Estimation of intergenerational mobility in small samples: evidence from German survey data

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Abstract
Using data from the German socio-economic panel, this paper provides new evidence on intergenerational mobility in Germany by focusing on intergenerational association in ranks—i.e. positions, which parents and children occupy in their respective income distributions. We find that the association of children’s ranks with ranks of their fathers is about 0.242 for individual labor earnings and it is higher for sons than for daughters. It is also higher in East Germany compared to West Germany. The results further show that rank-based measures of mobility are less sensitive than conventional measures of intergenerational income elasticity to different methodological and sample specification choices, such as the stages of the life cycle when incomes of children and parents are measured, the number of years for which incomes are considered, the treatment of zero values in income variables and the choice of annual versus hourly earnings. Moreover, they are more robust for sub-group comparisons of intergenerational mobility (e.g. across gender and region). This evidence suggests that, similarly to large administrative datasets, rank-based measures of intergenerational mobility perform better than elasticity-based measures in small samples based on survey data.

Keywords Intergenerational income elasticity · Intergenerational mobility · Rank-based measures of mobility · Robustness · Small samples

JEL classification D31 · D63 · J62

1 Introduction
The extent to which economic outcomes of children are associated with economic outcomes of their parents has been widely studied in the literature (for an extensive overview see Solon 2002; Black and Devereux 2011; Jäntti and Jenkins 2015). This literature, however, focuses predominantly on elasticities of children’s income with respect to income of
their parents whereas much less is known about intergenerational persistence in income ranks – i.e. positions which parents and children occupy in their income distributions. The available studies are relatively recent and so far cover only a restricted number of countries, such as Canada, the United States, or Nordic countries (see, among others, Dahl and DeLeire 2008; Chetty et al. 2014a, b; Mazumder 2016; Corak 2017; Heidrich 2017; Nybom and Stuhler 2017; Connolly et al. 2019). The evidence from these studies suggests that the estimates of intergenerational mobility based on ranks are less susceptible than intergenerational income elasticity estimates to attenuation and life cycle bias, rendering rank-based measures of mobility more appealing for studying intergenerational mobility, at least in large administrative datasets on which the research has been based so far. Attenuation bias arises when the scholars do not have information on lifelong income of individuals and proxy it with annual observations of income. In his seminal work, Solon (1992) shows that the use of annual income instead of permanent income results into severe underestimation of the degree of income persistence across generations. Life cycle bias relates to a mismatch in the stages of the life cycle at which children’s’ and parents’ incomes are taken into account. Haider and Solon (2006) demonstrate that measuring children’s income too early in their life cycle yields a downward bias in the estimates of intergenerational mobility. By comparing the degree of these two biases in various measures of intergenerational income mobility, Nybom and Stuhler (2017) provide convincing evidence that in large administrative datasets rank-based measures of intergenerational mobility perform much better than conventional measures based on income elasticities.

A second issue with classical measures of intergenerational income mobility concerns its confounding with the underlying inequality distribution. Measures of income elasticities between parental and children’s income are affected by the ratio of the parental and children’s income distributions, and thus, by changes in income inequality between generations. Moreover, due to this property, measures of intergenerational income elasticities are hardly comparable over time, across countries, and between groups. Rank-based measures of intergenerational income mobility, in contrast, are independent of the magnitude of the underlying income inequality because these are transformed into uniform rank distributions. This allows for a more direct comparison of intergenerational dependency of parental and children’s relative income positions between countries, over time, and between groups.1

This paper aims to analyze intergenerational rank mobility in Germany and to evaluate whether rank-based measures of intergenerational mobility are less sensitive than conventional elasticity-based measures to different measurement approaches also in small samples based on survey data. Using data from the German Socio-Economic Panel (SOEP), we estimate, in the first step, the level of intergenerational persistence in the positions (ranks) that children and parents occupy in their respective income distributions. As a next step, we explore to what extent these estimates are more robust to the mismatch in the stages of the life cycle when incomes of children and parents are measured, the number of years for which incomes are considered, treatment of zero values in income variables and the choice of annual versus hourly earnings as compared with intergenerational earning elasticity.

