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ABSTRACT

Trends in Assortative Mating and Offspring Outcomes*

Fertility patterns and assortative mating help shape the level and the distribution of offspring outcomes. Increased assortative mating among the less educated has been reported across Western nations, suggesting that inequality in parental resources may be on the rise. In times of rising attainment, we argue that it is difficult to interpret trends in educational assortative mating as they can arise from change in sorting into education as much as from change in sorting into partnerships. Using rank measures of parental resources that have constant marginal distributions, we uncover evidence of declining assortative mating over the last 30 years in Norway. We also find an increasingly positive selection into parenthood. Estimating the contribution of parental resources to offspring outcomes, we show that recent trends in mating have caused a small rise in average offspring education and earnings as well as a decline in offspring inequality.

JEL Classification: J12, J24, J62, D63

Keywords: assortative mating, homogamy, intergenerational mobility, inequality

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1 Introduction

This paper examines recent trends in assortative mating and their consequences for offspring outcomes. Existing research has revealed a considerable rise in educational assortative mating, or partner homogamy, at the lowest education levels. While an American without a high school degree in 1980 was 2.6 times more likely to be married within his or her own group than random matching would predict, this ratio increased to 7.2 by 2013 (Eika et al., 2018). Similar trends are found in Denmark, Germany, Norway, and the UK. While these developments clearly have implications for the distribution of wealth across adults, they may also influence educational and economic outcomes of the next generation (Kremer, 1997). In particular, stronger assortative mating at the bottom of the educational distribution may imply that more children are born into families where both parents are negatively selected in terms of human capital resources. Through the intergenerational transmission of economically, genetically, and socially inheritable traits, this may in turn result in increased inequality and reduced social and economic mobility in the offspring generation.

Educational assortative mating will influence offspring outcomes to the extent that parental education either affects these outcomes causally or signals more general parental human capital characteristics that have such effects. In spite of the strong statistical association between parental education and child outcomes (Hertz et al., 2007; Chevalier et al., 2009), estimated causal effects of parental education on offspring outcomes are typically modest (Black et al., 2005; Holmlund et al., 2011; Lundborg et al., 2014). This, in turn, means that the observed changes in educational assortative mating will substantially affect child outcomes only to the extent that they reflect changes in assortative mating *on these underlying factors*. Motivated by the extensive evidence on earnings persistence across generations (e.g., Corak, 2006; Jäntti et al., 2006; Black and Devereux, 2011, Blanden, 2013; Chetty et al., 2014; Bratberg et al., 2017; Pekkarinen et al., 2017), we propose an alternative indicator of assortative mating based on family background, i.e., social class defined by parental earnings rank.

For educational assortative mating measures, the secular increase in educational attainment makes it difficult to interpret observed trends. When marginal attainment distributions change over time, any trend in assortative mating may reflect altered sorting into education as well as altered sorting into partnerships. With educational sorting, the composition of educational groups has necessarily changed as a result of the dramatic rise in university degrees across cohorts. While the resultant mechanical changes in matching probabilities can be handled by normalizing the observed match frequencies with those that would have applied under random matching, such normalization does not deal with the possibly associated changes in the *composition* of educational groups.

As an illustration, consider a perfectly assortative mating case where individuals are sorted along some unobserved characteristic and match with their closest opposite-sex neighbor. If we observe some signal that identifies the bottom third of this distribution, the within-group counterfactual random match probability is 1/9. Since everyone marries with their closest neighbor such that the actual probability of a within-group match is 1, the normalized assortative mating metric (the actually observed frequency divided by the frequency consistent with random matching) is 9. If the signal instead identified the bottom tenth of the distribution, the random match counterfactual would be 1/100, and the normalized assortative mating metric would be 100, although the underlying matching pattern was exactly the same in both cases. This reflects that, while the actual probability of a within-group match in this example remains constant (and equal to 1), under the random match counterfactual the probability increases quadratically as a group's share increases. Simply put, if educational attainment increases across cohorts then this may cause low attainment to identify a smaller and more homogenous group and high attainment to identify a larger and more heterogeneous group *in terms of some other characteristic* that may be the actual matching factor. If this were the case, we would observe increasing educational assortative mating for the low education group and decreasing assortative mating for the high education group even if the underlying mating patterns were completely unchanged.

To assess trends in assortative mating in a way that isolates changes in mating patterns from changes in the assignment of assorted traits, we focus on traits that *by construction* have a fixed marginal distribution across time. Using administrative register data from Norway for all child-bearing couples formed between 1981 and 2011, we construct three measures over traits defined in terms of *rank* within each birth cohort distribution. The first is social class, defined on the basis of parents' prime age earnings rank. As shown in Markussen and Røed (2017), social class defined this way exhibits a strong and stable positive relationship with cognitive ability, as measured by IQ test scores, and is also a powerful predictor for marital prospects, partner choice, and economic outcomes. The second background indicator is the *IQ* *test score* itself, drawn from military conscription testing around age 18. As such test scores are available for men only, we need to proxy them (with brother scores) for women, implying considerable measurement error and also a loss of a large number of observations. Finally, our third indicator combines family class background and ability test scores into a measure of *predicted lifetime earnings* using estimated earnings premiums as weights.

Motivated by our focus on offspring outcomes, we define “mating” as the event of having a first child together and examine the *flow* of new matches. While assortative mating metrics reported in the literature typically are “local,” in the sense that they are based on the subset of actually matched individuals, we focus in this paper on “global” measures that are based on the whole population (including the unmatched). This is important in our context because the probability of, say, having two bottom class parents depends both on the overall mating frequency for bottom class individuals and on the extent to which they mate with partners from the same class. The selection of resource-bearing individuals into parenthood also determines the amount of resources passed on as a whole by one generation to the next.

While we find increasingly positive selection into parenthood in terms of social class and ability for both genders, there is no indication that these parental traits have become more unequally distributed across children over time. In stark contrast to prior results (and reconfirmed by us) based on educational attainment, we find declining trends in assortative mating at the bottom of the class/ability distributions and stable or slightly increasing assortative mating at the top. This implies a considerable reduction in the probability of having two negatively selected parents. Our results suggest that the observed changes in educational assortative mating largely stem from changes in sorting into education groups and not from changes in sorting into partnerships along traits such as social class or ability.

The consequences of parental assortative mating for offspring inequality depend on how combinations of parental resources influence child outcomes. To examine this, we estimate a production function where parental background characteristics are interpreted as inputs that affect child outcomes such as educational attainment and labor earnings. This allows us to examine both returns to scale (i.e., change in “output” when both parental inputs are increased proportionally), mother-father substitutability, and the marginal productivity of maternal and paternal resource contributions separately. Our findings suggest that mothers are slightly more important than fathers when parental resources are measured by social class.

There are decreasing returns to scale and a weak father-mother complementarity in the production of primary school results (GPA) and high school completion, whereas there are increasing returns to scale and/or considerable positive complementarities in the production of higher education and labor earnings. As a result, assortative mating reduces average primary and high school performances, but increases average attainment of higher education as well as labor earnings measured at age 35. Obviously, assortative mating also raises the degree of inequality in offspring outcomes.

Combined, our analysis of mating patterns and the family production functions shows that changes in Norwegian mating patterns have raised average offspring outcomes and reduced offspring inequality over the last three decades. Hence, at least for Norway, we can call off the widespread concern that parental resources in general have become much more unequally distributed across households, and that this has been a force for reduced social mobility in the offspring generation.

2 Related literature

Research on assortative mating cuts across the social science disciplines and biology. In social sciences, one strand of the literature deals with the extent to which mating patterns have changed over time in rich societies. Other contributions focus on the implications of assortative mating on inequality.

2.1 Assortative mating trends

Both economists and sociologists have documented secular increases in educational assortative mating and educational homogamy in the post-World War II United States; see, e.g., Greenwood et al. (2014), Schwartz and Mare (2005), and Mare (2008). Two recent US studies have questioned or imparted nuances to this evidence, however.

First, Eika et al. (2018) show that the degree of educational assortative mating varies considerably over the educational distribution. Their baseline measure of assortative mating is the share of married individuals who have married within their own educational group, relative to the share that would have prevailed under random matching. Based on this metric, the study finds striking heterogeneity in trends, with declining assortative mating among the highly educated and rapid increases at the bottom of the educational distribution. Similar results are reported for four European countries (Denmark, Germany, Norway, and the UK). For the US, the study confirms that educational assortative mating on average increased between 1962 and the mid-1980s, remaining stable since, and demonstrates that this conclusion is highly robust with respect to alternative measures of assortative mating.

Second, Gihleb and Lang (2017) outright reject the notion that US partners have become more similar in terms of educational attainment and show that measured trends in aggregate assortative mating are highly sensitive to the exact grouping of educational attainments. Using both CPS and Census/ACS data, they find that, when they use appropriate statistical measures, educational assortative mating remained constant over time for most educational classification alternatives. Other studies from Europe and Asia indicate that the evidence on educational sorting trends is not conclusive. Five European Social Survey waves show no clear tendency across countries of increased homogamy during recent decades (De Hauw et al, 2017). Evidence from ten East-Asian societies (Smits and Park, 2009) reveals a trend toward less educational homogamy and indicates that homogamy declines following educational expansions.

A related strand of studies focuses on earnings homogamy – the tendency for spouses to match on earnings. For the US, income correlation studies have attributed the increase in earnings inequality among married couples to a stronger association between spouses´ earnings, at least up until to the turn of the century (e.g., Schwartz, 2010; Larrimore, 2014). However, measuring assortative mating as the deviation from that of random matching, the evidence does not support the claim that assortative mating is an important driver of changes in household inequality; see, e.g., Pestel (2017) for Germany, Kuhn and Ravazzini (2017) for Switzerland, and Hryshko et al. (2017) for the US. Trends in earnings inequality turn out to be similar for observed matches and randomly paired counterfactual couples.

A complicating factor for studies of earnings homogamy is that earnings patterns are endogenous to partner choice, and may reflect specialization and labor supply decisions within households (Chiappori et al, 2016). For example, when labor supply of one partner responds to the wage of the other, trends in mating on observed earnings will be affected by changes in labor supply behavior. Therefore, several recent studies focus on (effects of) assortative mating on earnings potentials (measured strictly before the time of mating) rather than on realized earnings (Pestel, 2017; Kuhn and Ravazzini, 2017). Evidence for France suggests that assortative mating matters more for potential than for actual earnings (Frémeaux and Lefranc, 2017).

Studies of assortative mating trends seem to ignore the potential impact of selection into the group of matched couples, whether based on shared residence, parenthood, or both. For the present study, trends in childlessness are of particular relevance as we study matching of parents. Europe exhibited a U-shaped pattern in permanent childlessness among women born between 1900 and 1972 (Sobatka, 2017), with the lowest levels recorded among the 1940s cohorts. Until 1960, the US experienced a similar trend (Baudin et al. 2015) after which childlessness gradually declined (Frejka, 2017). Since selection into partnership/parenthood is unlikely to be random, studies of assortative mating should ideally consider the whole set of potential partners and not only observed matches.

2.2 Implications for inequality

If there are changes to educational assortative mating patterns, this will alter inequality in economic resources across households and family dynasties. Several recent empirical studies confirm that educational assortative mating accounts for a sizable proportion of the cross-sectional inequality in household income, though changes in assortative mating over time are unable to explain time trends in household income inequality (Breen and Salazar, 2011; Eika et al., 2018).

Assortative mating among parents is potentially an important factor in explaining persistence of inequality across generations. Motivated by the widespread concern that (more) assortative mating causes (higher) inequality in economic resources between households, as well as dynasties, Kremer (1997) develops a theoretical framework in which assortative mating potentially affects long run inequality. However, within the range of reasonable parameter values, the effects of more assortative mating are modest. Assortative mating may have more important consequences if, unlike in Kremer's model, mating also influences skill accumulation among offspring, e.g., because of credit constraints, feeding back into the matching process (Fernandez et al, 2005).

Within the empirical intergenerational mobility literature, Ermisch et al. (2006) argue that assortative mating on socioeconomic characteristics account for 40-50 percent of the covariance between parental and own permanent family incomes in Germany and Britain. Chadwick and Solon (2002), for example, show that in the US, the elasticity of daughters' *family* earnings with respect to her parents' income is of the same magnitude as that typically found for *individual* earnings of sons and fathers. Individual earnings of husbands and wives are equally highly correlated with the incomes of their parents-in-law as they are with incomes of their own parents. However, household labor supply decisions are likely to mitigate the effect of assortative mating on individual earnings persistence across generations. For example, among married women in the UK and the US, the elasticity of own earnings with respect to parents' earnings is much lower than that of family earnings, because strong cross-wage labor supply responses imply that married women respond to higher wages of husbands by working fewer hours or by withdrawing from the labor market (Raaum et al., 2007).

Sorting into parenthood affects the average resources available to the offspring generation as well as inequality of childhood conditions. The evidence on education and fertility at the extensive margin is mixed and the pattern varies across countries. While childlessness is U-shaped in female education in the US (Baudin et al. 2015), highly educated women are more likely to be without children in France, Austria and Switzerland (see the overview in Kreyenfeld and Konietzka, 2017). Within the Nordic countries, childlessness is equally distributed across education groups in Sweden, but is much higher among the less educated in Finland.

Even if human capital formation is a core element of models of transmission of inequality across generations, we are not aware of any studies that empirically examine trends in assortative mating among parents, including selection into parenthood, in a way that facilitates an evaluation of how changes in mating patterns have affected the distribution of outcomes in the offspring generation.

