fraction of cases that would need to be redistributed to achieve a distribution in which each educational category is represented by an equal share.[5] In Sweden,

[5] The dissimilarity index is defined as $D = \frac{1}{2}\sum_{i=1}^{N} |\frac{a_i}{A} - \frac{b_i}{A}|$, with a^i being the number of individuals with educational level i, A the number of all individuals and b_i the hypothetical number of individuals with educational level i if educational attainment were distributed equally across all educational levels i.

husbands' and wives' dissimilarity index has risen. That means the variation in educational levels declined. For Italian husbands and wives, the index declined from 2000 to 2018, while in the Czech Republic, it declined up to 2008 and increased afterwards. Therefore, trends in educational variation differ considerably across countries.

Also, gender differences in education have been changing over time. In Sweden, the ratio of higher educated wives to husbands had already reversed by 2000. In Italy, it reversed in 2002 and in the Czech Republic in 2008. In recent years, the ratio of higher educated wives to husbands reached approximately 1.3 in all countries. To illustrate that Figure A1 in the Appendix plots trends in education specific sex-ratios.

For a more intuitive analysis of trends in structural opportunities, the dashed lines in Figure 1 show educational sorting outcomes if husbands and wives would match randomly, and educational sorting outcomes were determined only by structural opportunities.[6] Observed and structural educational sorting outcomes differ substantially. If there were no assortative mating, homogamy rates would be lower, and heterogamy rates would be higher. Moreover, country differences in educational sorting outcomes would be smaller if matching were entirely random. This suggests that assortative mating contributes to between-country variation in sorting outcomes. In addition, sorting outcomes would have changed if there had been no assortative mating. For example, in Sweden, homogamy would have increased, and hypergamy would have declined. That suggests that trends in structural opportunities are, to some extent, linked to trends in educational sorting outcomes.

4.3. Assortative mating

To investigate trends and country differences in assortative mating, we estimated log-linear models. In these models, the interaction parameters are odds ratios. The models control for structural opportunities because odds ratios are invariant to changes in total sample size and row and column marginal distributions (Agresti 2002; Powers and Xie 2008; Von Eye and Mun 2013).[7]

[6] Katrňák and Manea (2020) label this as 'zero' homogamy, because it would occur if there were no association between spouses' education levels.

[7] Log-linear models have been used to identify assortative mating and social fluidity in social stratification research since the late 1980s (cf. Ganzeboom *et al.* 1991). We standardized the *n* in each two-way subtable to 5,000 marriages. For each country, we thus obtained a sample of marriages amounting to 55,000 (5,000×11 tables/years). The total number of marriages (N) is 165,000.

We present the goodness-of-fit statistics of all models in Table 2. Model 1 is the null association model, assuming that there is no association between husbands' and wives' education (MW). The model fits the data very poorly – it has a positive BIC (Raftery 1995), misclassified more than 25% of all marriages, and has an L^2 of 65,483 with 297 degrees of freedom. Model 2, a constant association model, assumes that the association between husbands' and wives' education (MW) is constant across time and countries. The model fits the data significantly better than the null association model, but still poorly, which indicates that assortative mating differs over time and across countries (the BIC criterion is still positive).

Model 3 is based on Model 2 but includes 32 additional parameters to identify trends in the association between husbands' and wives' education (MW) in each country. It is a model of uniform difference (Erikson and Goldthorpe 1992) or a log-multiplicative model (Xie 1992) assuming that the association pattern (MW) changes in the same way over countries and periods. In this model, there is a significant decrease in the L^2 (by 77% compared to Model 2; by 97% compared to Model 1), the dissimilarity index declines and the BIC turns negative. However, the L^2/d.f. ratio indicates that this is not the most satisfactory model to interpret our data (L^2/d.f. = 6.62). Model 4 is identical to Model 3, but we 'blocked' the main diagonals in the tables because it is known from social stratification research (Breen and Luijkx 2004; Erikson and Goldthorpe 1992; Hauser 1978) that the association is mostly concentrated on the diagonals. This 'hereditary effect' usually overrides any other pattern in the data. Therefore, we included 128 parameters for diagonal cells in all tables (33 analyzed tables times 4 cells on a diagonal, minus 4 cells that are part of the basic association). Model 4 fits the data better than previous ones (L^2/d.f. = 2.61, $\Delta = 0.82\%$), but the BIC criterion is higher than in Model 3, indicating model overestimation (more parameters than necessary are identified).