1 Apart from measurement issues, the literature on intergenerational mobility deals with causality issues related to the nature versus nurture debate (see, among others, Sacerdote 2002; Björklund et al. 2006; Lindquist 2015; Black et al. 2019). The main objective of this literature is to separate the impact of genetic factors (e.g. transmission of abilities from parents to children) from environmental factors (e.g. richer parents may provide better environment for their children in terms of education, networks, etc.).
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The choice of Germany is not random. Germany is a country where administrative data for intergenerational analysis is not available and existing evidence on the topic relies on survey data with a limited number of observations. The estimates of the IEE in the country vary from as low as 0.11 in early studies on intergenerational mobility to as high as 0.32 in the most recent ones (for a summary, see Table 10 in Appendix 1). The main reason of this variation, as highlighted by Schnitzlein et al. (2016), is the sensitivity of intergenerational mobility estimates to different criteria that researchers apply for the sample specification, especially with respect to the age at which income of children is measured and the number of years over which income of parents and children is averaged. Moreover, gender and regional differences in income inequality are particularly marked in Germany, rendering group comparisons in intergenerational income mobility highly sensitive to methodological choices.

Our contribution to the literature is threefold. First, we extend the existing evidence on intergenerational mobility in Germany by providing, along with conventional IEE estimates, estimates of intergenerational association in ranks. Up to our knowledge, the only study, which estimates rank mobility for Germany, is the one by Bratberg et al. (2017), whose main objective was to compare the level of intergenerational mobility in total pre-tax family income in Germany, Norway, Sweden, and the United States. We extend their work by providing estimates of relative rank mobility for individual gross annual earnings rather than family income. Second, we test whether rank-based measures of intergenerational mobility are less sensitive than the measures based on income elasticities to different methodological and sample specification choices. Third, we show that the confounding of mobility and inequality in the estimates of income elasticity across generations might have strong implications for studying group-differences. Regarding gender and regional differences, we indeed find opposing results for rank- and elasticity-based measures of intergenerational mobility.

The paper is structured as follows. Section 2 describes the estimation approach. Section 3 provides details on data and sample construction. Section 4 presents the results and Sect. 5 concludes.

2 Measuring intergenerational economic mobility

2.1 Intergenerational earnings elasticity

The vast majority of studies on intergenerational mobility focuses on estimating the elasticity of children’s income with respect to income of their parents:

$$\log Y_{i, \text{child}} = \beta_0 + \beta_1 \log Y_{i, \text{parent}} + \zeta,$$

where $Y_{i, \text{child}}$ and $Y_{i, \text{parent}}$ are log incomes of children and parents respectively, $\beta_1$ is an intergenerational elasticity of income, and $\zeta$ is a random error term. $\beta_1$ shows a percentage change in child’s income when parental income changes by 1 percent.
The OLS procedure applied to Eq. (1) yields the estimate of $\hat{\beta}_1$ equal to:

$$\hat{\beta}_1 = \rho(Y_{\text{child}}, Y_{\text{parent}}) \cdot \frac{SD(Y_{\text{child}})}{SD(Y_{\text{parent}})},$$

(2)

where $\rho(Y_{\text{child}}, Y_{\text{parent}})$ is a Pearson correlation coefficient between log incomes of children and parents; $SD(Y_{\text{child}})$ and $SD(Y_{\text{parent}})$ are standard deviations of these income variables.

From Eq. (2) it follows that beyond the correlation of children’s income with parental income, the estimate of intergenerational income elasticity captures the ratio of the marginal distributions of income in the two generations. A higher dispersion of income in the generation of children than in the generation of parents results into higher estimates of income persistence across generations, and vice versa.

### 2.2 Intergenerational association in ranks

The intergenerational association in ranks is a relatively new measure of intergenerational mobility. In contrast to intergenerational elasticity of income, estimates of intergenerational association in ranks are not sensitive to the differences in income inequality across generations. By construction, ranks of children and parents follow a uniform distribution with the same variance.