3 The Norwegian birth cohort data

Our empirical analysis builds on Norwegian administrative population data covering three generations. The starting point of our analysis is the set of all matches occurring between 1981 and 2011, where a match is defined as a couple having a first child together. For these parents, we add information about educational attainment (at age 28), family background (to define social class), IQ, and predicted lifetime earnings. As described in greater detail below, these latter three characteristics are used to specify each person's gender-specific *rank* within his/her own birth cohort. Importantly, the rankings are all based on *complete birth cohorts*, including those who never become parents (or become parents at some other point in time). This facilitates an examination of trends in assortative mating patterns that incorporates changes in sorting into the state of parenthood (being matched at all). In a second part of the paper, we examine data on early educational and earnings outcomes for all the children of the identified couples.

Table 1 gives an overview of the data structure. In total, 917,416 new couples were formed in Norway over the 31-year period, giving birth to 1,883,556 children. In our study of assortative mating patterns, it is critical that we are able to observe family background of the mating generation. In practice, this means that we require information on the parents of the two partners (the children's grandparents), including measures of their economic status. As can be calculated from Table 1, we have almost full coverage of couples where both partners are Norwegian born (98.7 %). However, because of the data requirement of linking three generations, a majority of immigrant couples drop out of our analysis.

Table 1. Data structure and numbers of observations

Matched partners 1981-2011	
All new matches (couples)	917,416
… of which between two Norwegian-born individuals	719,897
New matches for which we identify both his and her family background	742,250
… of which between two Norwegian-born individuals	710,376
New matches for which we identify both his and her IQ	226,861
Offspring of matched partners	
Total number of offspring	1,883,556
… of which by two Norwegian-born parents	1,484,959
Offspring for which we identify both parents' family background	1,515,861
… of which by two Norwegian-born parents	1,455,959
Offspring for which we identify both parents' predicted IQ	477,969

3.1 Assorted traits (the mating generation)

Although we focus on assortative mating on traits that exhibit constant marginal distributions, for ease of comparison we also present trends in mating patterns based on educational attainment. The traits we apply in this paper can be described as follows:

Education: Based on data drawn from the national educational registers, we collect information about the highest educational attainment obtained at age 28. As a default categorization, we follow the baseline specification in Eika et al. (2018) and use four educational categories: i) No high school education, ii) High school degree, iii) Some college, and iv) College degree.

Social Class (family background): Population registers identify family linkages, and an administrative register with information on pension entitlements identifies all labor-related earnings from 1967 and onwards. We use these data to characterize family class background on the basis of the sum of the mother's and father's earnings during their ages 52-58; see Markussen and Røed (2017) for a detailed description of and justification for the procedure.[1] These earnings are first inflated to a common nominal currency using the basic amount in the national pension system. Thereafter, all mating partners are attributed the decile rank of their own parents' earnings in the earnings distribution for all parents of the same birth cohort. This decile defines the social class.

Cognitive ability (IQ): Cognitive ability scores are based on the IQ test administered to the vast majority of Norwegian males around age 18-19 at compulsory military conscription. Test scores are available for most of the potential male mating partners in our data period, but not for females. However, given the strong genetic component in IQ, we can, for a considerable subsample of the population, proxy for missing female test scores with the scores of their brothers. To ensure constant marginal distributions, we rank each birth cohort in deciles separately for men and women. As the original test score takes only 9 stanine values, we add information about brother scores even for men in order to derive a more fine-grained scale facilitating decile ranks (in a few cases where identical test scores cross a decile border, we apply random assignment).

Predicted lifetime earnings: We combine social class and IQ decile scores (10*10=100 categories in total) to predict lifetime earnings. This is done on the basis of earnings data for the complete birth cohorts from 1952 through 1965, and lifetime earnings are proxied by total earnings during age 40-50. Again, the predictions are used to rank all individuals belonging to the same birth cohorts into the deciles of gender specific distributions.

As the two latter traits rely on IQ data, they are available for a subsample of the population only; see Table 1. In the analysis of mating patterns, we can only examine women with at least one scored brother, and we must live with the fact that our measures of cognitive ability and predicted lifetime earnings are of considerably poorer quality for women than for men. In the analysis of the influence of assortative mating on offspring outcomes, a symmetric treatment of mothers and fathers becomes essential; hence we must resort to predictions

[1] Markussen and Røed (2017) present evidence that 52-58 is the age interval for which earnings are most highly correlated with lifetime earnings. For some birth cohorts, the class ranking is based on ages slightly below or above the 52-58 range.

based on brother scores even for men. For these reasons, we build the main part of our analysis on the social class trait, which is identified for almost all Norwegian couples matched between 1981 and 2011. The two other traits will primarily be used to assess the robustness of our key findings, with results presented in the Appendix.

3.2 Offspring outcomes

For all realized matches, we have records of education and earnings outcomes for the offspring. In the analysis of offspring outcomes, we also include data on matches made before 1981, provided that we have sufficient data to characterize parents' family background and IQ. Analyzed child outcomes include:

Normalized Grade Point Average (GPA) score from primary school: These scores are measured at age 15-16 and the coverage in our data implies that we can observed this outcome for cohorts born from 1985 through 1999. The outcome has by construction the exact same distribution for each birth cohort.

Completion of high school by age 21: This is a dummy variable taking the value 1 if an offspring obtained a valid secondary education by age 21. Data on this outcome is available for offspring born before 1995.

Years of non-compulsory education by age 28: This outcome reports the number of years of attained education after primary school. It is available for offspring born before 1988.

Earnings at age 35: This outcome reports total labor earnings (including self-employment earnings) during the year of the 35th birthday. It covers offspring born before 1981.

4 Trends in the sorting into parenthood

We first examine trends in the sorting into the event of being partnered and thus become a parent. Starting with mating propensities by educational attainment, Figure 1 shows the fractions of new parents holding each of the four attainment levels. It illustrates that new parents of today are much more educated than 30 years ago, as expected given the rising educational attainment across cohorts. While less than one of two parents had completed high school in 1980, more than four in five had done so in 2011. The fraction with higher education has also risen remarkably, particularly for mothers.

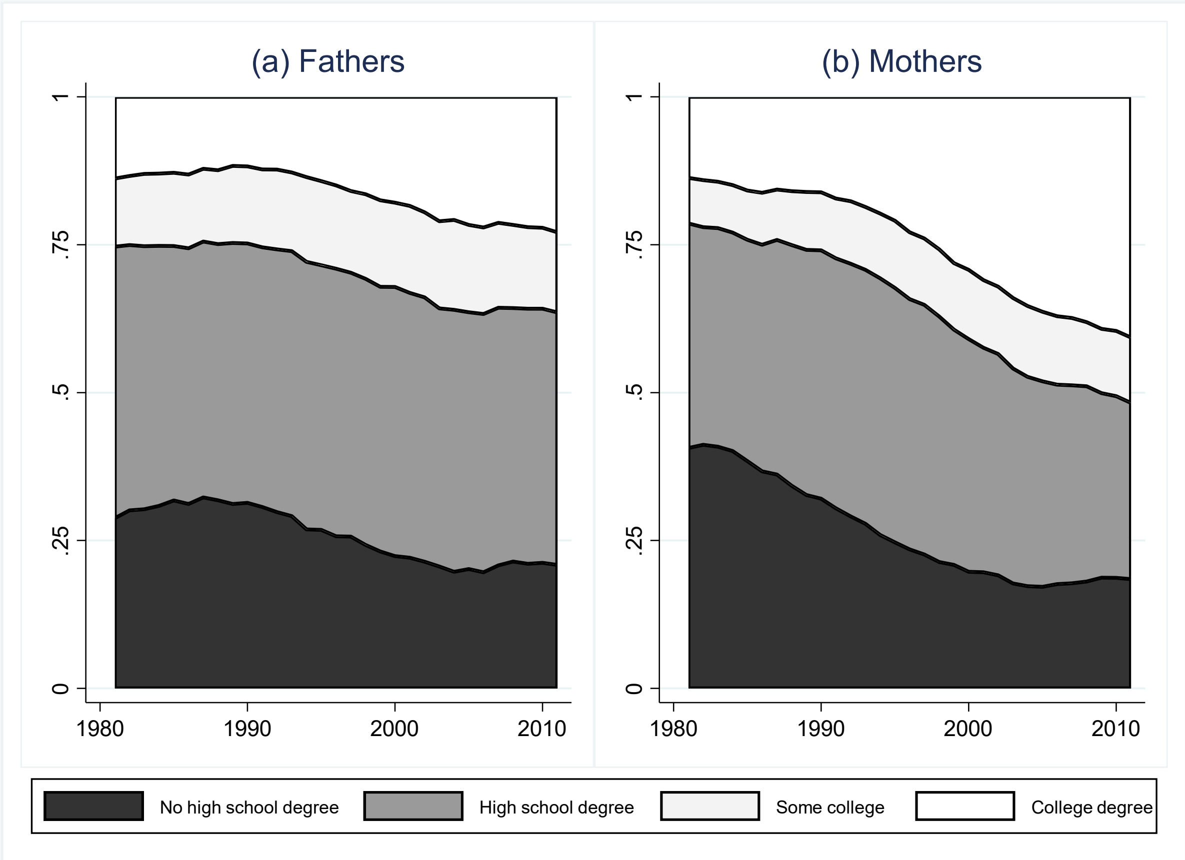

Figure 1. Parental educational attainment of birth cohorts 1981 to 2011.
Note: The graphs indicate the shares of fathers and mothers with different educational attainments by birth-year of their first child. The educational classification follows the baseline specification in Eika et al. (2018).

When education distributions change over time, it is hard to isolate any changes in sorting into parenthood from general trends due to educational expansions. Using our social class rank with constant marginal distributions, the upper two panels in Figure 2 show the trends in average social class for fathers and mothers. It is clear that parents have become more favorably selected over time also in terms of social class. Note that completely random assignment into parenthood would imply an average rank of 5.5 (marked in the figures by a horizontal line). Hence, while first-time mothers and fathers tended to be negatively selected in the early 1980s (and mothers also in the 1990s), they have now become positively selected. The two lower panels in Figure 2 show how selection into parenthood has shifted in the extremes of the distributions, by displaying trends in the fractions of new fathers' and mothers' drawn from the lowest and highest deciles of the social class distribution. In this case, the random counterfactual implies a stable fraction of 0.1. It is evident that there has been a strong trend in the direction of relatively lower fertility in the lowest class, and a somewhat weaker trend toward higher fertility in the top class.

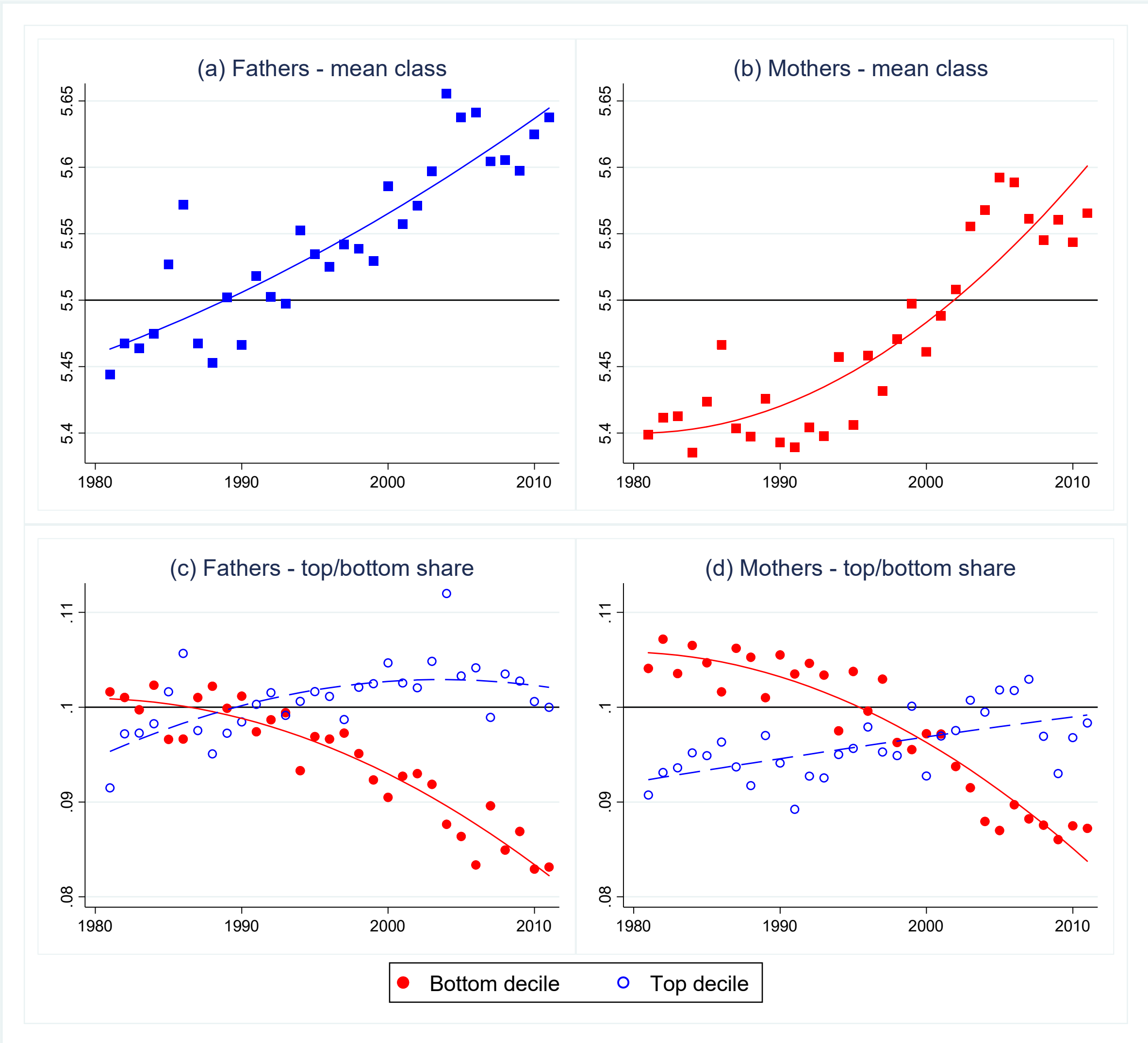

Figure 2. Social class of fathers and mothers in new partnerships 1981 to 2011.
Note: Panels (a) and (b) show the mean class decile for new fathers and mothers by birth-year of their first child, whereas panels (c) and (d) show the fraction of new fathers and mothers with background from the lowest and highest classes. Social class background is defined as the parents' (the new-born children's grandparents) decile position in their generation's prime-age earnings distribution. The trend lines are estimated with local polynomial (second order) regressions.

