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Barbara S. Grave
Christoph M. Schmidt

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Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

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Barbara S. Grave and Christoph M. Schmidt[1]

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Abstract

This paper examines the patterns of educational assortative mating in East and West Germany. In the literature it is well known that individuals do not mate randomly with respect to social and cultural traits, and that highly assortative mating can lead to polarization and exacerbate economic inequality. For Germany, little is known about actual patterns of marriage formation along educational lines. Our empirical analysis for Germany shows that educational assortative mating has increased significantly for East and West Germany during the last 15 and 30 years, respectively. To control for secular increases in educational attainment we apply different log-linear methods, leading to the conclusion that the observed changes in assortative mating in East and West Germany might be explained by changes in partner preferences. Especially within the group of low educated persons, the preferences for a homogamous partnership seems to have increased over time.

JEL Classification: I20, J12

Keywords: Assortative marriage; Microcensus; education; log-linear models

June 2012

1 *Barbara S. Grave, RWI; Christoph M. Schmidt, RWI, Ruhr-Universität Bochum, IZA Bonn, CEPR London.* – *We are grateful to Thomas Bauer, Katja Görlitz and Marcus Tamm for helpful comments and suggestions.* - *All remaining errors are our own.* – *All correspondence to Barbara S. Grave, RWI, Hohenzollernstr. 1–3, 45128 Essen, Germany, E-Mail: barbara.grave@rwi-essen.de.*

1 Introduction

In any country, overall economic and social inequality is the consequence of individual heterogeneity in education and other aspects of economic success, but also of the patterns of family formation and dissolution. Individuals tend to mate within their own social group, thereby reinforcing individual economic inequalities. Furthermore, the patterns of mating behavior, e.g. with respect to education, religion, ethnicity or occupation, can be seen as an indicator for the grade of openness of a society. Marriage between different groups (heterogamous marriages) open up the opportunity for cultural and socioeconomic change (Kalmijn, 1998). By contrast, getting married with a person who shares the same kind of advantageous (or disadvantageous) resources (homogamous marriages) tends to lead to polarization and thus to the reinforcement of social inequality.

In this context, educational matching of partners plays a special role because of the high relevance of education for occupational success and income (Shavit and Müller, 1998). It has been noted frequently that educational assortative mating tends to exacerbate income inequality in the population and it is likely to perpetuate social positions across generations (e.g. Fernández and Rogerson, 2001; Kalmijn, 1991a,b; Mare, 1991; Qian, 1998; Qian and Preston, 1993; Smits et al., 1998; Ultee and Luijkx, 1990).

In the United States, a comprehensive body of evidence demonstrates that the educational resemblance of spouses has steadily increased during the at least last four decades (e.g. Kalmijn, 1991a,b; Mare, 1991; Pencavel, 1998; Qian and Preston, 1993; Smits et al., 2000; Schwartz and Mare, 2005). Schwartz and Mare (2005), for instance, document strong trends in educational assortative mating between 1960 and 2003, in particular among college graduates, using a variety of data sources. They argue that the rising educational homogamy is a result of the decreasing intermarriage between the groups at both ends of the educational distribution.

One of the principal factors behind the observed trends in the US is the general rise of educational attainment, especially among women. On the one hand, due to this increase highly educated women are more prevalent on the marriage market. On the other hand, since institutions serve as important marriage markets, the remarkable expansion of education that women in all developed economies have experienced during previous decades has led a larger fraction of college graduates to marry other college graduates (e.g. Kalmijn, 1991a; Schwartz and Mare, 2005). Moreover, returns to education have steadily increased over time throughout the OECD, making education and, thus, earnings capacity potentially a more important trait in marriage formation. By contrast to traditional gender roles, nowadays women are also

expected to be breadwinners and hence, their human capital has become more relevant for the partner choice process.

These arguments would support the expectation that countries other than the US may have experienced similar trends towards stronger educational resemblance of spouses. Therefore it is interesting to speculate about the prevalence of the phenomenon in other societies. Yet, little is known about actual patterns of educational assortative mating in other countries, not least because of limited data availability. However, there is some evidence for countries other than the US. For Spain, Norway, and Britain there is even evidence of a decreasing trend in educational resemblance of spouses (Birkelund and Heldal, 2003; Esteve and Cortina, 2006; Chan, 2004). Smits et al. (1998) investigate educational homogamy in a mixed-country pattern. They conclude that educational homogamy is related to the level of economic development and document that the effect of industrialization on educational homogamy follows an inverted U-curve.

While successive waves of census data are available in the US, for Germany it will be quite difficult to construct a time series of marriage patterns from micro data. Thus, existing German evidence concentrated on comparisons of assortative mating of age groups. Wirth (1996) uses the German Microcensus 1991 to analyze the pattern of assortative mating in West German for different birth cohorts and does find evidence for changes in preferences of partners. She suggests that the increasing homogamy of spouses is the result of changes in educational attainment. Blossfeld and Timm (1997) also look at different birth cohorts, using SOEP data from 1984 to 1994, confirming that the homogamy of West German spouses has increased over time. They emphasize that educational institutions have become a more relevant marriage market, especially for the highly educated, raising the chances for the formation of homogamous marriages.

But the assessment of any trends in the educational resemblance of spouses must be conducted in the presence of other important developments that preclude a clear view on the phenomenon. Most importantly, as educational attainment among women has risen rapidly, the effect of this change in the marginal distribution of education needs to be isolated from genuine shifts in the assortative nature of marriage. Additionally, important changes to the institution of marriage itself have created yet another analytical obstacle, since many individuals now marry later in their lives or never.[2] Empirical evidence points out that the later in lifetime the marriage occurs and hence, the greater the time gap between school leaving and

[2]While in 1975 the average age at the first marriage was in West Germany 25.3 years for men and 22.7 years for women and in East Germany 23.7 years for men and 21.8 years for women, it increased until 2005 to 32.6 years for men and 29.6 years for women (Statistisches Bundesamt, 2008).

marriage, the smaller are the chances of homogamous marriages (e.g. Mare, 1991; Blossfeld and Timm, 1997). Clearly, the pool of potential partners inside educational institutions is more homogamous than the reservoir to be found outside. Furthermore, many couples nowadays choose cohabitation instead of marriage as their preferred mode of family formation (e.g. Nazio and Blossfeld, 2003; Ostner, 2001).

This paper utilizes 17 waves of the German Microcensus to construct a time series of educational resemblance in marriages for the period 1991 to 2005 for East Germany and 1976 to 2005 for West Germany, respectively. This descriptive research documents a substantially higher level of homogamy in East Germany than in West Germany, and a remarkable rise of the share of homogamous marriages in West Germany over the course of the last three and a half decades. Using a range of log-linear models we also demonstrate these secular changes to be a consequence of the alterations experienced in the education system, as female educational achievements have expanded tremendously.

The study is restricted to the analysis of intermarriages between native Germans, deferring the analysis of intermarriages between native Germans and immigrants to further contributions. Similarly, the assessment of the distorting effects of cohabitation as a rising phenomenon and the stability of marriages are not the object of this study. To allow for direct comparability with the literature on the US, we concentrate on marriages in which the wife is 18 to 40 years old, regardless of marriage parity of either partner. We augment this portrait by an analysis of the educational resemblance of marriages where the wife is 41 to 60 and 61 to 80 years old, respectively. Our results therefore allow both the characterization of the trend in the population of reproductive age and a discussion of age-group effects in mating behavior.