To relax the assumption of uniform difference, we calculated regression-type layer effect models (cf. Goodman and Hout 1998, 2001). Model 5 assumes a linear, but non-uniform, change in the pattern of association (MW) among countries and periods (for the extension of this model to four-way data see Katrňák and Manea 2020). According to the BIC, Model 5 is more parsimonious and fits the data much better than Models 3 and 4. However, it still does not reproduce the data sufficiently (L^2/d.f. = 4.07; $\Delta = 2.38\%$). In Model 6, the change in MW association is therefore modeled as categorical over time but

linear across countries. Model 7 assumes the opposite: changes in the MW association are linear over time but categorical across countries. Finally, Model 8 supposes that the change in MW association is categorical across time and countries. Model 7 fits the data the best (BIC = −2338; L^2/d.f. = 2.73; Δ = 1.95%). Change in the MW pattern is modeled as linear, represented by one parameter, but as categorical across countries, represented by one parameter for each country. Based on Model 7, we conclude that assortative mating exists in all countries, but the strength of assortative mating differs between countries. Trends in assortative mating have been comparatively linear over time.

Table 2. Statistics of models fit for the analysis of assortative mating by period and country.

	Model	Model description	L^2	Δ	d.f.	L^2/d.f.	BIC
1	CPM CPW	Conditional independence, no MW association	65482.58	25.52%	297	220.48	61914.51
2	model 1 + MW	Constant association, MW associations are the same by CP	7216.13	6.89%	288	25.06	3756.19
3[x]	model 1 + MW*φ^{CP}	Log-multiplicative uniform layer effect, MW associations change in uniform way by CP (Xie model)	1693.47	3.24%	256	6.62	−1382.04
4[x]	model 1 + MW*φ^{CP} + D	Log-multiplicative uniform layer effect, MW associations change in uniform way by CP (Xie model), blocked table diagonals	334.32	0.82%	128	2.61	−1203.44
5[x]	model 1 + MW + MW*r^P + MW*r^C	Regression-type layer effect, MW associations change in different ways by C and *P* (Goodman-Hout model)	1059.09	2.38%	260	4.07	−2064.47
6[x]	model 1 + MW + MW^P + MW*r^C	Regression-type layer effect, MW associations change in different ways by C and *P* (Goodman-Hout model), *P* is dummy (categorical)	977.39	2.36%	188	5.20	−1281.18
7[x]	model 1 + MW + MW*r^P + MW^C	Regression-type layer effect, MW associations change in different ways by C and *P* (Goodman-Hout model), C is dummy (categorical)	*689.34*	*1.95%*	*252*	*2.74*	*−2338.11*
8[x]	model 1 + MW + MW^P + MW^C	Regression-type layer effect, MW associations change in different ways by C and *P* (Goodman-Hout model), *P* and C are dummy (categorical)	608.59	1.87%	180	3.38	−1553.88

Note: C-country, *P*-year, M-man, W-woman, φ – multiplicative uniform layer effect among tables; D – blocked main diagonals; L^2 – the log-likelihood ratio chi-square statistic; df – degrees of freedom; BIC – Bayesian information criterion (BIC = L2 – (d.f.) log (N)); N – total number of cases (165 000); Δ – index of dissimilarity (indicates the proportion of cases misclassified by the model).