In the Appendix, we show that these trends are similar when we use the reduced sample with identified IQ and divide the population into deciles based on IQ or predicted earnings rather than social class; see Figures A1 and A2. The most important difference is that when we rank the population based on IQ or predicted earnings, the declining shares in the bottom decile are less pronounced. However, the result that the recruitment into parenthood has changed toward persons with higher rank, remains robust whether based on social class, IQ, or predicted earnings.

The trend toward higher ranked first-time parents coincides with child postponement as first-time parents have become older over time. During a transition period, we may observe compositional changes of first-time parents. In Appendix Figure A3 we show that the mean age at first parenthood between 1981 and 2013 indeed increased by approximately four years for both fathers and mothers (from 24 to 28 for mothers and from 27 to 31 for fathers), and remained stable thereafter. More importantly, from our perspective, we do not see any class gradient in the way age at first parenthood has increased. As shown in the lower panels of Figure A3, the increase was almost exactly the same at the bottom and top of the family class background distribution. It is indeed the case that fathers and mothers from the highest classes enter parenthood 2.5 (for women) or 2 (for men) years later than those from the lowest classes, but this class difference remained stable throughout our data period. We therefore conclude that the trend toward higher ranked parents over time is not driven by child postponement, but by genuine changes in the sorting into parenthood.

5 Trends in assortative mating

Most studies of trends in assortative mating are based on educational attainment. However, on the evidence of any trend over the recent decades they conclude differently. This partly reflects fundamental methodological challenges. Trends in educational assortative mating are typically studied in settings where (i) the marginal distributions of educational attainment change over time, (ii) there are several possible classification schemes, and (iii) the population of *potential* partners is not always well defined.

When comparing measures of sorting over time or across countries, the marginal distributions are generally different, and this will "mechanically" affect the probabilities of equal characteristics observed for both parents. Recent metrics of assortative mating deal with this statistical challenge. Liu and Hu (2006) argue that the degree of assortative mating must be measured by the relative distance between the realized outcome and a benchmark outcome where individuals are perfectly randomly matched. Along these lines, Eika et al. (2018) measure the degree of marital sorting for particular educational groups $Z_{m(other)}$ and $Z_{f(ather)}$ in terms of observed frequencies relative to the case of random matching:

(1) $$s(z_m, z_f) = \frac{P(Z_m = z_m, Z_f = z_f)}{P(Z_m = z_m)P(Z_f = z_f)}$$

where Z_m (Z_f) denotes the education level of the mother(father). To obtain a measure of overall educational assortative mating, Eika et al. (2018) then compute the weighted average of the sorting parameters along the diagonal of the matrix of combinations of mother's and father's education.

Although the normalization in (1) properly accounts for the implications of *mechanical* changes in match probabilities, a potentially important ambiguity remains. In the presence of sorting into education, expansion (or contraction) of educational groups are likely to change the composition of each group. This means that changes in $s(z_m, z_f)$ may reflect a systematic change in the composition of individuals within an educational subgroup in addition to any change in the underlying population mating patterns. As exemplified in the introduction to this paper, such compositional changes may be sufficient to cause considerable changes in $s(z_m, z_f)$ over time.

The second issue relates to the difficulty of defining a well-founded classification scheme for all educations that also has a stable interpretation over time. As pointed out in the US context (Gihleb and Lang, 2016), the reported trends in assortative mating tend to be highly sensitive with respect to the educational classification schemes.

Finally, the third challenge relates to the need for a defined set of "feasible matches" when calculating the random matching counterfactual required for normalization. In their baseline specification, Eika et al. (2018) identify this set with the set of existing marriages at the same point in time. The numerator in equation (1) will then reflect the shares of married couples (i.e., the stock of marriages) with different combinations of educational attainment, while the denominator is the product of marginal shares from the same population. This approach cannot shed light on the part of the matching process that relates to sorting into partnerships (marriage or cohabitation) since the sample leaves out those not matched.[2] Moreover, the stock of couples will change due to marriage and divorce patterns, albeit fairly slowly as the fraction of stable couples are high. In the present study, we focus on the flow of new matches, as the flow will reveal changing trends before they have accumulated sufficiently to affect the stock. Focusing on the flow also allows us to assess sorting into partnerships and

[2] In a robustness analysis, Eika et al. (2018) adjust for age and marriage propensity, such that the random assignment counterfactual corresponds to the marriage patterns if both the probability of marrying and who marries whom are independent of education, and show that this does not materially change the trend in aggregate educational assortative mating in the US.

thus enables a more comprehensive analysis of how mating patterns influence the sum and distribution of parental resources transferred to the next generation.

In this section, we present new evidence on trends in assortative mating based on background characteristics that by construction exhibit constant marginal distributions and which arguably address all these methodological challenges. To make our case clear, we start with the state of the art approach for studying educational assortative mating of Eika et al. (2018) before providing new evidence on the alternative assorted traits with constant marginal distributions.

5.1 Trends in educational assortative matching

Our measures of educational assortative mating are based on attainment at age 28 for all new parents of the 1981 to 2011 birth cohorts. For each education level, we calculate the sorting parameters $s(z_m, z_f)$ by birth cohort from Equation (1), where the observed probabilities of both parents holding the same attainment are divided by the product of the two shares.

Figure 3 displays the assortative mating metric by birth cohort for each of the four attainments. Although we base metrics on flows rather than stocks of prime-aged married couples, the trends coincide with those reported by Eika et al. (2018). Normalized against a random match counterfactual, assortative mating has increased considerably in the bottom of the educational distribution and declined at the top.

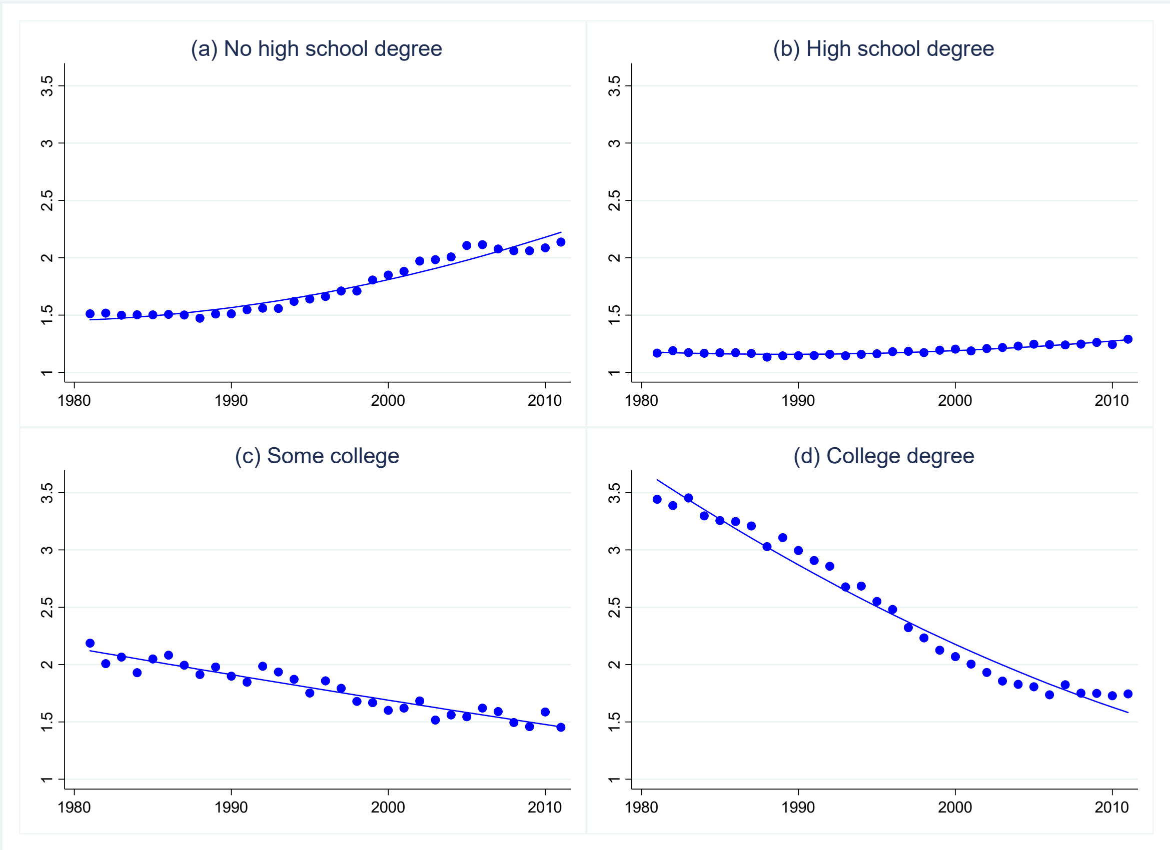

Figure 3. Trends in educational assortative mating by year of mating and education.
Note: The graphs show the educational assortative mating metrics computed from Equation (1) by birth-year of the couple's first child. The numbers indicate the fraction of new couples having the same level of educational attainment divided by the expected fraction with random matching. The random match counterfactual is based on the population that actually mated in each year. The educational classification follows Eika et al. (2018). Trend lines are estimated with local polynomial (second order) regressions.

Turning to the *aggregate* educational assortative mating metric, the circles shown in Figure 4, panel (a), describe the trend in the weighted sum of the four diagonal sorting parameters displayed in Figure 3. Based on this default classification of educational attainment, the metric indicates a small drop in assortative mating before 1990 and then a steady increase from about 1.42 to 1.58 over the next twenty years. Relative to random matching, it has become more common that both parents hold the same educational attainment. Considering the developments illustrated in Figure 3, increased sorting in the lower end of the distribution apparently dominates decreased sorting in the top. At face value, a difference of 0.16 appears modest, but is actually comparable to the observed change in the US between 1962 and 1980 where the aggregate assortative mating metric went from 1.7 to 1.9 (Eika et al., 2018). Hence, relative to random matching, the likelihood of having a partner with the same attainment is somewhat higher among US prime-aged couples compared to new parents in Norway.

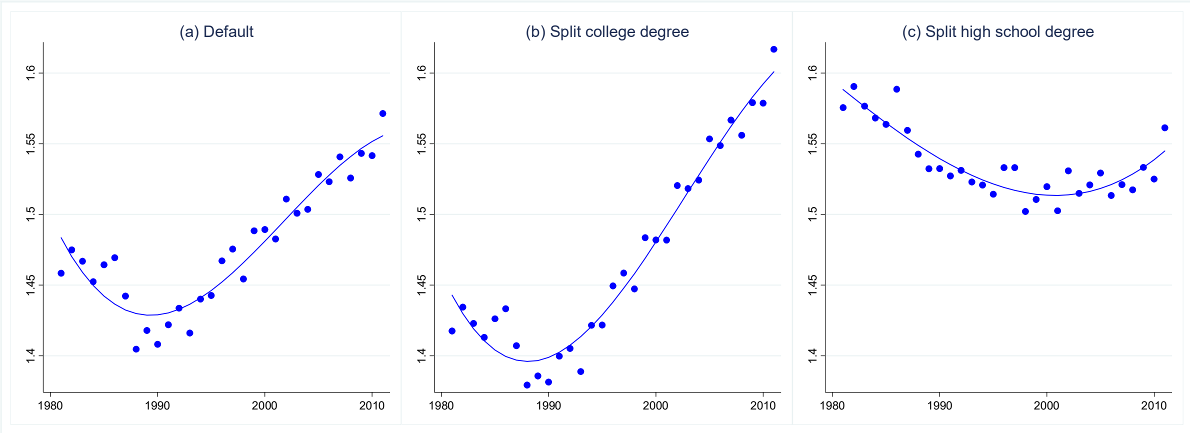

Figure 4. Trends in aggregate educational assortative mating under alternative educational classifications.

Note: The graphs show aggregate educational assortative mating metrics by birth-year of the couple's first child, computed as the as the weighted sum of sorting parameters from Equation (1) with the random match counter-factual based on the population that actually mated in each year. The default categorization in panel (a) follows Eika et al. (2018) and is the same as in Figure 1. In panel (b), the college degree category is split into bachelor's and master's degrees, and in panel (c) the high school degree category is split between a partial (1-2 years) and a full (3-4 years) degree. Trend lines are estimated with local polynomial (second order) regressions.

The other two panels in Figure 4 illustrate the sensitivity of the educational assortative mating metric with respect to the specification of educational qualifications, as we have added two alternative, albeit reasonable, classifications: One with more detailed categories at the top (panel (b)) and one with a split at high school level (panel (c)). The evidence in Figure 4 is mixed as splitting the college education group produces a pattern of a much larger increase in assortative mating, while splitting the high school education group produces a pattern of declining assortative mating. This squares with US evidence (Gihleb and Lang, 2016) showing that alternative educational classification schemes – for which we have no theoretical guidance – can substantively affect the inferred trends in educational assortative mating. For the decade of the 1990s, for instance, these different ways of categorizing educational levels allow us to display either rising or declining assortative mating.