The contribution is organized as follows. Section 2 describes the data and the methods used in this analysis. Section 3 documents the descriptive statistics characterizing our data, and section 4 presents the results of the estimation of log-linear models tailored to the analysis of evolving marriage homogamy. Finally, section 5 discusses the implications of these findings.

2 Data and methods

This section briefly describes the data base employed and the methods of analysis brought to bear on the data. The data set used is the German Microcensus from 1976 to 2005. Due to the importance of the availability of information about the educational degree our sample is drawn from the years 1976, 1978, 1982, 1989, 1991, 1993 and 1995 to 2005 of the German

Microcensus.[3] Hence, the relevant data base comprises 17 waves for West Germany and 13 waves for East Germany. In order to analyze trends in assortative mating behavior in Germany adequately, a distinction between East and West Germany is essential. The reason is the difference in the education system in both parts of Germany before reunification. The East German system was promoting the combination of educational investment and family formation and, correspondingly, the level of educational attainment of women was much higher than it was in the West. It is to be expected that at least some of these differences are reflected in distinct marriage patterns.

In the German Microcensus educational attainment is measured in terms of last secondary school degree and last post-secondary training or tertiary programm completed. We distinguish three categories of educational level, namely high, medium and low education. The category "high" comprises individuals at the most successful end of the educational spectrum, i.e. graduates of universities and technical colleges, while men and women with any other completed post-secondary training form the category "medium". This latter group mainly comprises graduates of vocational training programs which contain a large practical, company-based element. Also included in this group are those individuals who graduate from the highest tier of post-secondary education, the Gymnasium, with an entry certificate for college education, the Abitur, but who did not complete a post-secondary training program of any kind. A third group of people comprises all other individuals (category "low").

The starting point of our analysis are marginal and joint probabilities. Denote the probability that any marriage observed in period t ($t = 1976, \ldots, 2005$ for West Germany and $t = 1991, \ldots, 2005$ for East Germany) is between a wife in education category i ($i = 1, 2, 3$) and a husband in education category j ($j = 1, 2, 3$) as p_{ijt}. The corresponding marginal probability (conditional on being married) is defined as $p_{i.t}$ for wives and $p_{.jt}$ for husbands, respectively. For any period t one could form the following cross-table:

Table 1: Marginal and joint probabilities

	husbands' education			
wives' education	p_{11t}	p_{12t}	p_{13t}	$p_{1.t}$
	p_{21t}	p_{22t}	p_{23t}	$p_{2.t}$
	p_{31t}	p_{32t}	p_{23t}	$p_{3.t}$
	$p_{.1t}$	$p_{.2t}$	$p_{.3t}$	1

If education were not to play any role for mating behavior, then the joint probability p_{ijt}

[3] We use the Microcensus Scientific Use File which is an anonymized 70 percent subsample of the original Microcensus.

would simply be the product of the corresponding marginal probabilities, i.e. $p_{ijt} = p_{i.t} \cdot p_{.jt}$. This will hardly be the pattern observed in reality, though. One would rather expect the probability mass being concentrated along the diagonal. The highest attainable correspondence would be reached for $p_{llt} = min\{p_{l.t}, p_{.lt}\} \forall l$. Thus a high share of same-education marriages (i.e. entries on the diagonal) requires relatively similar marginal distributions of educational attainment. If, for instance, all men were college graduates and all women were in the medium education category, all entries on the diagonal would be zero.

In consequence, as female educational attainment has gradually approached the distribution of male educational attainment, the chances for educational resemblance of spouses have increased, even if the preference for same-education partners had been stable over time. Thus, when documenting changes in educational assortative mating, an increase of entries on the diagonal of these sorting cross-tables would not be sufficient to support the conclusion that preferences for homogamous marriages have increased. Rather, it would be important to isolate changes in the marginal distribution of educational attainment from genuine shifts in mating behavior.

A prominent way to condense the entries of cross-tables into a parsimonious representation is the log-linear model for contingency tables (e.g. Agresti, 2002). In the present context, main effects capture the baseline marginal distribution of educational achievements, and interaction effects reflect both assortative mating behavior and changes in the marginal distributions of educational attainment over time. Hence, log-linear models provide estimates of changes in the association between couples' educational characteristics while controlling for changes in their marginal distributions. To model different trends in assortative mating behavior we closely follow Schwartz and Mare (2005) and use homogamy and crossing models. Homogamy models allow for changes in the preferences for homogamous marriages in terms of a single parameter representing the odds that both spouses share the same educational level. Utilizing a different parameterization, the crossing models provide estimates of changes in the difficulty of intermarriages between different education groups where the additionally specified parameters capture the permeability of boundaries between adjacent education groups.

In order to analyze whether the trends in homogamous marriages are only due to the increased educational attainment or whether they are due to changed preferences or changes in the difficulty of crossing educational barriers, we start with a baseline model that does not allow for any (shifts in) assortative mating behavior, but exclusively controls for changes in the marginal distribution of husbands' and wives' education over time. We then compare this baseline model to different extended models that allow for deviations from independene between spouses' education. More precisely, in a first deviation we assume a time-stable

association between husband's and wife's education that is allowed to be different for each combination of husband's and wife's education (association model). In a second deviation, we restrict the association to be concentrated on the main diagonal, i.e. if both spouses have the same education (homogamy model). Finally, in a third extension, we assume that there exists an association for entries other than on the main diagonal, i.e. for spouses with different educational background (crossing models).

The baseline model pertaining to the absolute frequencies μ_{ijt} of different types of marriage in the sample observed at time t can be represented by the following equation:

$$\log(\mu_{ijt}) = \lambda + \lambda_i + \lambda_j + \lambda_t + \lambda_{it} + \lambda_{jt} + \varepsilon_{ijt} \tag{1}$$

In addition to the overall constant, the two main effects λ_i and λ_j account for the marginal distributions of wives' and husbands' educational distribution in the baseline period, with two entries, respectively, while the two-way interaction parameters λ_{it} and λ_{jt} capture the changing marginal distribution over time ($2 \times 16 = 32$ entries each). The main effect λ_t represents varying sample size over time, with 16 entries for West Germany and 12 for East Germany. Finally, the $(3 \times 3 \times t)$ terms ε_{ijt} are the random error terms of the model.