Figure 3 presents trends and cross-country differences in assortative mating for each marriage table cell. The rows of Figure 3 show the educational levels of men (L – low, LI – lower intermediate, UI – upper

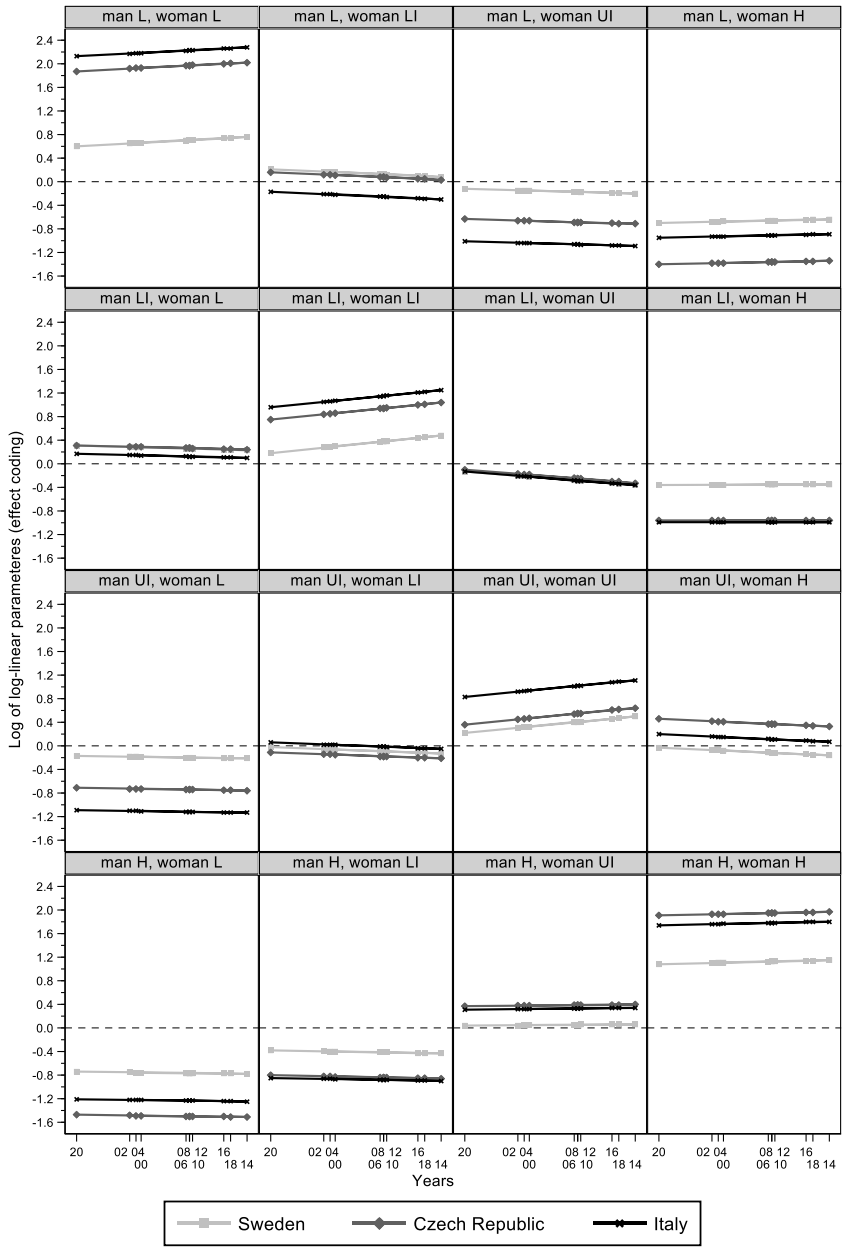

Figure 3. Trends in assortative mating patterns (model 7) by period and country.

Note: L – low, LI – lower intermediate, CS – upper intermediate, H – high

intermediate, and H – high). In the columns, we see women's educational levels. Inside each square, we depict the parameters of Model 7 for each period and country. The X-axis displays the model order of years and the distances between them. Years are arranged non-chronologically to facilitate modeling a linear change and distances in the MW association. Parameters above 0 (dashed line) indicate higher chances for this educational combination than if assortative mating were averaged across all countries and periods. If they are below 0, the chances for the educational combination are lower compared to average assortative mating.