5.2 New evidence based on stable rank measures

In this subsection, we describe trends in assortative mating based on social class background. The metric is defined in (1) and is the fraction of persons who mates with another person from exactly the same class background decile. There is no need for normalization since the marginal distributions by construction are constant over time, but we use the same metric for comparability with the analysis based on education. Given that random assignment always implies a probability of exactly 0.01 of observing a couple with a particular class combination, this amounts to multiply the observed fractions by 100.

Our main results are presented in Figures 5 and 6. Panels (a) and (b) of Figure 5 report the assortative mating trends at the lowest and the highest class deciles, respectively, with the education mating metrics (Figure 3) added to the figure for contrast. Focusing first on the trends displayed in panel (a), it is striking that, while the measure based on education indicates a sharp increase in assortative mating at the lowest level of human capital, the measure based on class background suggests a steady *decline*. Moving on to panel (b), we find that the dramatic decline in educational assortative mating at the top disappears when we base the metric on class background. Finally, panel (c) presents measures for aggregate assortative mating, defined as the weighted average of the sorting parameters along the diagonal. While we find that aggregate educational assortative mating increased, it has remained stable according to the class measure. The aggregate level of assortative mating is lower for social class than for education, probably reflecting that education is chosen by the individual while class is a family background characteristic. For both education and social class, it is clear that the degree of assortative mating is largest at the tails of the distribution, as the aggregate levels are well below those at the bottom and the top.

Since our class measure has 10 categories, whereas education has only four, it may be suspected that some of the differences in mating trends are related to the fact that the class-based trends are more focused on the tails of the human capital distribution. However, this does not explain the differential trends. In the appendix Figure A4, we present a version of Figure 5 based on class quartiles instead of deciles showing that conclusions regarding trends in class-based assortative mating are highly robust with respect to the choice of class size. However, the *levels* of assortative mating at the top and bottom are considerably reduced when we look at the top/bottom quartiles rather than the top/bottom deciles. The aggregate assortative mating metric is just slightly lower with quartiles, however, suggesting that group size is less important in the middle of the distribution.

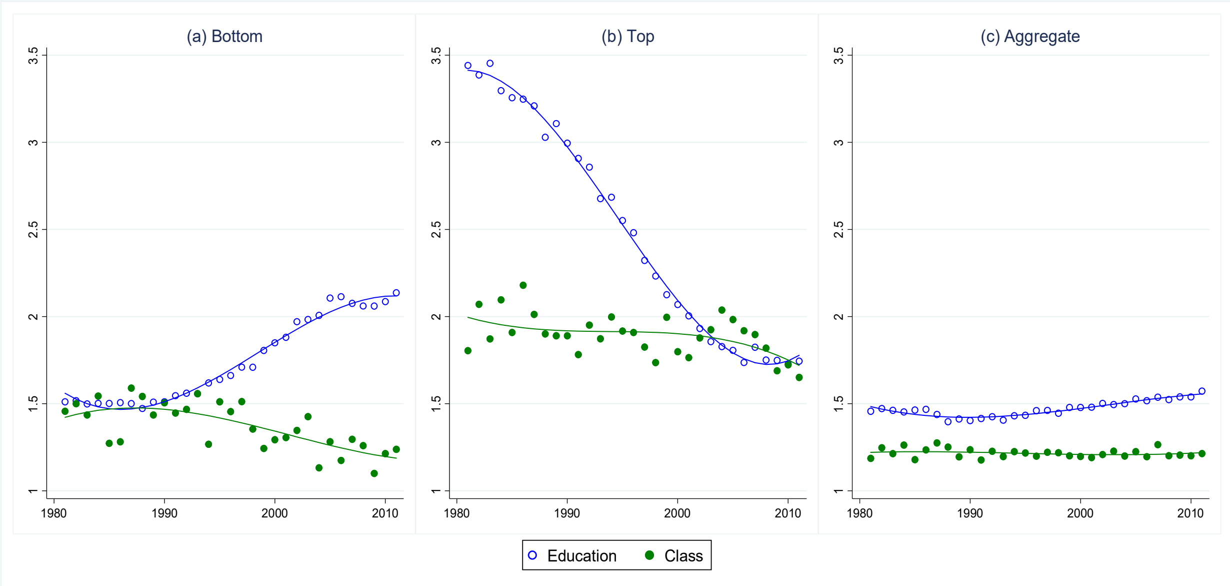

Figure 5. Assortative mating by education group and social class (decile of the parental earnings distribution).
Note: The graphs show assortative mating metrics computed from Equation (1) by birth-year of the couple's first child, based on education and class, respectively. The bottom and top groups in panels (a) and (b) are the lowest/highest decile of the parental earnings distribution (class) or the lowest/highest education group (education). The metric in panel (c) is the weighted average of the sorting parameters for all classes or education groups (along the diagonal). Trend lines are estimated with local polynomial (second order) regressions.

There are alternative metrics of assortative mating. Our measure potentially masks very different trends across the distribution, as it focuses exclusively on partner homogamy; i.e., the extent to which partners belong to the exact same group. All measures in Figure 5 ignore how close matching is "off the diagonal". For example, the metrics will not capture whether the middle class is more or less likely to find closely located partners outside their own group. Therefore, in Figure 6, we present measures describing the overall degree of association of parents' social classes. In panel (a), we show the average class distance between the mother and father, measured by the absolute value of the difference in decile rank (again normalized to the distance under random matching), and in panel (b) we show the social class correlations. These measures both indicate that the overall degree of assortative mating has declined somewhat, at least up to the turn of the century (note that higher decile distance implies less assortative matching).

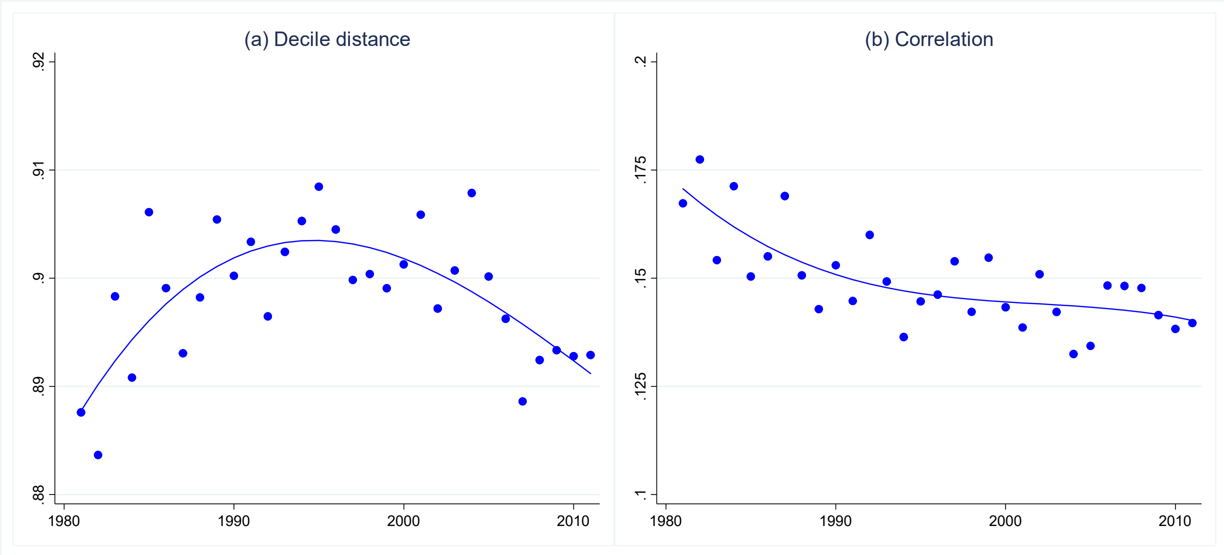

Figure 6. Absolute social class distance and correlation between new partners.
Note: Panel (a) shows the average absolute distance in social class background between new parents, relative to the expected distance under random matching, by birth-year of the couple's first child. Panel (b) shows the corresponding decile rank correlation coefficient. Trend lines are estimated with local polynomial (second order) regressions.

Except for education, assortative mating trends are fairly robust with respect to how we measure parental traits. In the Appendix, we reproduce (from the reduced sample) Figures 5 and 6 based on deciles in the IQ and predicted earnings distributions; see Appendix Figures A5 and A6. The aggregated assortative mating based on predicted earnings is around 1.35 (Figure A5), higher than for class and IQ, and much closer to what we find for educational attainment.

As far as trends are concerned, the metrics based on IQ and predicted earnings convey the same message as the parental earnings based social class metric. All three metrics show declining assortative mating in the aggregate as well as declining trends at the bottom of the human capital distribution. For the top group, the different metrics indicate somewhat different developments: The IQ based metric shows increasing assortative mating at the top, whereas the other two indicates decreasing assortative mating. However, the key message to be taken home from this analysis is that when we use human capital indicators that exhibit constant marginal distributions over time, there is no empirical support for the claim that parents of recent birth cohorts are more similar than they used to be.

5.3 Reconciling the evidence on educational and social class matching

The large discrepancy between trends in assortative mating when based on education and social class is striking. There are two important conceptual differences between the two assortative mating metrics that may explain the conflicting evidence. First, while the class measure is global, i.e., it examines mating patterns based on class affiliation in the *whole population* of potential mating partners, the education metric is local in the sense that it examines assortative mating patterns *among those who actually mate* in a given year. Second, while the marginal educational attainment distribution changes (with an increasing fraction holding a university degree), the metric based on class exhibits by construction exactly the same distribution every year. When social class affects both education and mating patterns and the composition of educational groups changes, we may observe that *educational* assortative mating changes even if mating patterns are stable. In this subsection, we provide some empirical evidence aimed at reconciling the apparently conflicting assortative mating patterns identified on the basis of education and class.

While it is not straightforward to design a global assortative mating metric based on education, as the trend in educational attainment would require the researcher to specify the risk population of all potential partners, we can illustrate the importance of the local-global-distinction by making the class-based assortative mating metric local. This is achieved by re-ranking into modified social classes the population actually mating each year. In Figure 7, we show how this would alter the class-based assortative mating trends in Figure 5. While switching from global to a local ranking has little influence on aggregate assortative mating (panel (c)) and on assortative mating at the top, it changes the conclusions regarding trends in assortative mating at the bottom quite substantially. Based on the local rank measure, we estimate increasing assortative mating at the bottom of the class distribution. However, even with an increase from around 1.4 to 1.7, this trend falls short of the increase in the education-based metric, which was approximately twice as large (conf. Figure 5).

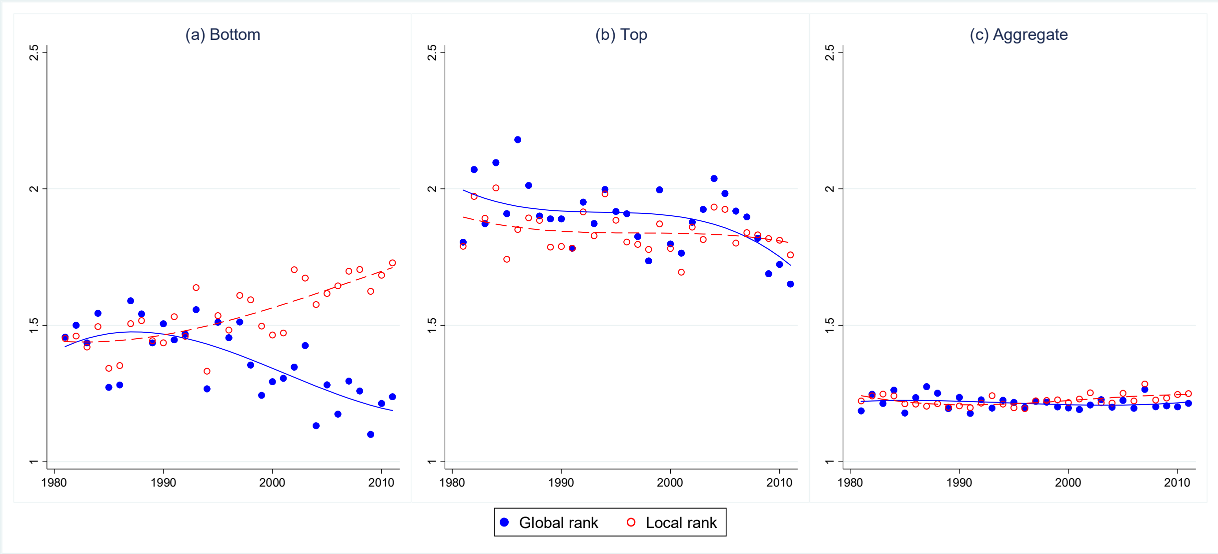

Figure 7. Trends in assortative mating based on alternative measures of class background.
Note: The graphs show assortative mating metrics computed from Equation (1) by birth-year of the couple's first child, based on two alternative measures of the new parents' class background. Global rank is based on the complete birth cohorts, whereas local rank is based on the population of actually mating individuals only. Trend lines are estimated with local polynomial (second order) regressions. See also note to Figure 6.

When the size of an educational group increases, the quadratically increasing random match reference probability may introduce an almost mechanical relationship between a group's share of the population and its assortative mating metric even when the underlying mating process is stable. Consistent with this, we find a close relationship between an education group's share of the population and the education based assortative mating metrics. Plotting the four assortative mating metrics from Figure 3 against the relative size of each education group in each year instead of against time itself, Figure 8 shows that there is a strikingly close relationship between group size and the normalized assortative mating metric. If the metric accounted for changes in marginal distributions in a "neutral" way, we would not expect a systematic association with group size. The patterns provide no conclusive evidence on the role of educational sorting, but it indicates that the changes in educational assortative mating may reflect changes in the sorting into education as much as they reflect change in mating patterns.