The first extension of the baseline model, the association model, permits a deviation from complete independence between husband's and wife's education. This is parameterized by the two-way interaction parameter λ_{ij}. Therefore the $(2 \times 2) = 4$ entries of λ_{ij} reflect assortative (or any other pattern of) mating behavior under the assumption of time-stable behavior.

$$\log(\mu_{ijt}) = baseline\,model + \lambda_{ij} + \varepsilon_{ijt} \tag{2}$$

The second deviation, the homogamy model, allows for the presence of changes in assortative mating behavior by adding a diagonal term, interacted with time.

$$\log(\mu_{ijt}) = baseline\,model + \tilde{\delta}_{ijt} \qquad \text{where} \quad \tilde{\delta}_{ijt} = \begin{cases} \delta_{ijt}, & \text{for i = j;} \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

where the three-way interaction δ_{ijt} captures trends in assortative mating across the different educational categories. These terms are particularly well-designed to represent individuals' preferences and opportunities for assortative mating. We assume that the trends towards homogamy are different for the three educational groups ($\delta_{11t} \neq \delta_{22t} \neq \delta_{33t}$). For the sake of completeness, we also allow the homogamy parameter to be time-stable by including δ_{ij} instead of δ_{ijt} in equation (3). We refer to this model as the constant homogamy model. Furthermore,

we also test whether the homogamy parameter is similar for the three educational groups, i.e. $\delta_{11} = \delta_{22} = \delta_{33}$ and $\delta_{11t} = \delta_{22t} = \delta_{33t}$, respectively (uniform constant homogamy model and uniform homogamy model).

The third deviation from the baseline model is the crossing model (Johnson, 1980; Powers and Xie, 2000). This model incorporates the idea that there are educational boundaries, and that it might be more difficult to cross these barriers, if the educational endowments of the two potential partners differ more severely.

$$\log(\mu_{ijt}) = baseline\,model + \gamma_{ijt}, \qquad \text{where} \quad \gamma_{ijt} = \begin{cases} \sum_{q=1}^{i-1} \gamma_{qt}, & \text{for i} > \text{j;} \\ \sum_{q=1}^{j-1} \gamma_{qt}, & \text{for i} < \text{j;} \\ 0, & \text{for i=j.} \end{cases} \tag{4}$$

Consequently, the term γ_{ijt} represents the change in the difficulty of crossing educational barrier q in year t relative to the baseline year, i.e. 1976 for West Germany and 1991 for East Germany, and the odds of crossing educational barriers. Again, for the sake of completeness, we assume the crossing parameter to be stable over time by incorporating γ_{ij} instead of γ_{ijt} in equation (4) (Constant crossing model). In both these specifications we assume that the odds of crossing educational barriers are symmetric by gender (Table 2). The odds for crossing more than one educational barrier are calculated by summarizing the crossing parameters for each barrier crossed (Johnson, 1980; Powers and Xie, 2000).

Table 2: Parameters for time varying crossing effects

wife's education	husband's education		
	low	medium	high
low	0	γ_{1t}	$\gamma_{1t} + \gamma_{2t}$
medium	γ_{1t}	0	γ_{1t}
high	$\gamma_{1t} + \gamma_{2t}$	γ_{1t}	0

Finally, in our analysis, we distinguish between three different age groups, namely young, middle and old couples. The first age group (young) comprises couples with wives aged between 18 and 40 years, the middle age group contains all those couples with wives aged between 41 and 60 years, and the oldest age group includes all those couples with wives aged between 61 and 80 years.

3 Descriptive statistics

Table 3 provides a first impression of educational trends in West Germany, displaying the distribution of husbands and wives education for West German couples with wives aged between 18 to 40 years, between 41 to 60 and between 61 to 80 years, respectively. This table reveals the well-know increases in educational attainment in West Germany during the last decades, especially for women. West German women experienced a remarkable increase in the medium education category, narrowing the gender gap in educational achievement tremendously. Correspondingly, between 1976 and 2005, for all age groups, the percentage of wives with a university or technical college degree increased significantly. For husbands, we also observe an increase, but compared to the increases for wives it is much smaller. This rise in educational qualification is accompanied by a markable decrease in the shares of spouses who did not complete any post-secondary training programm (low education). Even though this decrease is more pronounced for wives, as recently as in 2005 we still observe a markable difference in the educational qualification of husbands and wives.

For East Germany, the picture looks different (Table 4). Due to the different educational policies before reunification, East German women basically display the same educational achievements as men throughout the observation period. In consequence, in the East the proportion of low educated spouses was lower and that of high educated spouses was higher than in the West. While for the age groups 41 to 60 years and 61 to 80 years a decrease in the shares of low-educated spouses and an increase in those of high-educated spouses is observable over time, this is not the case for the youngest age group (18 to 40 years). For this age group, by contrast, the share of low-educated husbands and wives increased while the proportion or spouses with university of technical college degree decreased slightly. However, in 2005, at least for wives, the proportion of highly educated spouses is still higher in East Germany than in West Germany.

Trends in the share of homogamous marriages are depicted in Figure 1 for all three age groups and for East and West Germany, respectively. Especially in West Germany, the two younger age groups display an increase in homogamy. While for the youngest age group the proportion of homogamous marriages increased significantly from 56% in 1976 to 65% in 2005, for wives aged between 41 and 60 years the rise was even more pronounced, from 48% to 62%. For the oldest age group, the proportion of homogamous marriages remained roughly stable at 50%. Overall, the proportion of homogamous marriages is higher in East Germany. For all age groups the proportion of homogamous marriages increased significantly between 1991 and 2005. In the youngest age group, this share rose only slightly from 69% to 72%. The

Table 3: Distribution of husband's and wife's education in West Germany, by age group

wives' education	Husbands' education											
	(Wives aged 18-40 years)				(Wives aged 41-60 years)				(Wives aged 61-80 years)			
	low	medium	high	total	low	medium	high	total	low	medium	high	total
1976												
low	9.83	20.90	4.32	**35.04**	18.88	32.47	6.48	**57.83**	27.60	35.24	7.96	**70.81**
medium	3.96	41.67	12.80	**58.44**	3.62	26.77	8.25	**38.64**	2.48	18.76	5.67	**26.91**
high	0.24	1.26	5.02	**6.52**	0.21	0.76	2.56	**3.53**	0.26	0.51	1.51	**2.28**
total	**14.03**	**63.83**	**22.14**	**100**	**22.70**	**60.00**	**17.30**	**100**	**30.35**	**54.51**	**15.14**	**100**
1982												
low	6.30	16.15	3.53	**25.99**	16.61	30.96	6.05	**53.61**	22.61	35.52	7.69	**65.82**
medium	3.89	45.38	15.09	**64.36**	3.42	28.18	10.22	**41.81**	2.65	22.02	6.77	**31.44**
high	0.25	1.87	7.53	**9.65**	0.19	0.90	3.48	**4.57**	0.23	0.57	1.94	**2.74**
total	**10.44**	**63.41**	**26.16**	**100**	**20.22**	**60.04**	**19.74**	**100**	**25.49**	**58.12**	**16.39**	**100**
1991												
low	3.63	10.47	2.05	**16.16**	8.79	21.48	5.25	**35.52**	16.36	32.23	6.83	**55.42**
medium	3.07	49.67	17.74	**70.48**	2.74	36.35	17.02	**56.12**	2.65	27.60	9.85	**40.10**
high	0.20	3.14	10.02	**13.36**	0.15	1.24	6.97	**8.36**	0.09	0.88	3.51	**4.48**
total	**6.90**	**63.28**	**29.81**	**100**	**11.68**	**59.07**	**29.24**	**100**	**19.09**	**60.72**	**20.19**	**100**
1995												
low	3.41	9.04	1.71	**14.16**	7.04	17.04	4.38	**28.46**	15.11	31.23	6.31	**52.66**
medium	2.89	49.82	18.70	**71.40**	2.85	40.04	17.88	**60.78**	2.84	30.40	10.18	**43.42**
high	0.27	3.49	10.69	**14.44**	0.20	1.73	8.84	**10.76**	0.19	0.74	2.99	**3.92**
total	**6.56**	**62.35**	**31.09**	**100**	**10.09**	**58.82**	**31.10**	**100**	**18.14**	**62.37**	**19.49**	**100**
2000												
low	4.02	7.25	1.49	**12.75**	6.05	13.12	3.80	**22.97**	16.01	28.64	6.52	**51.16**
medium	2.51	48.17	19.57	**70.24**	2.29	42.06	18.58	**62.92**	2.20	30.39	11.29	**43.89**
high	0.28	4.09	12.64	**17.00**	0.19	2.73	11.18	**14.11**	0.12	0.85	3.98	**4.95**
total	**6.80**	**59.51**	**33.70**	**100**	**8.53**	**57.91**	**33.56**	**100**	**18.33**	**59.89**	**21.79**	**100**
2005												
low	4.56	6.51	1.43	**12.50**	5.36	10.68	2.82	**18.86**	13.10	26.38	6.19	**45.66**
medium	2.85	47.30	18.85	**68.99**	2.74	43.79	18.38	**64.90**	2.49	31.01	14.28	**47.78**
high	0.29	4.67	13.55	**18.51**	0.23	3.40	12.61	**16.23**	0.15	1.12	5.27	**6.55**
total	**7.70**	**58.47**	**33.83**	**100**	**8.33**	**57.87**	**33.80**	**100**	**15.74**	**58.51**	**25.74**	**100**