In all countries, homogamous assortative mating (diagonal of Figure 3) is higher at the margins of the educational distribution (low and high education). Furthermore, larger differences between spouses' educational levels are associated with lower chances for the educational combination to occur. Homogamous assortative mating is the lowest in Sweden in all educational categories. Moreover, the model suggests that the trends are similar in all countries and that changes are relatively small throughout the analyzed period. In all educational categories except higher education, there is a change in homogamous assortative mating. However, the years are not ordered strictly chronologically from left to right on the X-axis. From the first-year cluster (2000–2004), over the second-year cluster (2006–2012) up to the third-year cluster (2014–2018) homogamous assortative mating increased for first three education categories. Year 2020 marks a change in this trend, indicating a decline in assortative mating. Heterogamous assortative mating changes in all educational categories, except for higher education as well. Thus, we observe cross-country and cross-temporal variation in the opportunity structure and in assortative mating. In the next section, we analyze to what extent observed differences in educational sorting in marriages can be explained by structural opportunities and assortative mating.

4.4. Decomposition of educational sorting outcomes in marriages

Figure 4 presents the decomposition results of trends in educational sorting outcomes in marriages. The sum of the light grey and dark grey bars equals observed differences in homogamy, hypogamy, and hypergamy rates compared to the reference year 2000. The light grey bars show to what extent changes in educational sorting outcomes are attributable to trends in assortative mating. The dark grey bars indicate the importance of changing opportunity structures for trends in

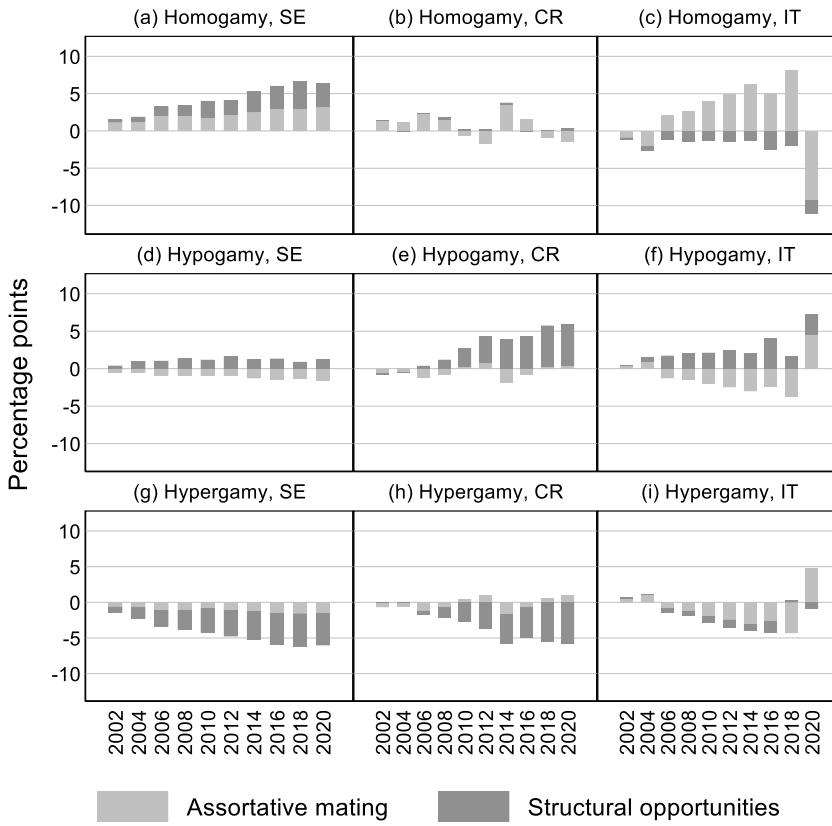

Figure 4. Decomposition of trends in educational sorting outcomes in marriages. (a) Homogamy, SE; (b) Homogamy, CR; (c) Homogamy, IT; (d) Hypogamy, SE; (e) Hypogamy, CR; (f) Hypogamy, IT; (g) Hypergamy, SE; (h) Hypergamy, CR; (i) Hypergamy, IT.
Note: SE – Sweden, CR – Czech Republic, IT – Italy.

educational sorting outcomes. The exact decomposition results and standard errors are shown in Tables A2 to A4 in the Appendix. The standard errors were estimated via bootstrapping by resampling 500 samples with replacement. In addition, Figure A2 in the Appendix depicts trends in educational sorting if only assortative mating (green line) or structural opportunities (red line) had changed.