Let $R_{\text{child}}^i$ denote the percentile rank of child $i$ (normalized at the unit interval) in the distribution of life-long income of children, so that $R_{\text{child}}^i \in [0;1]$. Let $R_{\text{parent}}^i$ stand for the percentile rank of child’s $i$ parent in the parental distribution of life-long income, so that $R_{\text{parent}}^i \in [0;1]$. Then, the association between child’s and parent’s percentile ranks can be identified via the ordinary least squares (OLS) procedure as follows:

$$R_{\text{child}}^i = \hat{\beta}_0 + \hat{\beta}_1 R_{\text{parent}}^i + \epsilon_i,$$

(3)

where $\hat{\beta}_0$ is an intercept, $\hat{\beta}_1$ is a rank-rank slope, and $\epsilon_i$ is a random uniformly distributed error component capturing factors which might affect distributional positions of children independently from the ranks of their parents. The slope coefficient, $\hat{\beta}_1$, is the main estimate of our interest in Eq. (3). It measures the relative association between child’s and parent’s positions in the respective distributions of income. The OLS estimate of $\hat{\beta}_1$ equals to:

$$\hat{\beta}_1 = \rho(R_{\text{child}}, R_{\text{parent}}),$$

(4)

where $\rho(R_{\text{child}}, R_{\text{father}})$ is a Pearson coefficient of correlation capturing the dependence structure between ranks of children and parents. In particular, it shows the percentile point change in child’s rank with respect to a percentile point change in the parent’s rank. If $\hat{\beta}_1$ equals to 0, the position of a child in the distribution of income is independent from the distributional position of a parent, and the society can be characterized as ‘perfectly’ mobile, with perfect mobility being equal to a lottery. The larger the value of $\hat{\beta}_1$, the higher is the rank persistence across generations and the lower is mobility. When $\hat{\beta}_1$ takes the value of 1, a child’s distributional position is fully determined by the position of the parent. Hence, $\hat{\beta}_1$ can only vary between 0 (perfect mobility) and 1 (perfect persistence).

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2 Note that ‘parental income distribution’ only refers to parents with grown-up children.

3 Since the expected mean rank is 0.5 for both children and parents, the slope coefficient $\beta_1$ is the only free parameter in the model (Chetty et al. 2014a). In this type of model, $\beta_0$ will always depend on $\beta_1$ as follows: $\beta_0 = (1 - \beta_1)/2$. 

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The $\beta_1$ derived from Eqs. (1) and (3), i.e. intergenerational income elasticity and rank-correlation, are not directly comparable in magnitude. This incomparability becomes evident from the simple fact that a given rank distribution may represent various income distributions. For instance, any way of scaling a given income distribution – even scaling certain parts of the income distribution differently – leaves the rank-transformed distribution identical.

### 2.3 Measurement concerns

The availability of information on life-long income for both children and parents is the key prerequisite for obtaining consistent estimates of intergenerational income mobility. In real life, however, it is challenging to find a dataset, which would contain information on parental and children’s income over the entire life course and would allow deriving their lifelong positions in the respective income distributions. Researchers typically observe only snapshots of income trajectories in both generations, which they use as proxies for unobserved lifetime income and which might generate a severe measurement problem and lead to a bias in intergenerational mobility estimates (this issue has been extensively discussed in Björklund 1993; Angrist and Krueger 1999; Böhlmark and Lindquist 2006; Haider and Solon 2006; and Brenner 2010). The size of the bias, however, is smaller in the estimates of intergenerational association in ranks compared to the estimates of intergenerational association in income, because ranks are less sensitive to extreme observations at the tails of the distribution (Dahl and DeLeire 2008; Chetty et al. 2014a, b; Nybom and Stuhler 2017). Nybom and Stuhler (2017), for example, have shown that the estimate of intergenerational association in ranks falls close to the true value of $\beta_1$ when income of parents is averaged over five to ten years covering the middle stage of their life cycles. Similar evidence is also found in Chetty et al. (2014a) and Corak (2017), who show that the estimates are relatively robust to the choice of the number of years, over which parental income is averaged, as soon as this number exceeds five. With respect to children’s income, both Chetty et al. (2014a) and Corak (2017) find no significant change in the estimates of rank-rank associations across generations as soon as children’s incomes are averaged at least over two years.