Notes: Number of observations for age group 18-40: 440,752, for age group 41-60: 591,978 and for age group 61-80: 310,982.
Source: German Microcensus.

Table 4: Distribution of husband's and wife's education in East Germany, by age group

wives' education	Husbands' education											
	(Wives aged 18-40 years)				(Wives aged 41-60 years)				(Wives aged 61-80 years)			
	low	medium	high	total	low	medium	high	total	low	medium	high	total
1991												
low	1.07	2.05	0.60	**3.72**	3.14	7.99	3.05	**14.18**	7.69	20.52	8.76	**36.97**
medium	1.00	49.40	11.94	**62.35**	1.78	38.55	21.48	**61.81**	2.06	33.92	17.78	**53.76**
high	0.42	14.71	18.80	**33.93**	0.50	6.32	17.19	**24.01**	0.37	2.32	6.59	**9.27**
total	**2.49**	**66.16**	**31.35**	**100**	**5.42**	**52.86**	**41.72**	**100**	**10.12**	**56.76**	**33.13**	**100**
1995												
low	0.82	1.99	0.36	**3.18**	2.18	6.01	2.00	**10.19**	6.87	17.62	6.24	**30.73**
medium	0.82	51.39	11.66	**63.87**	1.57	41.84	19.41	**62.83**	2.51	35.86	20.75	**59.12**
high	0.36	14.64	17.95	**32.95**	0.23	7.26	19.50	**26.98**	0.33	2.16	7.67	**10.15**
total	**2.01**	**68.01**	**29.98**	**100**	**3.98**	**55.11**	**40.91**	**100**	**9.70**	**55.64**	**34.66**	**100**
2000												
low	1.34	2.11	0.43	**3.88**	1.95	4.03	1.30	**7.28**	7.29	16.12	5.48	**28.89**
medium	1.06	52.65	10.43	**64.14**	1.13	42.76	16.94	**60.84**	1.75	35.91	19.43	**57.09**
high	0.45	13.72	17.82	**31.99**	0.25	9.26	22.37	**31.88**	0.23	3.25	10.54	**14.02**
total	**2.84**	**68.48**	**28.68**	**100**	**3.33**	**56.06**	**40.61**	**100**	**9.27**	**55.28**	**35.45**	**100**
2005												
low	2.00	2.21	0.42	**4.63**	2.32	2.45	0.83	**5.60**	5.59	12.57	4.06	**22.22**
medium	0.94	52.18	10.41	**63.52**	1.08	44.16	15.33	**60.58**	2.01	34.98	21.36	**58.35**
high	0.60	13.91	17.33	**31.85**	0.36	12.00	21.46	**33.82**	0.25	4.27	14.90	**19.43**
total	**3.54**	**68.30**	**28.16**	**100**	**3.77**	**58.61**	**37.62**	**100**	**7.85**	**51.83**	**40.32**	**100**

Notes: Number of observations for age group 18-40: 73,572, for age group 41-60: 115,193 and for age group 61-80: 61,314.
Source: German Microcensus.

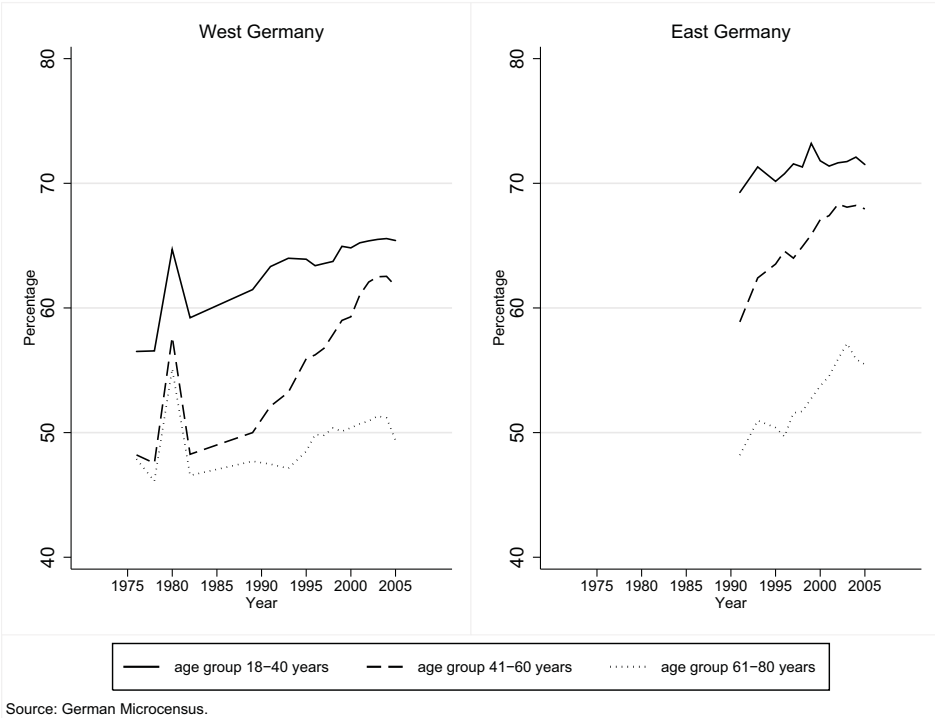
increases were higher from 59% to 68% in the middle age group and from 49% to 56% in the oldest age group.