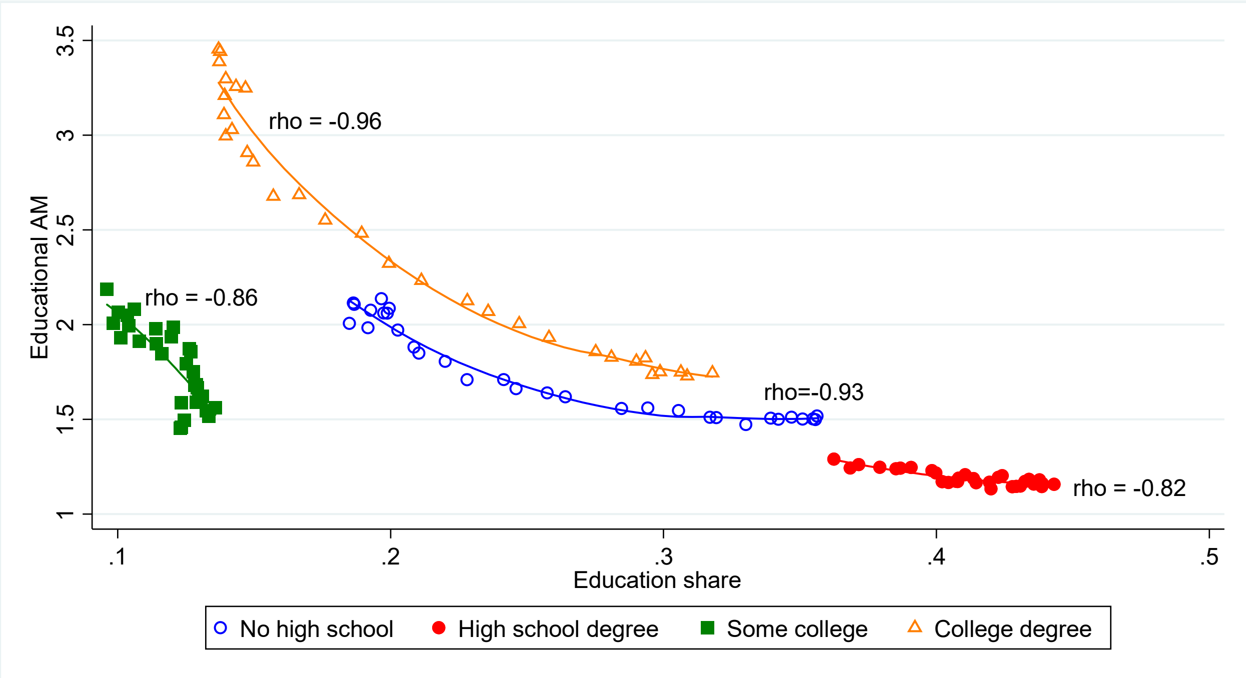

Figure 8. Association between educational assortative mating metrics and education shares.
Note: The graphs display the educational assortative mating metrics already reported in Figure 3 by each education's population share instead of by birth-year of the first child. Education shares reported on the horizontal axis are computed as the averages for mothers and fathers. The rho reported for each educational category is the correlation coefficient between the educational assortative mating metric and the group share. Solid lines are estimated with local polynomial (second order) regressions.

Direct evidence on changes in the sorting into educational groups is provided by Figure 9 which illustrates how class composition within the bottom and top education groups has developed among those who actually mate each year. Since the no-high-school-degree group has become smaller over time, we expect this group to have become more homogenous – in the sense that the likelihood that a randomly selected man and women from this education group are from the same class has increased. And this is indeed exactly what we see in panel (a). For college educated, we note the opposite trends; see panel (b). Given the large expansion of this group, it has become more heterogeneous in terms of social class; hence the probability that randomly drawn college educated men and women have the same class has dropped considerably. The general rise in educational attainment has also had the implication that the mean class level has declined both within the lowest and the highest educational categories; see panels (c) and (d). This development reflects that the low education group has become more dominated by the lowest classes, whereas the high education group has become less dominated by the highest classes.

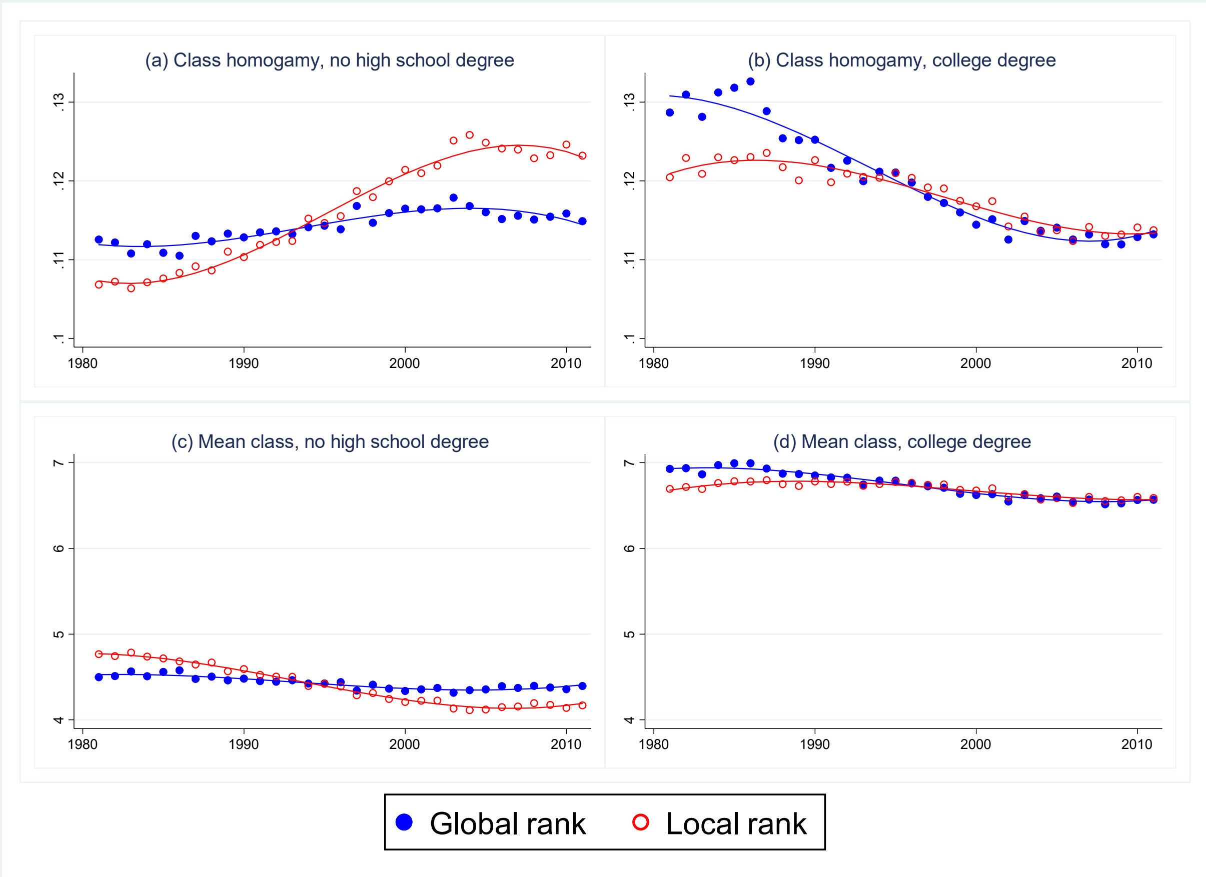

Figure 9. Social class composition of the lowest and highest education groups by year of mating.

Note: Panels (a) and (b) show trends in class homogamy within education groups, defined as the probability that a randomly chosen man and a randomly chosen woman come from the same class. Global rank refers to the parental earnings rank within the group of all Norwegian men/women belonging to the same birth cohort. Local rank refers to the parental earnings rank within the group of persons who actually mated each year. Trend lines are estimated with local polynomial (second order) regressions.

6 Consequences for the offspring

Since human capital, broadly defined, is transferred across generations, we would expect that the patterns of marital sorting and selection into parenthood influence economic and educational outcomes in the offspring generation. Theoretically, parental mating patterns affect the degree of inequality in the offspring generation (Kremer, 1997) and potentially also average offspring outcome. To examine this in more detail, we estimate in this section the empirical relationship between parental social class and offspring education and earnings). Our analysis builds on a simple production function framework where we interpret parental earnings rank as a proxy for parental human capital resources. Complete results based on IQ and predicted own earnings rank instead of parental earnings rank are provided in Appendix.

6.1 An intergenerational human capital production function

Assume that outcome Z_{it}, for offspring *i* belonging to birth cohort *t,* can be expressed as a function of parental inputs (R_{mi}, R_{fi}), where R_{mi} and R_{fi} represent the human capital of i's mother and father, respectively, in this section as proxied by their social classes. Our interest then lies in the characteristics of this function, particularly in terms of its scale properties and the degree of complementarity/substitutability between maternal and paternal inputs. If the intergenerational human capital transfer technology is linear with perfect substitutability, the offspring mean is unaffected by how the parents are mixed. For a given set of parents, assortative mating will then only affect who gets the benefit of a father or mother with above average human capital levels, but the total sum of contributions passed on to the next generation is fixed. This can be contrasted with a situation where, say, the marginal effect of the mother´s human capital is smaller if the father has a high human capital, in which case strong assortative mating would reduce the mean of offspring outcomes relative to random matching.

Many parametric technologies have complementarities (i.e. non-zero cross derivatives), but a natural starting point is a model where the offspring outcome is quadratic in the sum of parental human capital. Hence, as the foundation for our analysis, we use the following empirical mode:

(2) $$Z_{it} = \alpha_1 \left(R_{mi} + R_{fi} \right) + \alpha_2 \left(R_{mi} + R_{fi} \right)^2 + \alpha_3 R_{mi} + \alpha_4 R_{mi} R_{fi} + x_{it}^{'} \beta + \varepsilon_{it}$$

where x_{it} is a vector of controls (including birth-year dummy variables for parents and offspring, indicators for offspring birth order, and a constant term) and ε_{it} is a residual with expectation equal to zero. Assuming that $\alpha_1 > 0$, this specification nests alternative human capital formation technologies, facilitating tests of different properties:

(a) Linearity with perfect substitutability; $\alpha_2 = \alpha_3 = \alpha_4 = 0$

(b) Symmetry (mother and father equally important); $\alpha_3 = 0$

(c) No interaction effects beyond non-linearity; $\alpha_4 = 0$

Note that the coefficients in Equation (2) do not have a strictly causal interpretation in the sense that policies manipulating parental ranks – e.g., through redistributive programs in the parent generation – necessarily alter offspring outcomes. However, they are causal in the sense that policies manipulating mating patterns are indeed expected to affect offspring outcomes. The causality then refers to all relevant causally active factors that correlate with social class, and not to the class itself.

We focus on the implications of parental sorting on the mean and variance of outcomes. With a slight manipulation of terms, we can write the expectation of (2) as

(3)
$$E(Z_{it}) = \alpha_1 E\left(R_{mi} + R_{fi}\right) + \alpha_2\left[\left(E\left(R_{mi} + R_{fi}\right)\right)^2 + Var(R_{mi}) + Var(R_{fi}) + 2Cov(R_{mi}, R_{fi})\right]$$
$$+\alpha_3 E(R_{mi}) + \alpha_4\left[E(R_{mi})E(R_{fi}) + Cov(R_{mi}, R_{fi})\right] + E(x_{it}^{'})\beta.$$

Hence, the derivative of the expected offspring outcome with respect to the degree of assortative mating within the group of parents – interpreted as the covariance of parental ranks – reads

(4)
$$\frac{\partial E(Z_{it})}{\partial Cov(R_{mi}, R_{fi})} = 2\alpha_2 + \alpha_4 \ .$$

Assortative mating contributes negatively to the average outcome if the technology exhibits decreasing returns to scale $(\alpha_2 < 0)$, unless there is a sufficiently strong complementarity between the mother's and the father's inputs ($(\alpha_4 > -2\alpha_2)$.[3] With strong complementarities and/or constant or increasing returns, assortative mating raises the average outcome. The intuition is simple; with decreasing returns to scale and low degree of complementarity, a highly ranked parent makes a larger marginal positive impact on the offspring's outcomes if the other parent has a low rank.

While the effect of assortative mating on average child outcomes depends on the properties of the human capital formation technology, the effect on the variance of offspring outcomes is simpler: As long as the marginal contribution of each parent's human capital is positive, the lowest variance will be achieved by minimizing the variance in parental contributions to the children. For example, in the simplest case with a linear production function in the sum of parental human capital, i.e., $\alpha_2 = \alpha_3 = \alpha_4 = \beta = 0$ (e.g., Kremer, 1997), offspring generation inequality increases with assortative mating by the factor $2\alpha_1^2$; i.e.,

(4)
$$Var\left(Z_{it}\right) = \alpha_1^2\left[Var\left(R_{mi}\right) + Var\left(R_{fi}\right) + 2Cov\left(R_{mi}, R_{fi}\right)\right] + Var\left(\varepsilon_{it}\right).$$

[3] Note that the scale properties of (2) not only depend on α_2, but also on α_4 and on the parental inputs. It can be shown that there are decreasing returns to scale if $\alpha_2(R_{mi} + R_{fi})^2 + \alpha_4 R_{mi} R_{fi} < 0$. A sufficient condition for this to hold is that $\alpha_4 < -4\alpha_2$.