Apart from the number of years over which incomes are averaged to obtain a life-long proxy, ranks also tend to be less susceptible to the mismatch in the stages of the life cycle at which incomes of children and parents are retained. Using administrative data, Dahl and DeLeire (2008) and Nybom and Stuhler (2017) have shown that rank profiles of individuals stabilize earlier in their life cycle than log-income profiles. Whereas estimates of intergenerational income elasticity are downward biased if income observations are taken prior to the age of 35–40, for rank-based measures of mobility this cut-off is rather at 30 years.4

All above-mentioned studies are based on large administrative datasets. In what follows, we will investigate to what extent rank-based measures of mobility are also more robust than the intergenerational income elasticity to various methodological and sample specification choices in small samples driven from survey data.

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4 Moreover, Vogel (2006) shows that earnings-profiles over age differ across educational groups.
3 Data and sample construction

To derive an intergenerational sample for our analysis we use data from the German Socio-Economic Panel (SOEP), a longitudinal survey conducted by the German Institute for Economic Research (DIW). The SOEP started in 1984 with a representative sample of almost six thousand private households living in the Federal Republic of Germany and expanded to the territory of the German Democratic Republic in June 1990 (Goebel et al. 2019). Over time, the survey has undergone several sample refreshments to better capture recent immigrants, increase the sample size, or collect information on particular socio-economic sub-groups (for a detailed description of the SOEP samples see Table 11 in Appendix 2). This paper covers only individuals who were included in the initial SOEP samples (A, B, and C) because only for them we have enough observations of income in both parents’ and children’s samples.

The main advantage of the SOEP for intergenerational mobility research is that it follows individuals over time, even when they move from one household to another. To qualify for a personal interview, a person must be at least 16 years old and either be an initial member of the sampled household, or join it later as a result of birth or residential mobility. Every person above age 16 who have ever become a member of a SOEP household, be it an original or non-original sample member, will be traced throughout life until he/she finally refuses to take part in the survey, deceases or moves abroad. Due to this follow-up principle, we can link children who have reached adulthood and moved out from parental households to their parents interviewed in the first waves of the SOEP.

In this paper, we use SOEP data for 1984–2014 (SOEPv31). Our children’s sample consists of individuals born between 1968 and 1977, who reached their mid-30s between 2002 and 2013. We are interested in measuring income at this age because income observations at earlier stages of the life cycle have proved to be noisy measures of life-long income (Solon 2002; Haiden and Solon 2006; Chen et al. 2017; Nybom and Stuhler 2017). To decrease the risk of underestimation of intergenerational association in ranks due to the use of annual rather than life-long information on income we average children’s income over three years, when children are between 34 and 36 years old.5

In a similar way, to reduce the error-in-variable problem in parental income and ranks, we average parents’ income over the 5-year period when children are between 15 and 19 years old. This restriction implies that information on parental income refers to the years between 1983 and 1996. Only parents with at least three valid observations of income in the 5-year period are included in the analysis. We also consider only those parent–child pairs where parents are between 15 and 40 years old when the child was born.

In this paper, we focus on father’s individual gross annual earnings as a measure of income. Individual gross annual earnings have been widely used as an income measure in the literature on intergenerational earnings mobility (for the survey of this literature, see Solon 2002; Jäntti and Jenkins 2015). In the SOEP, individual gross annual earnings include wages and salary from all types of employment including training, primary and secondary jobs, self-employment, income from bonuses, over-time work, and profit sharing. In line with most studies in the field, we focus on the relationship between children’s earnings and earnings of their fathers. In our primary sample, we also exclude observations

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5 Averaging children’s incomes over a longer period (for example, between the age of 30 and 38) would result into a decrease in the sample size because we would need to provide every child with the same possibility of having their incomes observed over a given (larger) number of years.
with zero values of individual earnings or earnings smaller than 1200 Euros per year. We evaluate the impact of this restriction on the estimation results by performing calculations for two alternative samples in Sect. 4.4.