These contrasts between East and West German women and across waves should be interpreted with caution, since they reflect quite different marginal distribution of husbands' and wives' education. Differences in educational attainment influence the prevalence of homogamous marriages, since the propensity of meeting an educationally similar potential partner is affected by a number of reasons. Therefore, the respective environment in terms of educational attainment is controlled for by using log-linear models in the next section.

4 Results

To decide which of the models described in section 2 fits the data best we follow the literature by using the Bayesian information criterion (BIC) and the deviance G_2 (see e.g. Agresti, 2002). Lower values of both the test statistics indicate a better model fit. The results are depicted in Table A1 in the Appendix. For West German young and middle age couples, the homogamy model (equation (3) and model (6) in Table A1) is most suitable to capture the pattern found in the data. However, for the oldest West German spouses the picture is less clear. Depending

Figure 1: Proportion of homogamous marriages for East and West German couples, by age group



on which of the test statistics is used, either the association model (equation (2) and model (2) in Table A1) or the homogamy model (equation (3) and model (6) in Table A1) provides the best fit to the data. For the crossing models (equation (4) and models (7) and (8) in Table A1), both the test statistics indicate that these models fit the data poorly.

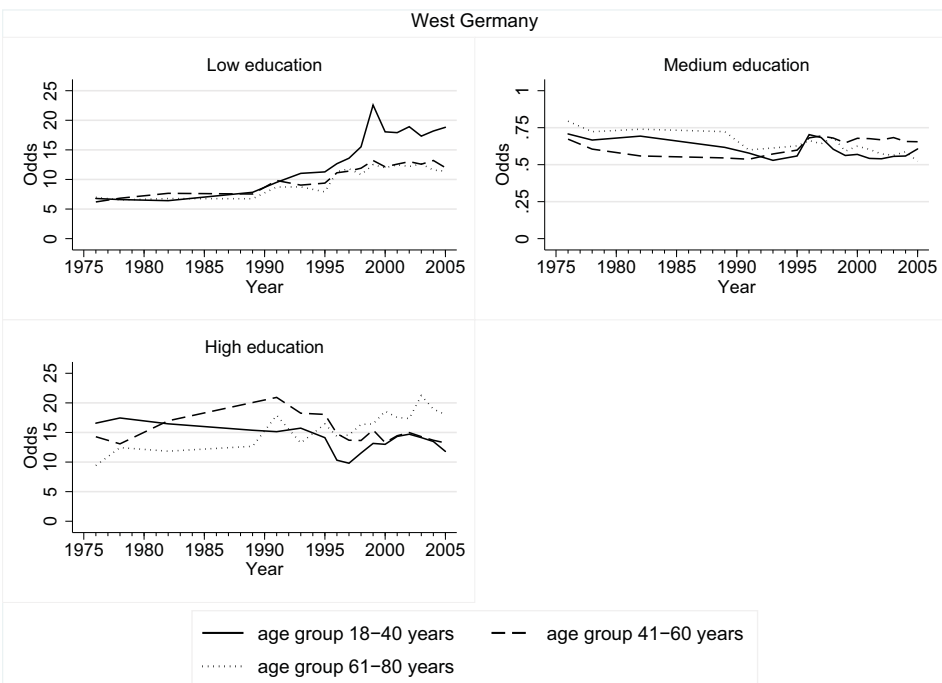
Hence, in the following, we only present the results for the homogamy model for all three West German age groups. Figure 2 shows the odds of homogamy for young, middle and old age West Germany couples, derived from the estimated homogamy model (equation (3)). Table A3 in the Appendix reports the estimated parameters underlying these illustrations. The results for the three educational groups are displayed separately, as in our preferred specification for each entry on the diagonal a distinct parameter is estimated. In general, a value of 1 means that the likelihood to marry homogamously equals the likelihood to marry heterogamously. Values that are smaller than 1 represent lower odds and values above 1 accordingly higher odds of marrying homogamously.

In 1976, among the young couples, there was a strong tendency for low educated persons to marry each other in West Germany. More precisely, within this group it was about 6 times

as likely to marry homogamously as to marry heterogamously. Until 2005, this tendency has almost tripled. For spouses belonging to either the age group 41 to 60 years or 61 to 80 years, similar patterns are found, even though the increase over time is much less pronounced. Regarding the spouses with university or technical college degree (high education), the odds of homogamy are comparatively high in 1976. While for the youngest age group the odds dropped from 17 in 1976 to 12 in 2005, they stayed relatively stable for the middle age group. For them it is about 14 times as likely to marry within their educational group than outside their group. For the oldest couples, the odds were smaller in 1976 (odds of 9) but doubled over time.

For the middle educational group, it is less likely to marry homogamously. For all three age groups, the odds are persistently below 1. For the youngest and oldest couples the odds decreased over time meaning that it became even less likely to marry homogamous. The low values within this education category compared to the other two groups tend to reflect the fact that this education group forms the middle category and the spouses belonging to this group can marry upward and downward. By contrast, spouses belonging to the low or the high education group can only either marry upward or marry downward.

Figure 2: Odds of homogamy in West Germany, by age group



When looking at the results for East German couples, the test statistics do not provide such a clear picture. As for the old West German couples, both the association model (equation (2) and model (2) in Table A1) and the homogamy model (equation (3) and model (6) in Table A1) fit the data best. Again, the hypotheses of the crossing models on the association between spouse's education are rejected by the test statistics (models (7) and (8) in Table A1). Hence, in the following, we apply the same reasoning as for West German couples and present the results obtained by the homogamy model estimated from equation (3).

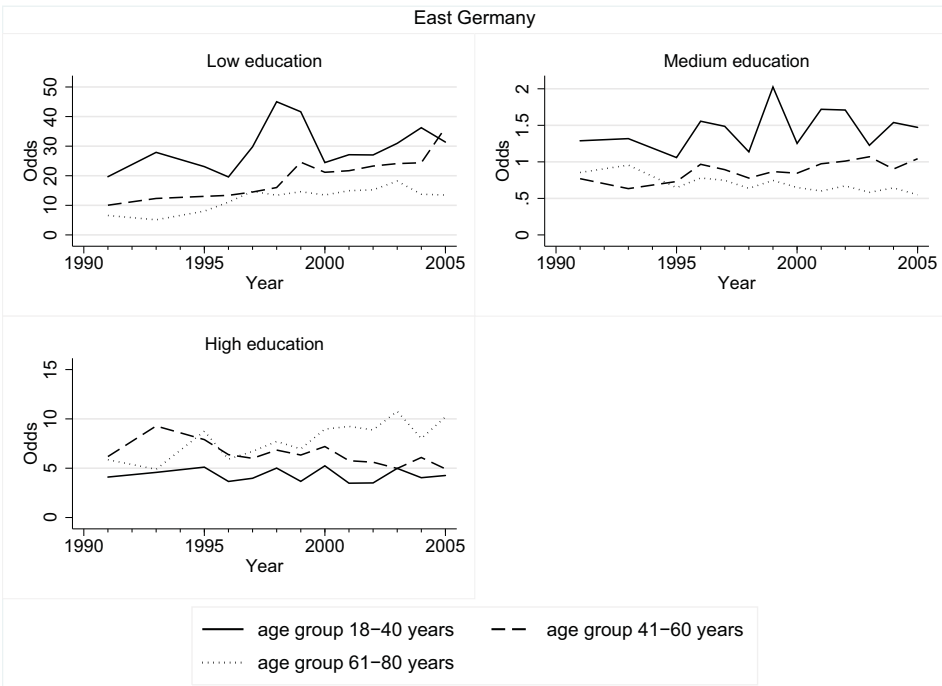
In contrast to the West German results, the odds of homogamy were highest for the lowest educational group ranging between values from 7 for the oldest to 20 for the youngest couples in 1991 (see Figure 3). Over time, these odds increased further. The increase is most pronounced for the middle age spouses, the odds almost quadrupled. For the oldest couples the odds doubled and for the youngest age cohort the odds increased by 60%. Couples, in which both spouses hold a university or technical college degree, have odds of marrying homogamously, which in 1991 ranged between values of 4 to 6 and remained stable for all age groups but the oldest. For the oldest age group, the odds almost doubled over time. Similar to West Germany, homogamous marriages within the middle education group were less likely and the odds stayed quite stable over time. The only exception is the youngest age group, where the odds of marrying homogamously were slightly above one.