The offspring human capital variance is increasing in the covariance between mother's and father's human capital, and more so if intergenerational persistence (α_1) is strong. Assuming separability (the human capital passed on by a high class and low class parent is the same irrespective of whether the father or mother has the high class), minimizing inequality in the offspring generation will be equivalent to minimizing the variance in total parental capital across households. Conversely, perfect assortative mating maximizes the variance in child outcomes.

6.2 Data and estimation results

We estimate Equation (2) for four different offspring outcomes: grade point average at age 16, high school completion at age 21, years of non-compulsory schooling at age 28, and earnings at age 35. As we use social class as a proxy for the parents' human capital, parental inputs take integer values from 1 to 10, representing the parents' social classes (the grandparents' earnings ranks). Table 2 summarizes the data used in this section.

Table 2. Data and descriptive statistics

Grade points, standardized (age 16)	
Mean	0.008
Standard deviation	0.986
Average class father	5.541
Average class mother	5.475
Number of observations	760,400
High school completion (age 21)	
Mean	0.698
Standard deviation	0.459
Average class father	5.472
Average class mother	5.399
Number of observations	991,480
Years of non-compulsory education (age 28)	
Mean	3.815
Standard deviation	2.585
Average class father	5.438
Average class mother	5.361
Number of observations	636,909
Annual earnings (age 35)[#]	
Mean	5.062
Standard deviation	3.629
Average class father	5.398
Average class mother	5.299
Number of observations	332,085

[#]Earnings are recorded in the year of the 35th birthday and are expressed in units of basic amount of the social security system (approximately 10,000 Euros in 2016).

Estimated coefficients are listed in Table 3.[4] Since almost all the estimates are highly statistically significant, we only mark the non-significant coefficients (at the 5 % level). Consider first the grade point average (GPA) at the end of compulsory lower secondary school, typically at age 16. The GPA is standardized within birth cohort so the estimates express the effects in terms of GPA standard deviations. The linear perfect substitutes technology is rejected and there are decreasing returns to scale. When we calculate the marginal effect of father´s class, shown in panel (c), the estimate is reduced by more than one half if we compare the higher and lower ends of combined parental social class (0.019 vs. 0.046 percentage point). The mother´s class appears to be slightly more important than the father´s, as $\alpha_3 > 0$. In the middle of the class distribution, the estimate of 0.004 implies that the marginal effect of raising the mother's class is approximately 12 percent larger than the effect of raising the father's class. The two parents are not perfect substitutes, as $\alpha_4 > 0$, and the marginal effect of one parent's human capital is slightly decreasing in the other's (not shown in the table).

The effects of parental human capital on high school graduation at age 21 are very much in line with those found for GPA. The marginal effect of moving one step up the social class ladder (i.e., having a father one decile up in his parents' earnings distribution) varies between about 0.3 to 2.2 percentage points, showing that the evidence of decreasing returns is even stronger than for grades at age 16. Actually, in the upper end of the parental distribution the marginal effect of the fathers´ human capital is close to zero. Taken together, the estimates discussed so far suggest that the stronger is the degree of assortative mating, the lower is the average grade point score and the lower is the rate of high school completion. This is illustrated by the negative coefficients reported in panel (b), which are both statistically significant.

[4] All the estimations reported in this section have also been done separately for male and female offspring. As the results indicated no important differences between the sexes, we do not report these results here.

Table 3. Intergenerational human capital production technology based on parents' earnings rank (social class). OLS.

	GPA at age 16	High school completion by age 21	Years of schooling at age 28	Earnings at age 35
(a) regression coefficients				
$R_{mi}+R_{fi}$ (α_1)	0.0549	0.0240	0.0479	0.0441
	(0.0013)	(0.0005)	(0.0037)	(0.0075)
$(R_{mi}+R_{fi})^2$ (α_2)	-0.0016	-0.0010	0.0027	0.0009^{ns}
	(0.0001)	(0.0000)	(0.0003)	(0.0006)
R_{mi} (α_3)	0.0041	0.0023	0.0141	0.0023^{ns}
	(0.0006)	(0.0005)	(0.0017)	(0.0034)
$R_{mi}\times R_{fi}$ (α_4)	0.0026	0.0017	-0.0032	0.0005^{ns}
	(0.0003)	(0.0001)	(0.0008)	(0.0016)
(b) Impact of assortative mating ($Cov(R_{mi},R_{fi})$) on average outcome				
$2\alpha_2+\alpha_4$	-0.0006	-0.0003	0.0022	0.0023
	(0.0001)	(0.0001)	(0.0004)	(0.0008)
(c) Marginal effect of father´s human capital if				
$R_{mi}=R_{fi}=1$	0.0457	0.0217	0.0555	0.0482
$R_{mi}=R_{fi}=5$	0.0343	0.0125	0.0859	0.0646
$R_{mi}=R_{fi}=9$	0.0191	0.0033	0.1163	0.0810
Observations	760,400	991,480	636,909	332,085
R^2	0.0344	0.0462	0.0949	0.0166

Note: ^{ns} denotes non-significant at the 5% level. Fixed effects: Offspring birth cohort, birth order, fathers birth cohort and mothers birth cohort.

For years of schooling at age 28, our estimates imply that the marginal effect of parental class is increasing; see panel (c). For earnings at age 35 (measured in units of basic amount of the social security system, about 10,000 Euros in 2016), neither the quadratic nor the interaction term is significant, implying that linear perfect substitutability is not rejected, yet the estimated marginal effects are increasing also for this outcome. For both post compulsory education and earnings, we note that more assortative mating contributes to higher average outcomes. The reason is that there tends to be either positive returns to scale and/or positive complementarities in parental inputs. In general, the intergenerational transmission technology appears to be more concave for early outcomes like GPA or high school completion than for subsequent outcomes. About 70% have completed high school at age 21 and parental resources are strong predictors of who passes that hurdle. With both parents in the upper part of the rank distribution, the probability of passing is very high, and we would expect the increase associated with even more parental human capital to be limited. For a disadvantaged child, however, there is more at stake and marginal effects may be considerable. The human capital production functions for adult outcomes which are not top-coded (e.g., earnings), have properties that are more in line with constant returns. For completed years of schooling and earnings, the right tail of the outcome distribution is also important and the evidence suggests that linear perfect substitutability is a fairly good approximation of the production function. In others word, even the children who are always-takers for high school graduation gain in terms of education and earnings.

Results obtained with the reduced sample based on IQ and predicted earnings ranks are reported in the Appendix Tables A1 and A2. These results are similar to those discussed above, although the estimated effects generally become larger and the explanatory power increases. As IQ and predicted own earnings (based on IQ and social class) clearly provide better proxies for own human capital than parental earnings, this is as expected.

7 Trends in assortative mating and offspring outcomes

Based on the assortative mating patterns described in Sections 4 and 5 and the intergenerational transmission mechanisms estimated in Section 6, we are now in the position to predict how trends in mating patterns over the past decades will affect the mean and the standard deviation of outcomes for offspring born between 1981 and 2011. Our main results are presented in Figure 10, which shows how predicted outcome means and standard deviations for the offspring generation are affected by the observed mating patterns, relative to the 1981 cohort. It is evident that the changes in mating patterns have contributed to improved average outcomes, as well as reduced inequality. Note that we cannot compare the predictions in Figure 10 with actual developments, as many of the data points in the graphs will be outside the observation window for the outcome measures.

The trends shown in Figure 10 come from two sources: i) changes in the population of parents and ii) changes in mating patterns within the group of parents. To examine the role of sorting into parenthood, we repeat the whole exercise behind Figure 10, but this time based on the assumption that mating *within* the group of parents is completely random throughout the period. For the mean outcomes, we then obtain almost exactly the same pattern as those described in Figure 10 (not shown). Hence, virtually all the predicted changes in average offspring outcomes, following from changes in mating patterns, arise from changes in sorting into parenthood, and not from changes in mating patterns within that population. For the standard deviations, the picture is a bit more mixed, but a considerable part of the trends is accounted for by changes in sorting into parenthood.

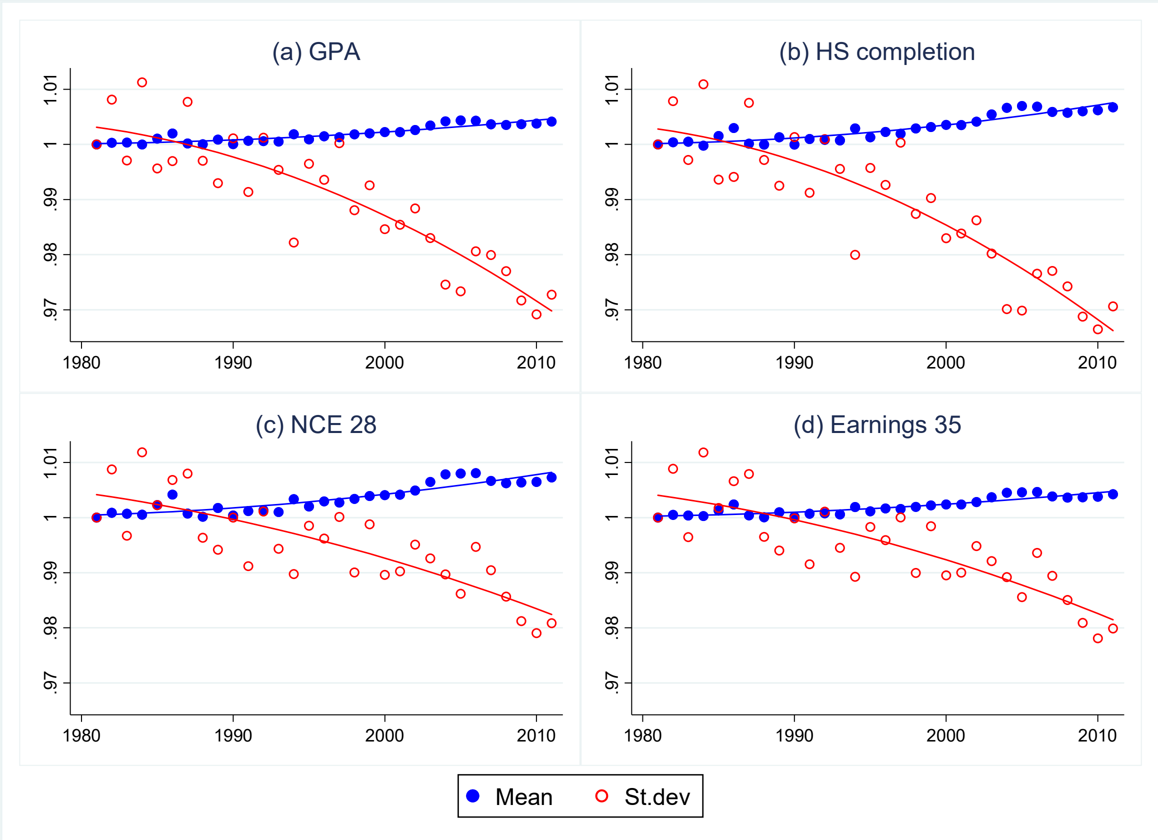

Figure 10. Trends in predicted offspring outcomes based on observed mating patterns and the production functions estimated in Section 6.2
Note: The graphs show the means and standard deviations of predicted outcomes by birth-year, based on observed mating patterns. Data points are normalized to unity in 1981. Trend lines are estimated with local polynomial (second order) regressions.

As a further illustration of the limited role that sorting within the parent group plays in shaping average offspring outcomes, we have used the estimated production functions from Section 6 to compute the results of some extreme counterfactual mating patterns *within* the population of all new couples for which we have data. Table 4 presents the results. Here, we compare the observed offspring means and standard deviations with the predicted means and standard deviations under three alternative counterfactual assumptions: i) completely random matching, ii) perfect assortative mating, and iii) perfect disassortative mating. A striking feature of this table is that the mean outcomes are almost insensitive to the mating patterns.

For example, looking at the high school completion rate, we note that moving from perfectly assortative to perfectly disassortative mating raises the predicted high school completion rate by a mere 0.4 percentage points.

Table 4. Predicted offspring outcomes under counterfactual social class mating among actual parents

	GPA age 16		High school at age 21	Years of schooling at age 28		Earnings at age 35	
	Mean	Std dev	Share	Mean	Std dev	Mean	Std dev
Observed parents	-0.06126	0.15658	0.75516	4.5867	0.42405	5.5873	0.29658
Mating counterfactuals:							
Random	-0.06052	0.14665	0.75546	4.5840	0.39438	5.5845	0.27576
Assortative	-0.06542	0.20724	0.75343	4.6019	0.55656	5.6032	0.38955
Disassortative	-0.05564	0.02510	0.75749	4.5662	0.05591	5.5658	0.02364

Note: With perfectly assortative mating $Corr(R_{mi},R_{fi})\approx 1$, with perfectly disassortative mating $Corr(R_{mi},R_{fi})\approx -1$.

Again, we report results for the ranks based on IQ and predicted earnings in Appendix; see Figures A7 and A8 and Table A3. The substantive conclusions are robust with respect to the choice of proxy for human capital rank. As expected, we find that the predicted trends in mean offspring outcomes have been even more favorable when we use IQ or predicted earnings as the foundation for ranking.