Trends in homogamy. The extent to which the rise in homogamy rates is attributable to trends in assortative mating and structural opportunities differs across countries. In Sweden, changing opportunity structures and assortative mating patterns both contribute to the rising homogamy rate. For instance, from 2000 to 2020, the homogamy rate increased by 6.4 percentage points. The change in assortative mating accounts for 3.2, and the

change in structural opportunities for 3.2 percentage points of this trend. In the Czech Republic, homogamy rates fluctuate without a clear trend. This pattern is almost exclusively ascribable to trends in assortative mating. In Italy, the growth in homogamy from 2004 to 2018 was entirely driven by changes in assortative mating. The fraction of homogamous marriages would have declined if only structural opportunities had changed. Thus, the rise in the percentage of homogamous marriages would have been even more pronounced if structural opportunities had not changed. Also, the substantial decline in homogamy in 2020 is predominantly due to changes in assortative mating.

Trends in hypogamy. In Sweden, the percentage of hypogamous marriages has hardly changed since the turn of the millennium. Our decomposition analysis reveals that this apparent stability results from the balance of two opposite forces. If only assortative mating differed between 2000 and 2020, we would have observed a decline in hypogamy by 1.6 percentage points. However, if 2000 and 2020 only differed in structural opportunities, the hypogamy rate would have increased by 1.3 percentage points. In the Czech Republic, changes in structural opportunities are the main driver of the growth in hypogamy. In Italy, trends in structural opportunities are linked to rising hypogamy, while trends in assortative mating were associated with declining hypogamy. Like in Sweden, both trends have been mainly offsetting each other.

Trends in hypergamy. Overall, hypergamy has been declining in all three countries. Despite the similarity in trends in hypergamy, the drivers of these trends differ between countries. In Sweden and the Czech Republic, the decline in hypergamy can predominantly be ascribed to changes in structural opportunities. For example, in Sweden, hypergamy declined by 6.0 percentage points from 2000 to 2020; 4.5 percentage points of this decline are attributable to changes in the opportunity structure. In contrast, in Italy, up to 2018, mainly trends in assortative mating were responsible for the decline in hypergamy. However, in general, we find an association between trends in structural opportunities and rising hypogamy and declining hypergamy rates.

In conclusion, despite the similarities in trends in educational sorting outcomes, the extent to which these trends are attributable to trends in structural opportunities and assortative mating varies across countries. However, we find that trends in structural opportunities are associated with rising hypogamy and declining hypergamy rates, while trends in assortative mating tend to be linked to rising homogamy rates.

Figure 5 shows the decomposition of country differences in educational sorting outcomes. Exact values and standard errors are provided in Tables A5 to A7 in the Appendix. The sum of the light grey and dark grey bars equals observed differences in homogamy, hypogamy, or hypergamy rates in the indicated year. For example, the first bar in panel (a) shows that in 2000 the Italian homogamy rate was 18.8 percentage points higher than in Sweden. The light grey bar indicates that this gap can be attributed to differences in assortative mating. The dark grey bar shows that if structural opportunities would not differ between Italy and Sweden, the gaps in homogamy rates would be even slightly higher. Overall, observed differences between countries' educational