5 Conclusion

The existing literature points out that individuals do not mate randomly according to social and cultural traits. Marrying within a socio-economic group can lead to polarization and exacerbate economic inequality. Furthermore, the remarkable expansion of education that especially women in all developed economies have experienced during previous decades, may have an influence on mating behavior. In the US, there is compelling evidence indicating that the educational similarity of spouses has steadily increased during the at least last four decades. For other countries e.g. Spain, Norway, and Britain a decreasing trend in educational resemblance of spouses has been identified. For Germany, however, little is known about actual patterns of educational assortative mating. This paper sheds some light on the pattern and trends of assortative mating in East and West Germany between 1991 and 2005 and between 1976 and 2005, respectively, using German Microcensus data.

Concentrating on spouses in which husband and wife are German, we find an upward trend in homogamy, i.e. marriages between spouses of the same educational level, for East and West Germany. Among West German couples, especially for those with wives aged between 18 to 40

Figure 3: Odds of homogamy in East Germany, by age group



years and between 41 to 60 years, the share of homogamous marriages increased significantly between 1976 and 2005. In East Germany, couples of all ages experienced a significant increase of homogamy. We use log-linear models to disentangle whether this increase in homogamy is solely due to the educational expansion or whether the increase is due to changes in partner preferences for a similarly educated partner (homogamy model) or in tendencies to cross educational barriers (crossing model). Our results indeed suggest that changes in assortative mating behavior of East and West German couples are related to changes in the preference for the partners' education and that these changes differ by education group. By contrast, we do not find evidence that educational boundaries became less permeable as it is assumed by the crossing model.

In 1976, the odds of homogamy in West Germany were highest for the highly educated, ranging between values of 9 and 17. However, for the low educated we observe also strong tendencies to marry within the education group. Over time, the odds developed differently for the three age groups. While for the youngest couples the odds decreased for the high educated and increased for the low educated, for middle age couples only the odds for the low educated increased. The odds of homogamy at the upper tail of the educational distribution remained quite stable. For the oldest age group, the odds of a homogamous marriages increased at both ends of the educational distribution.

For East German couples, the picture looks slightly different. Even if the tendency of marrying homogamous is relatively high for low and high educated persons, the odds of homogamy are most pronounced for the low educated. In 1991, the odds of homogamy for spouses with less than completed post-second training ranged between values of 7 and 20. Over time, these odds increased markedly, especially for spouses with wives aged between 41 and 60. The odds of homogamy among the high educated remained stable over time. The only exception is the oldest age group. For those couples, the odds increased.

To summarize, our results point out that the increase in homogamy of East and West German spouses is not only due to the increased educational attainment. It is rather the consequence of changes in the preferences for the partners' education among the low educated. To look behind the driving forces of these changes, further investigation is needed, because assortative mating could lead to polarization and the exacerbation of income inequality. Additionally, since the educational background of parents is strongly correlated with the educational attainment of their children, assortative mating behavior may also have an influence on the next generations.

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Appendix

Table A1: Goodness-of-fit tests for log-linear models

	West Germany			East Germany		
	G^2	BIC	df	G^2	BIC	df
	Wives aged 18-40 years					
(1) Baseline model (HY,WY)	93351.5	93009.4	68	14538.3	14290.7	52
(2) Association model (HY,WY, WH)	1486.7	1164.7	64	79.0	-149.6	48
(3) Uniform constant homogamy model ($\delta_{11} = \delta_{22} = \delta_{33}$)	27202.1	26865.1	67	1828.6	1585.8	51
(4) Uniform homogamy model ($\delta_{11t} = \delta_{22t} = \delta_{33t}$)	26725.6	26469.1	51	1778.7	1592.9	39
(5) Constant homogamy model ($\delta_{11} \neq \delta_{22} \neq \delta_{33}$)	1952.3	1625.3	65	110.9	-122.4	49
(6) Homogamy model ($\delta_{11t} \neq \delta_{22t} \neq \delta_{33t}$)	579.7	494.2	17	44.9	-17.0	13
(7) Constant crossing model(γ_{ij})	3972.8	3640.8	66	161.9	-76.2	50
(8) Crossing model (γ_{ijt})	2544.7	2373.6	34	109.2	-14.6	26
	Wives aged 41-60 years					
(1) Baseline model (HY,WY)	130041.8	129699.7	68	23843.8	23596.1	52
(2) Association model (HY,WY, WH)	1247.9	926.0	64	245.8	17.2	48
(3) Uniform constant homogamy model ($\delta_{11} = \delta_{22} = \delta_{33}$)	48929.4	48592.4	67	4296.1	4053.2	51
(4) Uniform homogamy model ($\delta_{11t} = \delta_{22t} = \delta_{33t}$)	47106.2	46849.7	51	4260.0	4074.3	39
(5) Constant homogamy model ($\delta_{11} \neq \delta_{22} \neq \delta_{33}$)	1822.3	1495.3	65	332.5	99.2	49
(6) Homogamy model ($\delta_{11t} \neq \delta_{22t} \neq \delta_{33t}$)	664.8	579.3	17	110.2	48.3	13
(7) Constant crossing model(γ_{ij})	5587.2	5255.2	66	376.2	138.1	50
(8) Crossing model (γ_{ijt})	4449.3	4278.3	34	185.9	62.1	26
	Wives aged 61-80 years					
(1) Baseline model (HY,WY)	57646.5	57304.4	68	11935.4	11687.8	52
(2) Association model (HY,WY, WH)	391.7	69.8	64	162.4	-66.2	48
(3) Uniform constant homogamy model ($\delta_{11} = \delta_{22} = \delta_{33}$)	26077.1	25740.1	67	4741.1	4498.2	51
(4) Uniform homogamy model ($\delta_{11t} = \delta_{22t} = \delta_{33t}$)	25929.2	25672.6	51	4695.5	4509.7	39
(5) Constant homogamy model ($\delta_{11} \neq \delta_{22} \neq \delta_{33}$)	728.9	401.9	65	258.9	25.6	49
(6) Homogamy model ($\delta_{11t} \neq \delta_{22t} \neq \delta_{33t}$)	357.6	272.1	17	124.2	62.3	13
(7) Constant crossing model(γ_{ij})	2962.9	2630.9	66	546.1	308.0	50
(8) Crossing model (γ_{ijt})	2703.6	2532.5	34	456.5	332.7	26

Notes: BIC=Bayesian information criterion, df=degrees of freedom. Smaller values of the G^2 and BIC indicate a better model fit.
Source: German Microcensus, own calculations.