8 Concluding remarks

This paper was partly motivated by the concern that stronger assortative mating, particularly at the bottom of the human capital distribution, has been a force for increased inequality and reduced social mobility in the offspring generation. Based on Norwegian birth cohort data, we have presented empirical evidence to the contrary: When measured by traits exhibiting a constant marginal distribution over time – such as parental earnings rank and/or cognitive ability rank within own birth cohort – we have found that the degree of assortative mating has declined, and that the decline has been particularly large at the bottom of the distribution. These patterns stand in sharp contrast to trends in educational assortative mating, which indicate a sharp increase in assortative mating precisely at the bottom of the distribution. In an era of increasing educational attainment, we argue that trends in educational assortative mating have a highly ambiguous interpretation as they can arise from changes in the sorting into education as much as from sorting into partnerships. In line with US evidence, we also show that measures of educational assortative mating are highly sensitive with respect to the way educational categories are defined.

Our findings show that over the past three decades, the probability that a newborn child is raised by two parents who *both* belong to lowest social class has declined considerably. Most of this change has been caused by changes in the sorting into parenthood, such that the average social class of parents has increased over time. When examining the relationship between parental social class and early offspring outcomes such as primary school results and high school completion, we find some evidence of decreasing returns to parental inputs, suggesting that the marginal contribution of a high ranked parent is larger when matched with a low ranked parent. Taken as a whole, the observed decline in assortative mating in Norway has not only contributed to a considerable decline in offspring inequality, but also to a small improvement in average offspring outcomes.

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Appendix

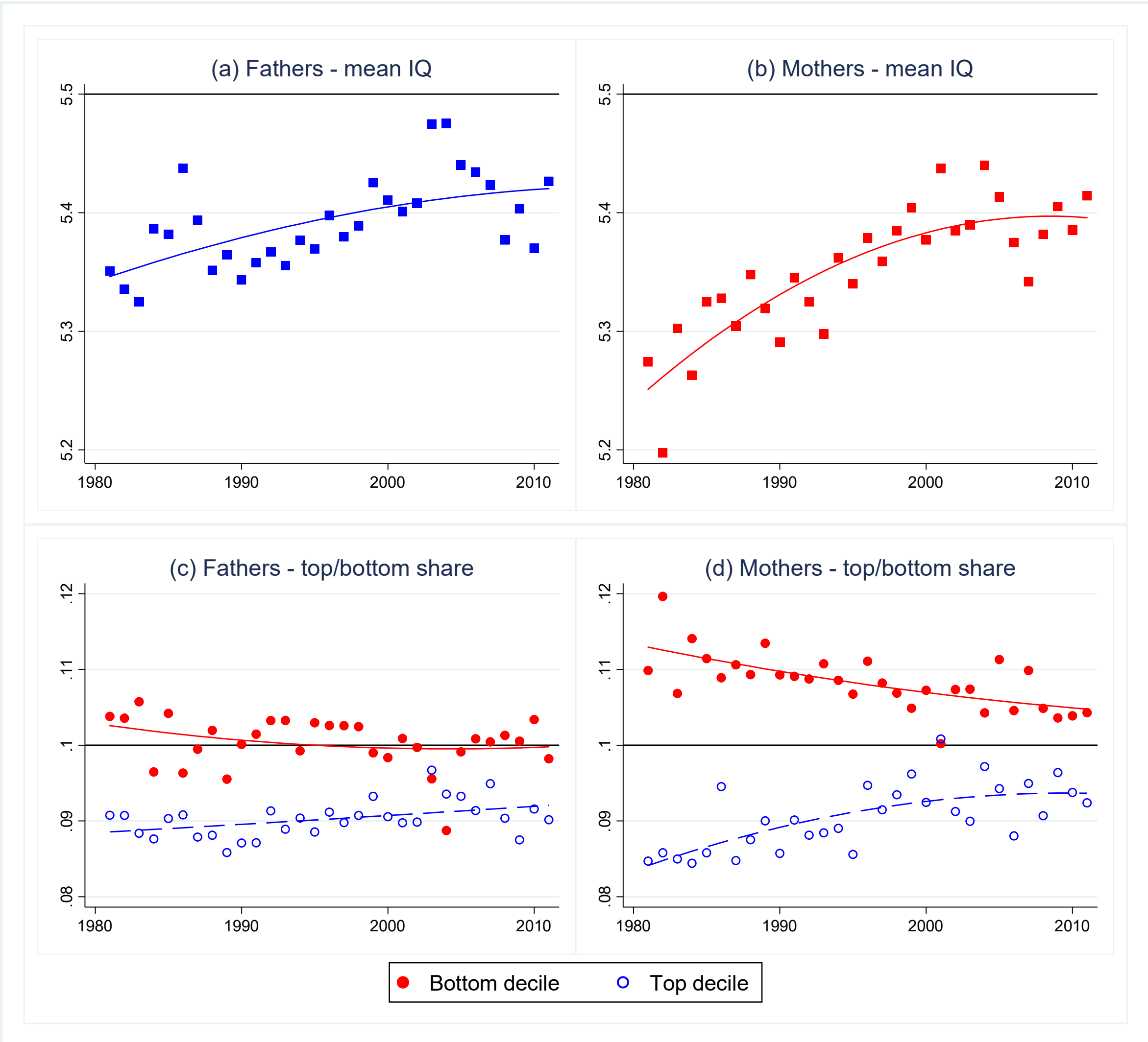

Figure A1. IQ rank (decile) of fathers and mothers in new partnerships 1981-2011.

Note: Panels (a) and (b) show the mean decile in the IQ score distribution for new fathers and mothers by birth-year of their first child, with female scores predicted from brother scores. show the fraction of new fathers and mothers from the lowest and highest IQ ranks. The trend lines are estimated with local polynomial (second order) regressions.

Figure A2. Predicted earnings rank (decile) of fathers and mothers in new partnerships 1981-2011.

Note: Note: Panels (a) and (b) show the mean decile in the predicted earnings rank distribution for new fathers and mothers by birth-year of their first child. Rank is defined as the decile of the predicted lifetime earnings distribution, where predictions are made on the basis of observed age 40-50 earnings recorded for all Norwegians born between 1952 through 1965, using all combinations of parental earnings and IQ decile (100 dummies) as explanatory variables. Panels (c) and (d) show the fraction of new fathers and mothers from the lowest and highest deciles. The trend lines are estimated with local polynomial (second order) regressions.

Figure A3. Mean age at the establishment of new partnerships (first-time parenthood) 1981-2011.

Note: Panels (a) and (b) show the average age of fathers and mothers at the birth of their first child. Panels (c) and (d) show the corresponding averages for mothers and fathers belonging to the lowest and highest decile of the family class background distribution.

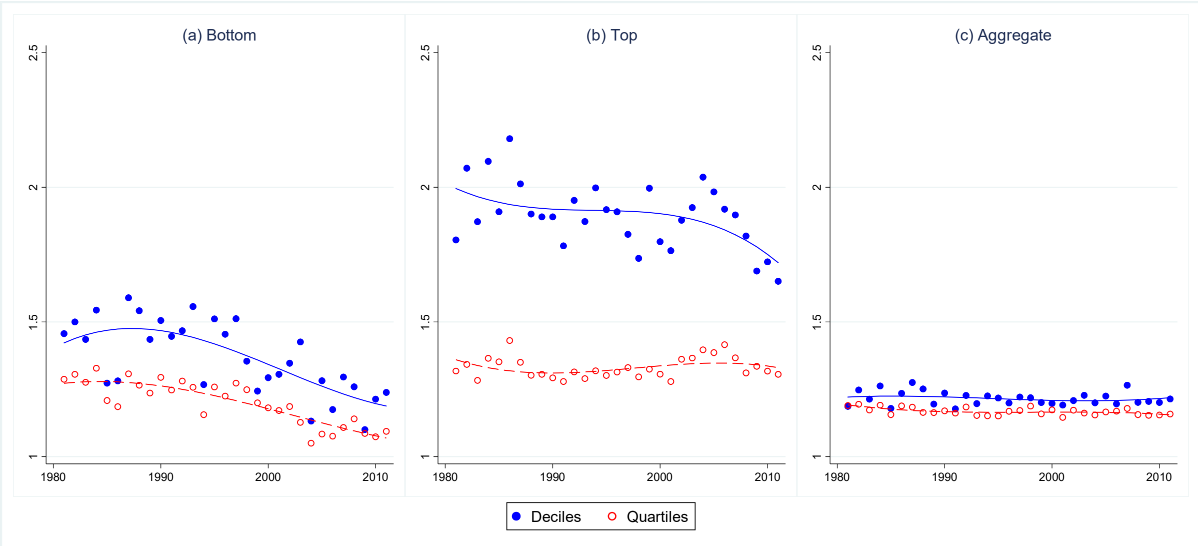

Figure A4. Assortative mating by social class, based on deciles and quartiles

Note: The graphs show assortative mating metrics computed from Equation (1) by birth-year of the couple's first child, based on classes grouped into deciles or quartiles. The bottom and top groups in panels (a) and (b) are the lowest/highest decile or quartile in the parental earnings distribution. The metrics reported in panel (c) are the weighted averages of the sorting parameters for all classes. Trend lines are estimated with local polynomial (second order) regressions.

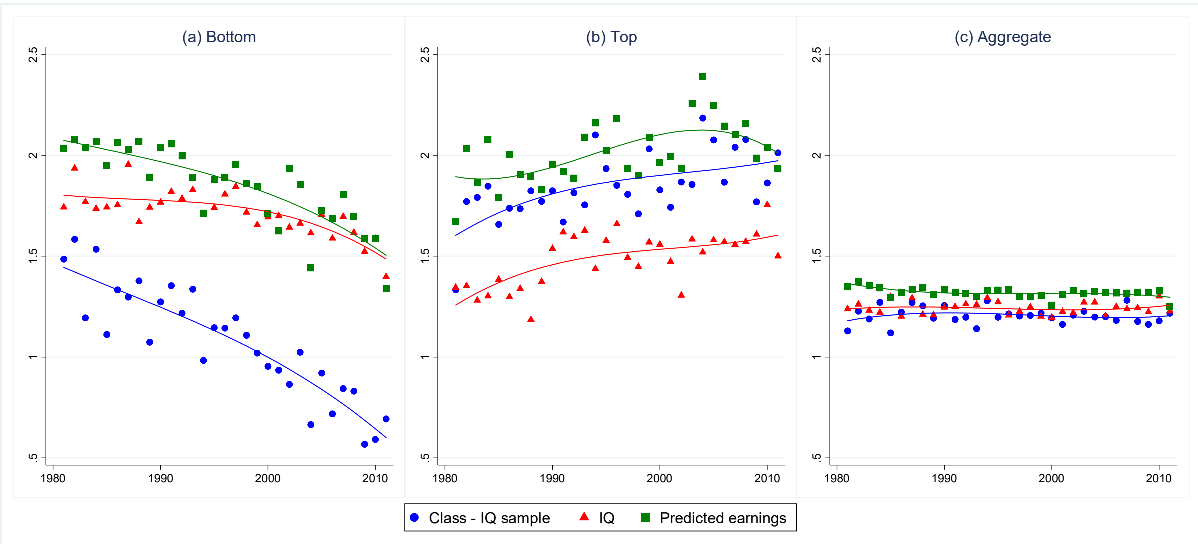

Figure A5. Assortative mating IQ and predicted earnings rank (deciles)

Note: The graphs show assortative mating metrics computed from Equation (1) by birth-year of the couple's first child, based on alternative ranking criteria. The bottom and top groups in panels (a) and (b) are the lowest/highest decile in the IQ and predicted earnings distributions. The metric reported in panel (c) is the weighted average of the sorting parameters for all classes (along the diagonal). Trend lines are estimated with local polynomial (second order) regressions.

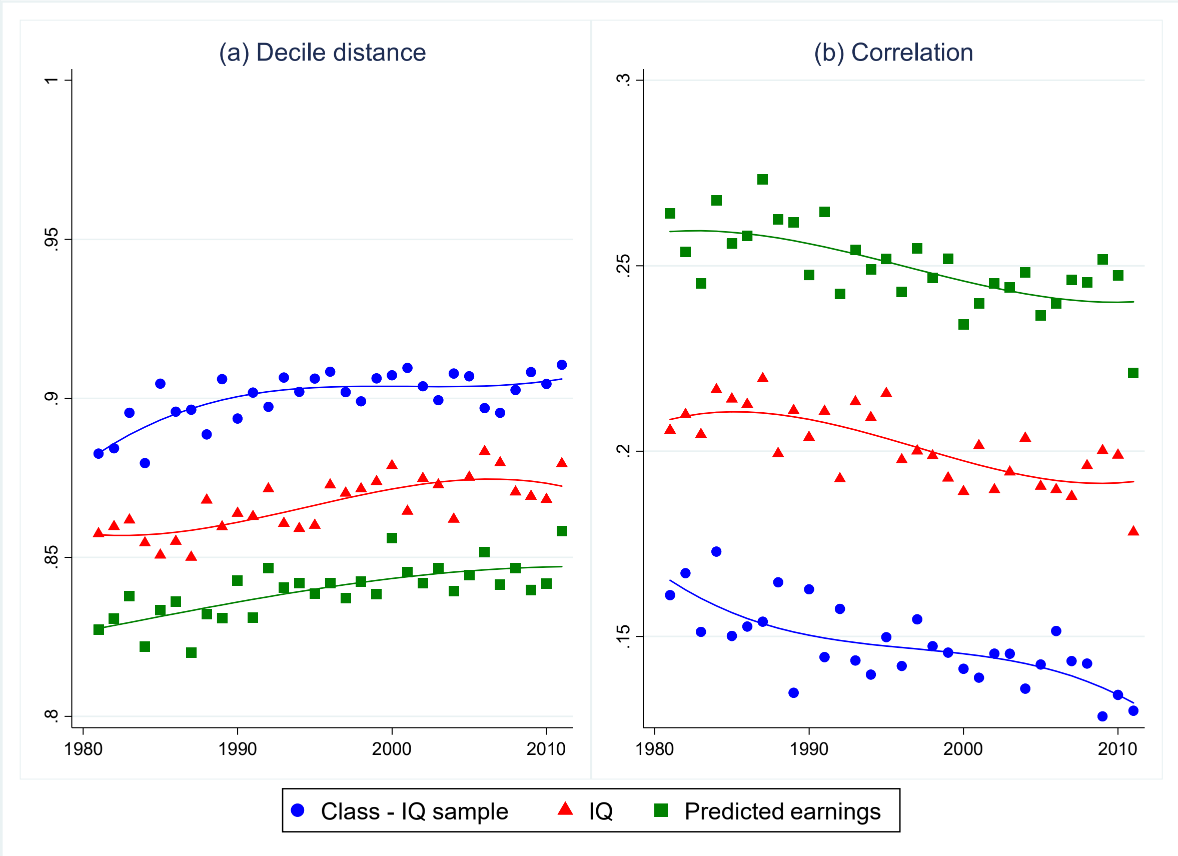

Figure A6. Absolute rank distance and rank correlation between new partners, based on IQ and predicted earnings.