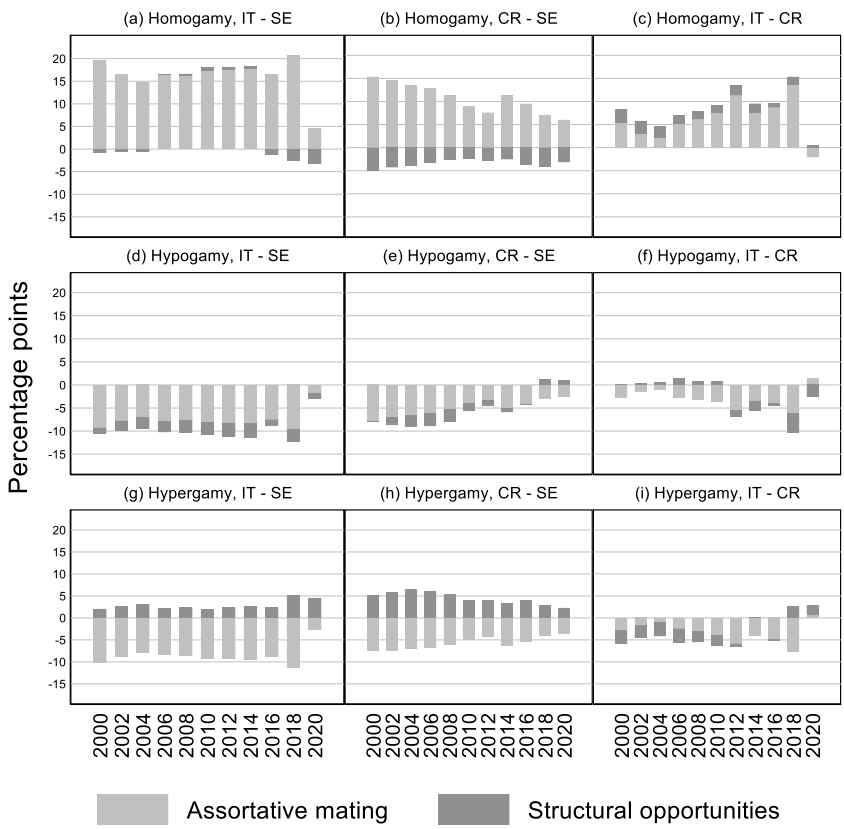

Figure 5. Decomposition of cross-country differences in educational sorting outcomes in marriages. (a) Homogamy, IT – SE; (b) Homogamy, CR – SE; (c) Homogamy, IT – CR; (d) Hypogamy, IT – SE; (e) Hypogamy, CR – SE; (f) Hypogamy, IT – CR; (g) Hypergamy, IT – SE; (h) Hypergamy, CR – SE; (i) Hypergamy, IT – CR.

Note: SE – Sweden, CR – Czech Republic, IT – Italy

sorting outcomes are primarily attributable to between-country variation in assortative mating.

Country differences in homogamy. From 2000 to 2018, homogamy rates were the highest in Italy and the lowest in Sweden. These differences are almost entirely linked to differences in assortative mating. The gaps in homogamy rates between the Czech Republic and Sweden can be primarily ascribed to differences in assortative mating. The negative dark grey bars indicate that the observed differences in homogamy would even be more pronounced if there were no differences in structural opportunities. Moreover, the assortative mating component drops substantially throughout the observation period suggesting that convergence in assortative mating patterns contributed to converging homogamy rates. Differences in homogamy rates between the Czech Republic and Italy are driven by assortative mating and structural opportunities. The structural opportunity component is, however, substantially smaller.

Country differences in hypogamy. Hypogamy rates are the highest in Sweden and the lowest in Italy. Country differences in hypogamy rates are mainly associated with different assortative mating patterns. For example, in 2018, the hypogamy rate in Italy was 12.2 percentage points lower than in Sweden. 9.5 percentage points of this difference can be attributed to assortative mating and 2.7 percentage points to structural opportunities. However, for differences between the Czech Republic and Sweden, the assortative mating component declined over time.

Country differences in hypergamy. Hypergamy rates are generally the highest in Sweden, followed by the Czech Republic and Italy. These patterns are mainly attributable to differences in assortative mating. In most years, differences in structural opportunities had a counteracting 'effect'. That means if structural opportunities were the same, gaps in hypergamy would be more pronounced. The only exception from this pattern is the difference in hypergamy rates between Italy and the Czech Republic, which partly stems from differences in structural opportunities.