Table A2: Odds of homogamy for West Germany, by age group

	Age group 18-40 years			Age group 41-60 years			Age group 61-80 years		
$\delta_{i=j=1}$	6.7880	***	(0.2824)	6.2038	***	(0.2563)	6.9857	***	(0.4754)
$\delta_{i=j=1}\times$1978	0.9725		(0.0582)	1.1011	*	(0.0634)	0.9373		(0.0914)
$\delta_{i=j=1}\times$1982	0.9453		(0.0601)	1.2350	***	(0.0693)	0.9695		(0.0917)
$\delta_{i=j=1}\times$1989	1.1533	**	(0.0789)	1.2161	***	(0.0704)	0.9660		(0.0879)
$\delta_{i=j=1}\times$1991	1.4016	***	(0.1037)	1.5832	***	(0.0960)	1.2486	**	(0.1174)
$\delta_{i=j=1}\times$1993	1.6255	***	(0.1262)	1.4582	***	(0.0882)	1.2519	**	(0.1163)
$\delta_{i=j=1}\times$1995	1.6619	***	(0.1269)	1.5130	***	(0.0919)	1.1322		(0.1030)
$\delta_{i=j=1}\times$1996	1.8663	***	(0.1345)	1.7941	***	(0.1093)	1.6193	***	(0.1508)
$\delta_{i=j=1}\times$1997	2.0025	***	(0.1487)	1.8396	***	(0.1127)	1.6909	***	(0.1562)
$\delta_{i=j=1}\times$1998	2.2857	***	(0.1746)	1.9193	***	(0.1187)	1.5491	***	(0.1410)
$\delta_{i=j=1}\times$1999	3.3258	***	(0.2656)	2.1286	***	(0.1346)	1.7874	***	(0.1629)
$\delta_{i=j=1}\times$2000	2.6593	***	(0.2187)	1.9564	***	(0.1278)	1.7166	***	(0.1578)
$\delta_{i=j=1}\times$2001	2.6392	***	(0.2185)	2.0294	***	(0.1339)	1.7855	***	(0.1624)
$\delta_{i=j=1}\times$2002	2.7866	***	(0.2376)	2.0977	***	(0.1407)	1.7465	***	(0.1580)
$\delta_{i=j=1}\times$2003	2.5527	***	(0.2232)	2.0278	***	(0.1374)	1.8063	***	(0.1622)
$\delta_{i=j=1}\times$2004	2.6795	***	(0.2418)	2.1288	***	(0.1444)	1.6583	***	(0.1471)
$\delta_{i=j=1}\times$2005	2.7721	***	(0.2453)	1.9336	***	(0.1265)	1.6335	***	(0.1414)
$\delta_{i=j=2}$	0.7079	***	(0.0225)	0.6725	***	(0.0213)	0.7937	***	(0.0402)
$\delta_{i=j=2}\times$1978	0.9415		(0.0431)	0.9000	**	(0.0394)	0.9113		(0.0662)
$\delta_{i=j=2}\times$1982	0.9791		(0.0474)	0.8311	***	(0.0352)	0.9321		(0.0649)
$\delta_{i=j=2}\times$1989	0.8717	***	(0.0456)	0.8113	***	(0.0349)	0.9115		(0.0607)
$\delta_{i=j=2}\times$1991	0.8170	***	(0.0460)	0.7981	***	(0.0348)	0.7555	***	(0.0509)
$\delta_{i=j=2}\times$1993	0.7476	***	(0.0446)	0.8513	***	(0.0373)	0.7724	***	(0.0511)
$\delta_{i=j=2}\times$1995	0.7894	***	(0.0465)	0.8896	***	(0.0394)	0.7901	***	(0.0522)
$\delta_{i=j=2}\times$1996	0.9935		(0.0557)	1.0129		(0.0446)	0.8354	***	(0.0551)
$\delta_{i=j=2}\times$1997	0.9655		(0.0557)	1.0317		(0.0455)	0.8084	***	(0.0526)
$\delta_{i=j=2}\times$1998	0.8539	***	(0.0514)	1.0113		(0.0455)	0.8627	**	(0.0557)
$\delta_{i=j=2}\times$1999	0.7942	***	(0.0503)	0.9629		(0.0445)	0.7451	***	(0.0482)
$\delta_{i=j=2}\times$2000	0.8046	***	(0.0525)	1.0089		(0.0473)	0.7874	***	(0.0509)
$\delta_{i=j=2}\times$2001	0.7661	***	(0.0510)	1.0054		(0.0485)	0.7605	***	(0.0485)
$\delta_{i=j=2}\times$2002	0.7625	***	(0.0523)	0.9931		(0.0490)	0.7215	***	(0.0461)
$\delta_{i=j=2}\times$2003	0.7857	***	(0.0550)	1.0161		(0.0508)	0.7105	***	(0.0450)
$\delta_{i=j=2}\times$2004	0.7890	***	(0.0574)	0.9767		(0.0494)	0.7401	***	(0.0466)
$\delta_{i=j=2}\times$2005	0.8567	**	(0.0623)	0.9743		(0.0481)	0.6589	***	(0.0407)
$\delta_{i=j=3}$	16.5762	***	(0.9163)	14.2802	***	(0.9806)	9.4178	***	(1.1182)
$\delta_{i=j=3}\times$1978	1.0529		(0.0812)	0.9158		(0.0852)	1.3208		(0.2293)
$\delta_{i=j=3}\times$1982	0.9934		(0.0767)	1.1890	*	(0.1070)	1.2574		(0.2050)
$\delta_{i=j=3}\times$1989	0.9277		(0.0714)	1.4049	***	(0.1250)	1.3452	*	(0.2049)
$\delta_{i=j=3}\times$1991	0.9133		(0.0723)	1.4656	***	(0.1292)	1.9014	***	(0.2912)
$\delta_{i=j=3}\times$1993	0.9491		(0.0772)	1.2788	***	(0.1109)	1.4053	**	(0.2096)
$\delta_{i=j=3}\times$1995	0.8521	**	(0.0684)	1.2640	***	(0.1067)	1.7440	***	(0.2650)
$\delta_{i=j=3}\times$1996	0.6222	***	(0.0486)	1.0372		(0.0870)	1.5220	***	(0.2260)
$\delta_{i=j=3}\times$1997	0.5915	***	(0.0467)	0.9587		(0.0792)	1.5478	***	(0.2268)
$\delta_{i=j=3}\times$1998	0.6951	***	(0.0562)	0.9556		(0.0790)	1.7380	***	(0.2549)
$\delta_{i=j=3}\times$1999	0.7936	***	(0.0662)	1.0799		(0.0903)	1.7458	***	(0.2547)
$\delta_{i=j=3}\times$2000	0.7842	***	(0.0665)	0.9311		(0.0775)	1.9743	***	(0.2912)
$\delta_{i=j=3}\times$2001	0.8647	*	(0.0741)	1.0119		(0.0849)	1.8623	***	(0.2651)
$\delta_{i=j=3}\times$2002	0.8874		(0.0778)	1.0492		(0.0883)	1.8436	***	(0.2607)
$\delta_{i=j=3}\times$2003	0.8526	*	(0.0754)	1.0016		(0.0842)	2.2546	***	(0.3225)
$\delta_{i=j=3}\times$2004	0.8129	**	(0.0736)	0.9584		(0.0803)	2.0126	***	(0.2824)
$\delta_{i=j=3}\times$2005	0.7118	***	(0.0647)	0.9271		(0.0770)	1.9134	***	(0.2638)