Note: Panel (a) shows the average absolute distance in the ranks of new parents, relative to the expected distance under random matching, by birth-year of the couple's first child, based on alternative ranking criteria. Panel (b) shows the corresponding decile rank correlation coefficient. Trend lines are estimated with local polynomial (second order) regressions.

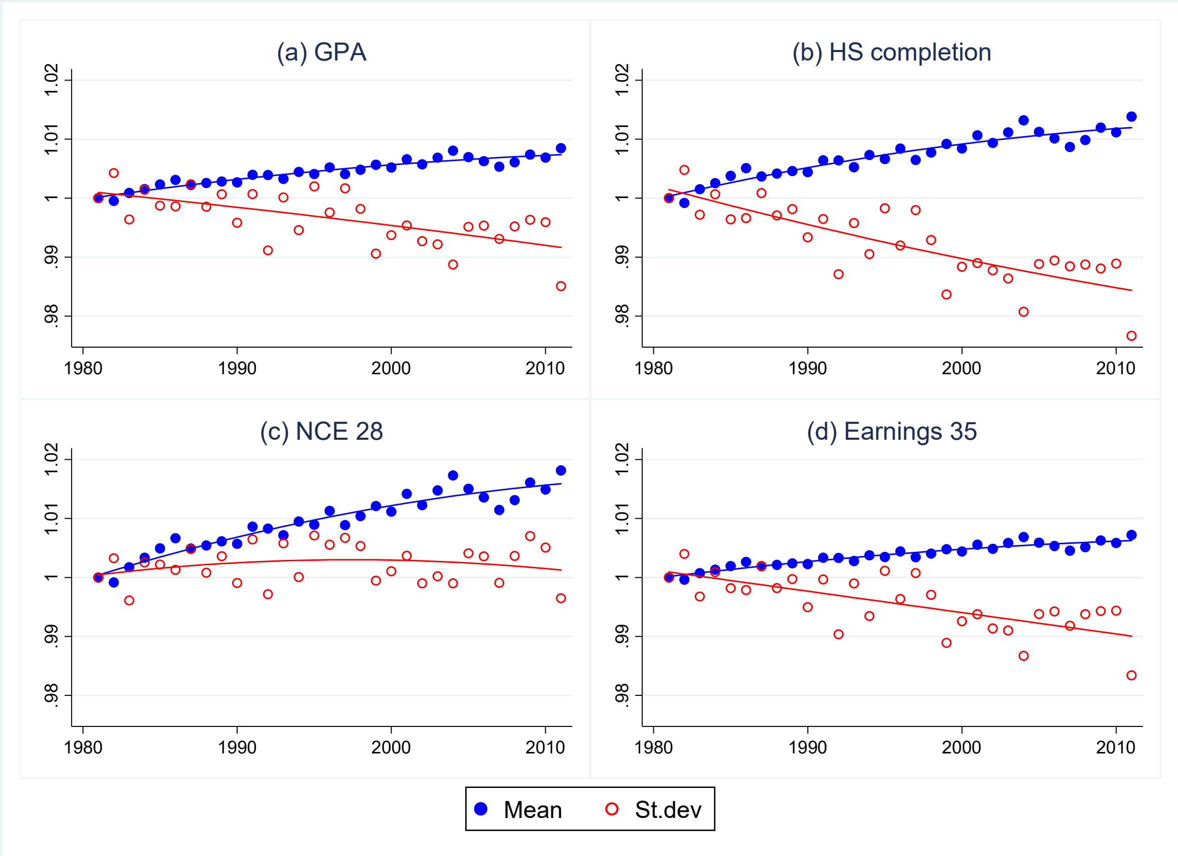

Figure A7. Trends in predicted offspring outcomes based on observed mating patterns and the production functions estimated with parental IQ ranks as inputs.

Note: The graphs show the means and standard deviations of predicted outcomes by birth-year, based on observed mating patterns. Data points are normalized to unity in 1981. Trend lines are estimated with local polynomial (second order) regressions.

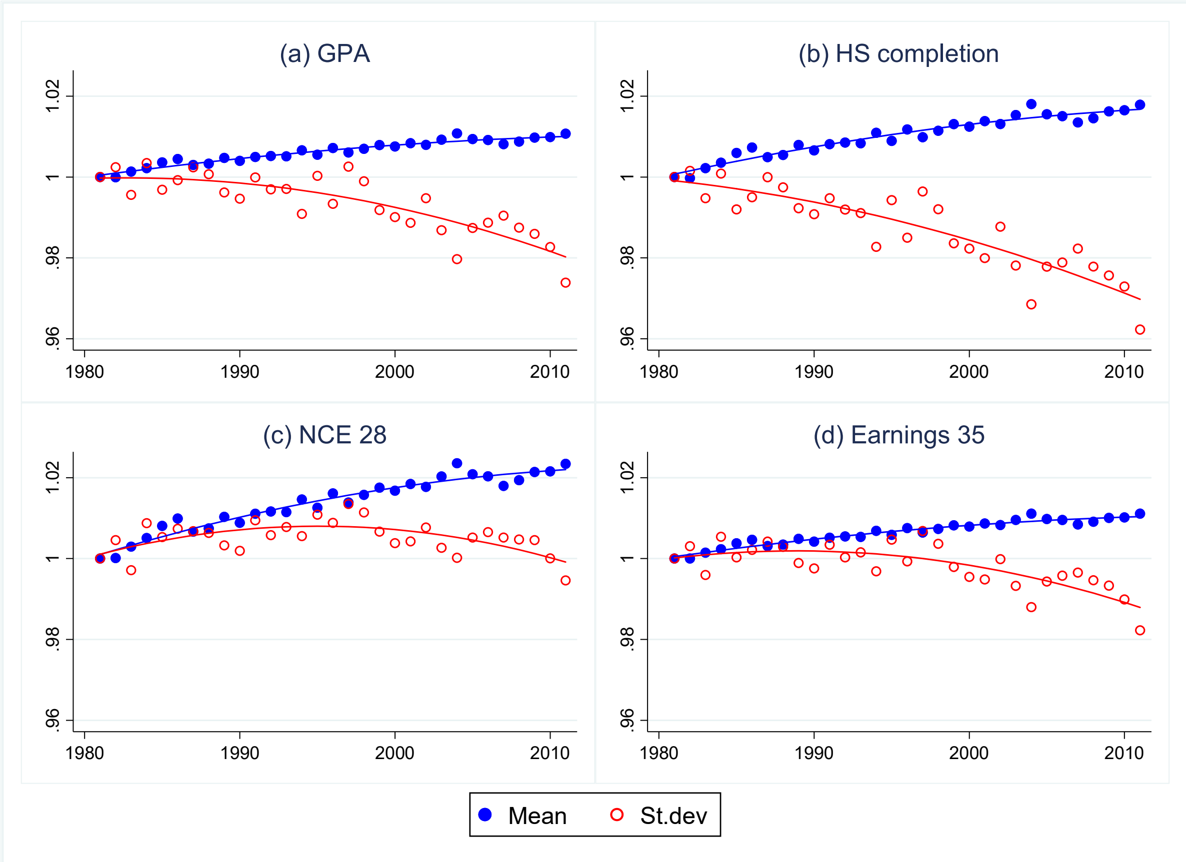

Figure A8. Trends in predicted offspring outcomes based on observed mating patterns and the production functions estimated with parental predicted earnings ranks as inputs.

Note: The graphs show the means and standard deviations of predicted outcomes by birth-year, based on observed mating patterns. Data points are normalized to unity in 1981. Trend lines are estimated with local polynomial (second order) regressions.

Table A1. Intergenerational human capital production technology based on parents' IQ class. OLS.

	GPA at age 16	High school completion by age 21	Years of schooling at age 28	Earnings at age 35
(a) regression coefficients				
$R_{mi}+R_{fi}$ (α_1)	0.0786	0.0345	0.1541	0.1160
	(0.0022)	(0.0011)	(0.0079)	(0.0185)
$(R_{mi}+R_{fi})^2$ (α_2)	-0.0021	-0.0012	-0.0028	-0.0033
	(0.0002)	(0.0001)	(0.0007)	(0.0016)
R_{mi} (α_3)	-0.0020^{ns}	-0.0011	-0.0112	-0.0079^{ns}
	(0.0010)	(0.0004)	(0.0037)	(0.0087)
$R_{mi}\times R_{fi}$ (α_4)	0.0035	0.0019	0.0093	0.0055^{ns}
	(0.0005)	(0.0003)	(0.0017)	(0.0040)
(b) Impact of assortative mating (Cov(R_{mi},R_{fi})) on average outcome				
$2\alpha_2+\alpha_4$	-0.0007	-0.0006	0.0037	0.0011^{ns}
	(0.0002)	(0.0001)	(0.0008)	(0.0020)
(c) Marginal effect of father´s human capital if				
$R_{mi}=R_{fi}=1$	0.0737	0.0316	0.1522	0.1083
$R_{mi}=R_{fi}=5$	0.0541	0.0200	0.1446	0.0775
$R_{mi}=R_{fi}=9$	0.0345	0.0084	0.1370	0.0467
Observations	262,536	255,497	130,965	47,503
R^2	0.0582	0.0574	0.1267	0.0183

Note: ns denotes non-significant at 5% level. Fixed effects: Offspring birth cohort, birth order, fathers birth cohort and mothers birth cohort.

Table A2. Intergenerational human capital production technology based on parents' predicted earnings class. OLS.

	GPA at age 16	High school completion by age 21	Years of schooling at age 28	Earnings at age 35
(a) regression coefficients				
R_{mi}+R_{fi} (α_1)	0.0884	0.0385	0.1438	0.1181
	(0.0021)	(0.0010)	(0.0778)	(0.0185)
$(R_{mi}+R_{fi})^2$ (α_2)	-0.0033	-0.0017	-0.0028	-0.0030^{ns}
	(0.0002)	(0.0001)	(0.0010)	(0.0016)
R_{mi} (α_3)	0.0010^{ns}	0.0009^{ns}	0.0038^{ns}	0.0020^{ns}
	(0.0010)	(0.0007)	(0.0054)	(0.0089)
$R_{mi}\times R_{fi}$ (α_4)	0.0063	0.0031	0.0100	0.0056^{ns}
	(0.0005)	(0.0002)	(0.0018)	(0.0043)
(b) Impact of assortative mating ($Cov(R_{mi},R_{fi})$) on average outcome				
$2\alpha_2 + \alpha_4$	-0.0003^{ns}	-0.0004	0.0043	-0.0004^{ns}
	(0.0002)	(0.0001)	(0.0009)	(0.0021)
(c) Marginal effect of father´s human capital if				
$R_{mi}=R_{fi}=1$	0.0815	0.0349	0.1426	0.1117
$R_{mi}=R_{fi}=5$	0.0539	0.0206	0.1378	0.0861
$R_{mi}=R_{fi}=9$	0.0263	0.0063	0.1330	0.0605
Observations	257,373	250,443	127,903	46,169
R^2	0.0650	0.0588	0.1268	0.0215

Note: ^{ns} means non-significant at 5% level. Fixed effects: Offspring birth cohort, birth order, fathers birth cohort and mothers birth cohort.

Table A3. Counterfactual mating among actual parents and predicted offspring outcomes. Based on IQ and predicted earnings rank

	GPA age 16		High school at age 21	Years of schooling at age 28		Predicted earnings at age 35	
Parental human capital	Mean	Std dev	Share	Mean	Std dev	Mean	Std dev
(a) IQ							
Observed	-0.02357	0.22731	0.70813	4.1902	0.61006	5.4230	0.31239
Counterfactuals:							
Random	-0.02243	0.20740	0.70905	4.1841	0.55594	5.4245	0.28521
Assortative	-0.02800	0.29340	0.70458	4.2142	0.78547	5.4160	0.40313
Disassortative	-0.01693	0.02926	0.71345	4.1543	0.08225	5.4336	0.04782
(b) Predicted earnings							
Observed	-0.00283	0.23180	0.70228	4.1874	0.62401	5.4552	0.38298
Counterfactuals:							
Random	-0.00223	0.20840	0.70309	4.1787	0.55858	5.4023	0.28581
Assortative	-0.00461	0.29444	0.69996	4.2134	0.78732	5.4531	0.48494
Disassortative	0.00015	0.04663	0.70632	4.1440	0.08342	5.4588	0.04850

Note: With perfectly assortative mating $Corr(R_{mi},R_{fi})\approx 1$, with perfectly disassortative mating $Corr(R_{mi},R_{fi})\approx -1$.