In conclusion, the findings suggest that cross-country differences in educational sorting outcomes are primarily attributable to differences in assortative mating. In contrast, within-country trends in structural opportunities have been more important for trends in educational sorting outcomes, especially for trends in hypogamy and hypergamy rates.

5. Discussion

Using population-level incidence data on marriages from Sweden, the Czech Republic, and Italy between 2000 and 2020, our study sought to explain within-country trends and cross-country differences in educational sorting outcomes. First, we examined how structural opportunities, assortative mating, and educational sorting outcomes vary over time and across countries. Subsequently, we analyzed the extent to which variations in assortative mating and structural opportunities have shaped observed trends and differences in educational sorting outcomes.

With respect to within-country trends we found that the proportions of homogamous (wife and husband equally educated) and hypogamous marriages (wife more educated than husband) either increased or remained stable. In all three countries, the percentage of hypergamous marriages (wife less educated than husband) declined. Using log-linear models, we found a slight increase in homogamous assortative mating, while changes in heterogamous assortative mating were minimal. Decomposition results suggested that these trends in assortative mating favored homogamous and disfavored heterogamous marriages in Sweden and Italy, while no clear trend emerged in the Czech Republic. Furthermore, a substantial increase in husbands' and wives' educational attainment resulted in changes in structural opportunities. In all three countries, we identified these changes as a driving force of rising hypogamy and declining hypergamy. The influence of changing structural opportunities on trends in the share of homogamous marriages differed between countries. Moreover, the extent to which observed trends in educational sorting outcomes can be attributed to changes in assortative mating and structural opportunities differs across countries. For example, although changes in assortative mating and structural opportunities were consistently linked to a declining fraction of hypergamous marriages, in Sweden the 'structural opportunity effect' predominated, while in Italy the 'assortative mating effect' was stronger.

For cross-country differences we found the highest proportion of homogamous marriages in Italy, followed by the Czech Republic and Sweden at the lower end. Conversely, Sweden had the highest rates of hypogamy and hypergamy, while Italy recorded the lowest. Using log-linear analyses, we identified substantial cross-country differences in homogamous and heterogamous assortative mating. Decomposition results indicated that these differences in assortative mating were

crucial in shaping variations in educational sorting outcomes across countries. Consequently, cross-country differences in structural opportunities – despite differences in actual educational distributions – were less relevant in accounting for disparities in homogamy and heterogamy outcomes across countries.

Our findings provide valuable insights into the structural causes of within-country trends in educational sorting outcomes. For example, researchers hypothesized that the rise in women's socioeconomic attainment relative to men's could have led to an increase in hypogamous and a decline in hypergamous assortative mating (Han 2022; Schwartz 2013). Another body of research argues that the reversal of the gender gap in higher education has altered structural opportunities, leading to more hypogamous and fewer hypergamous unions and marriages (De Hauw *et al.* 2017; Esteve *et al.* 2016; Van Bavel 2012). Our study can contribute to this debate. In line with the structural explanation, we found that changes in structural opportunities alone would have led to a shift from hypergamous to hypogamous marriages. However, if only assortative mating had changed, the proportions of hypogamous and hypergamous marriages would have both declined. Therefore, our results suggest that changing assortative mating patterns due to the rise in women's socioeconomic attainment relative to men's are not the main driver of the surge in 'non-traditional' unions in which women 'marry down' in education.

The results of this study also improve our understanding of variations in educational sorting outcomes across countries. Scholars anticipated that factors such as economic inequalities or welfare regimes shape cross-country differences in assortative mating (Domański and Przybysz 2007; Fernandez *et al.* 2005). While our study could not investigate why assortative mating varied across countries, our findings highlight the role of these variations in explaining differences in homogamy and heterogamy outcomes between countries. This underscores the importance of studying the reasons behind cross-country differences in assortative mating. Furthermore, even though countries differ in husbands' and wives' educational compositions, the impact of cross-country differences in structural opportunities on educational sorting outcomes was small. This indicates that the educational attainment within the groups of homogamous, hypogamous, and hypergamous marriages differ across countries. For example, even though Sweden and Italy would have a similar homogamy rate if they would differ only in structural opportunities, there might be more highly educated homogamous marriages in