Notes: $\lambda = log(\delta)$. - $\delta_{i=j=1}$ displays the odds that both spouses belong to the education category low, $\delta_{i=j=2}$ that they belong to the category medium, and $\delta_{i=j=3}$ that they are in the category high, respectively. The year-specific odds are calculated by multiplication. - * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: German Microcensus, own calculations.

Table A3: Odds of homogamy for East Germany, by age group

	Age group 18-40 years			Age group 41-60 years			Age group 61-80 years		
$\delta_{i=j=1}$	19.6781	***	(3.1409)	10.0434	***	(1.0621)	6.5771	***	(0.9182)
$\delta_{i=j=1}\times$1993	1.4182		(0.3357)	1.2276		(0.1949)	0.7775		(0.1494)
$\delta_{i=j=1}\times$1995	1.1735		(0.3043)	1.2982		(0.2093)	1.2241		(0.2343)
$\delta_{i=j=1}\times$1996	0.9958		(0.2352)	1.3321	*	(0.2048)	1.6853	***	(0.3239)
$\delta_{i=j=1}\times$1997	1.5135		(0.3906)	1.4440	**	(0.2329)	2.2369	***	(0.4405)
$\delta_{i=j=1}\times$1998	2.2878	***	(0.6304)	1.5945	***	(0.2603)	2.0392	***	(0.3918)
$\delta_{i=j=1}\times$1999	2.1150	***	(0.5396)	2.4471	***	(0.4084)	2.2224	***	(0.4290)
$\delta_{i=j=1}\times$2000	1.2431		(0.3340)	2.1087	***	(0.3730)	2.0523	***	(0.3952)
$\delta_{i=j=1}\times$2001	1.3780		(0.3825)	2.1614	***	(0.3808)	2.2727	***	(0.4414)
$\delta_{i=j=1}\times$2002	1.3739		(0.3829)	2.3179	***	(0.4261)	2.3169	***	(0.4487)
$\delta_{i=j=1}\times$2003	1.5729		(0.4702)	2.4004	***	(0.4598)	2.7652	***	(0.5447)
$\delta_{i=j=1}\times$2004	1.8417	*	(0.6098)	2.4281	***	(0.4958)	2.0928	***	(0.4008)
$\delta_{i=j=1}\times$2005	1.5951		(0.4581)	3.6102	***	(0.6431)	2.0499	***	(0.3774)
$\delta_{i=j=2}$	1.2887	**	(0.1566)	0.7699	***	(0.0546)	0.8549	*	(0.0706)
$\delta_{i=j=2}\times$1993	1.0228		(0.1907)	0.8233	*	(0.0907)	1.1180		(0.1324)
$\delta_{i=j=2}\times$1995	0.8217		(0.1623)	0.9497		(0.1036)	0.7567	**	(0.0891)
$\delta_{i=j=2}\times$1996	1.2077		(0.2227)	1.2557	**	(0.1342)	0.9118		(0.1032)
$\delta_{i=j=2}\times$1997	1.1535		(0.2365)	1.1607		(0.1280)	0.8741		(0.0995)
$\delta_{i=j=2}\times$1998	0.8823		(0.1990)	1.0108		(0.1187)	0.7457	**	(0.0857)
$\delta_{i=j=2}\times$1999	1.5713	**	(0.3284)	1.1258		(0.1350)	0.8733		(0.0990)
$\delta_{i=j=2}\times$2000	0.9720		(0.2081)	1.0977		(0.1365)	0.7598	**	(0.0877)
$\delta_{i=j=2}\times$2001	1.3345		(0.2898)	1.2651	*	(0.1610)	0.7031	***	(0.0815)
$\delta_{i=j=2}\times$2002	1.3267		(0.2942)	1.3127	**	(0.1751)	0.7856	**	(0.0909)
$\delta_{i=j=2}\times$2003	0.9519		(0.2312)	1.3896	**	(0.1936)	0.6816	***	(0.0807)
$\delta_{i=j=2}\times$2004	1.1941		(0.3081)	1.1718		(0.1701)	0.7532	**	(0.0876)
$\delta_{i=j=2}\times$2005	1.1424		(0.2702)	1.3547	**	(0.1863)	0.6426	***	(0.0736)
$\delta_{i=j=3}$	4.1025	***	(0.5037)	6.1825	***	(0.4905)	5.8612	***	(0.8050)
$\delta_{i=j=3}\times$1993	1.1153		(0.2101)	1.5009	***	(0.1837)	0.8337		(0.1718)
$\delta_{i=j=3}\times$1995	1.2455		(0.2483)	1.2781	**	(0.1520)	1.4930	**	(0.2872)
$\delta_{i=j=3}\times$1996	0.8918		(0.1667)	1.0313		(0.1201)	1.0094		(0.1854)
$\delta_{i=j=3}\times$1997	0.9703		(0.2010)	0.9707		(0.1156)	1.1438		(0.2064)
$\delta_{i=j=3}\times$1998	1.2220		(0.2781)	1.1061		(0.1387)	1.3160		(0.2344)
$\delta_{i=j=3}\times$1999	0.8938		(0.1886)	1.0247		(0.1309)	1.1864		(0.2100)
$\delta_{i=j=3}\times$2000	1.2777		(0.2765)	1.1642		(0.1532)	1.5292	**	(0.2712)
$\delta_{i=j=3}\times$2001	0.8485		(0.1863)	0.9321		(0.1252)	1.5764	***	(0.2772)
$\delta_{i=j=3}\times$2002	0.8551		(0.1919)	0.9071		(0.1269)	1.5145	**	(0.2651)
$\delta_{i=j=3}\times$2003	1.2148		(0.2982)	0.8047		(0.1170)	1.8375	***	(0.3223)
$\delta_{i=j=3}\times$2004	0.9838		(0.2561)	0.9847		(0.1486)	1.3673	*	(0.2338)
$\delta_{i=j=3}\times$2005	1.0386		(0.2486)	0.7986		(0.1144)	1.7398	***	(0.2936)

Notes: $\lambda = log(\delta)$. - $\delta_{i=j=1}$ displays the odds that both spouses belong to the education category low, $\delta_{i=j=2}$ that they belong to the category medium, and $\delta_{i=j=3}$ that they are in the category high, respectively. The year-specific odds are calculated by multiplication. - * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: German Microcensus, own calculations.