Sweden compared to Italy. For a more detailed understanding of cross-country differences in educational sorting outcomes, future research could investigate these outcomes disaggregated by husbands' and wives' education (i.e. each cell in a marriage table).[8]

Our study advances existing research that explored the roles of changing structural opportunities and assortative mating patterns in shaping trends in educational sorting outcomes. Results from this study support previous findings by linking changes in structural opportunities to a rise in hypogamy and a decline in hypergamy (Leesch and Skopek 2023). However, in contrast to previous research (Leesch and Skopek 2023; Permanyer *et al.* 2019), we found that changes in assortative mating were an important driver of increasing homogamy. Several factors could explain these conflicting results. Compared to our study, Leesch and Skopek (2023) examined a different country context (Ireland) and timeframe (1991–2016), and worked with marriage stock data rather than incidence data. Moreover, the existing literature used different measures of educational attainment and focused on young, partnered women, whereas we included all marriages (Leesch and Skopek 2023; Permanyer *et al.* 2019). Consequently, changes in the timing of union formation might contribute to these differences in findings.

Lastly, we note some limitations of our study. First, conceptually, we treat assortative mating and structural opportunities as two independent components, while there might be some endogeneity if structural opportunities have shaped assortative mating and vice versa. For instance, individuals aiming to find a highly educated partner might pursue higher education themselves. However, this is a general limitation our study shares with other decomposition analyses in this line of research (e.g. Leesch and Skopek 2023; Permanyer *et al.* 2019) as well as the long tradition of log-linear modelling in research on assortative mating (e.g. Kalmijn 1991; Mare 1991; Schwartz and Mare 2005).

Second, changes and cross-country differences in the selection into marriages could affect our results. Leesch and Skopek (2023) found a small but non-negligible link between changes in the educational gradient in union formation and educational sorting outcomes in Ireland. In recent decades, the educational gradient in marriage has remained

[8]Such analyses can also improve our understanding of educational inequalities between couples, as the percentage of homogamous marriages alone is not sufficient to evaluate how educational resources are distributed between couples. For example, if homogamy occurs at the upper and lower ends of the educational spectrum, it indicates high levels of educational inequality between couples. However, if all marriages were between tertiary-educated partners, there would be no educational inequality between couples.

relatively stable in Sweden, the Czech Republic, and Italy, but it varies considerably between countries (Bertrand *et al.* 2021). Therefore, in our study, education-specific selection into unions might have a more pronounced effect on cross-country differences in educational sorting outcomes than within-country trends.

Third, research indicates that assortative mating differs between married couples and unmarried cohabitors (Blackwell and Lichter 2000; Schoen and Weinick 1993). If these differences vary over time or across countries, they might influence our findings on trends and cross-country differences in educational sorting outcomes. Additionally, since our data include first and higher-order marriages, differences in the selectivity into remarriages might also affect our results.

Fourth, patterns of assortative mating and educational sorting outcomes can be sensitive to the chosen educational categories (Gihleb and Lang 2016), which is typically a limitation in research on assortative mating and educational sorting outcomes. In this study, the educational classification is not strictly comparable across countries but reflects the country-specific boundaries of the educational systems. Thus, particularly when comparing educational sorting outcomes across countries, the measurement of education can be a limitation in our study.

Despite these limitations, our study contributes to a better empirical understanding of trends and cross-country differences in homogamy and heterogamy outcomes. It is the first study to link cross-country differences in educational sorting outcomes primarily to differences in assortative mating. Additionally, we contribute to a small but growing body of research that analytically distinguishes the impact of assortative mating and structural opportunities on trends in educational sorting outcomes.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was supported by Trinity College Dublin and the Czech Science Foundation (grant number GA22-33722S: Development of Social Mobility in Central and Eastern European Countries from 1970s to Present: A Dynamic Equilibrium?).

Data availability statement

Replication files are available at the Open Science Framework via https://doi.org/10.17605/OSF.IO/AYGH5.

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