We define ranks of children based on their positions in the distribution of individual earnings where the distribution encompasses all children born within the country in the same year. For parents, we define ranks relative to other parents, who have children born in the same year. In order to analyze rank mobility across generations separately for daughters and sons, we redefine ranks within the respective gender sub-samples. In the same vein, when estimating intergenerational rank mobility separately for West and East Germany, ranks are based on the respective regional samples. Our final core sample comprises

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**Table 1** Summary statistics

| Characteristic | All children | Only sons | Only daughters |
|----------------|-------------|-----------|---------------|
|                | Mean | SD | Mean | SD | Mean | S.D |
| Father’s age   | 45.4 | 4.46 | 45.5 | 4.50 | 45.2 | 4.41 |
| Child’s age    | 35.0 | 0.20 | 35.0 | 0.16 | 34.9 | 0.23 |
| Father’s log earnings | 10.52 | 0.45 | 10.54 | 0.47 | 10.49 | 0.42 |
| Child’s log earnings | 10.21 | 0.77 | 10.57 | 0.52 | 9.78 | 0.79 |
| Father’s earnings at the 50th percentile of the distribution | 35,748 | – | 36,569 | – | 35,123 | – |
| Child’s earnings at the 50th percentile of the distribution | 31,935 | – | 40,879 | – | 18,643 | – |
| Number of observations | 447 | – | 246 | – | 201 | – |

**East Germany**

| Characteristic | All children | Only sons | Only daughters |
|----------------|-------------|-----------|---------------|
|                | Mean | SD | Mean | SD | Mean | S.D |
| Father’s age   | 43.9 | 4.44 | 43.5 | 4.47 | 44.3 | 4.45 |
| Child’s age    | 35.0 | 0.19 | 35.0 | 0.09 | 35.0 | 0.25 |
| Father’s log earnings | 10.06 | 0.39 | 10.05 | 0.39 | 10.07 | 0.40 |
| Child’s log earnings | 9.99 | 0.59 | 10.30 | 0.38 | 9.73 | 0.60 |
| Father’s earnings at the 50th percentile of the distribution | 23,876 | – | 23,691 | – | 24,060 | – |
| Child’s earnings at the 50th percentile of the distribution | 24,008 | – | 28,422 | – | 18,275 | – |
| Number of observations | 66 | – | 29 | – | 37 | – |

**West Germany**

| Characteristic | All children | Only sons | Only daughters |
|----------------|-------------|-----------|---------------|
|                | Mean | SD | Mean | SD | Mean | S.D |
| Father’s age   | 45.6 | 4.43 | 45.7 | 4.46 | 45.4 | 4.39 |
| Child’s age    | 35.0 | 0.20 | 35.0 | 0.16 | 35.0 | 0.24 |
| Father’s log earnings | 10.60 | 0.41 | 10.6 | 0.44 | 10.59 | 0.37 |
| Child’s log earnings | 10.24 | 0.78 | 10.6 | 0.53 | 9.79 | 0.83 |
| Father’s earnings at the 50th percentile of the distribution | 37,913 | – | 38,053 | – | 37,410 | – |
| Child’s earnings at the 50th percentile of the distribution | 33,536 | – | 41,937 | – | 18,704 | – |
| Number of observations | 379 | – | 215 | – | 164 | – |

Authors’ calculations based on SOEP data. Parents’ and children’s age refers to the age for which income information is retained.

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6 Note that fathers and children are ranked within the observed samples of fathers and children. These ranks might differ from the ones, which they would hold if the ranking were done among all men (with and without children) and all children (including those raised by single mothers) accordingly.
On average, fathers in our sample are 45.5 years old when children reach the age between 15 and 19. The mean age of children in the sample is, by definition of the sample, 35 years. The average size of fathers’ earnings is the same as the average size of sons’ earnings but it is slightly larger than the average size of daughters’ earnings. Noticeably, the variance of earnings is larger in the generation of children than in the generation of parents, implying higher levels of inequality among the former. However, the earnings dispersion is considerably higher for daughters (SD = 0.79) as compared to sons (SD = 0.52). It is also remarkable that the size of annual earnings at the 50th percentile of daughters’ earnings distribution is more than two times smaller than the size of annual earnings at the 50th percentile of the sons’ earnings distribution. This implies that reaching the same percentile for daughters and sons implies different gains in terms of economic resources.

When looking at regional differences we can see that the average size of fathers’ and children’s earnings is a bit larger in West than in East Germany, and that the earnings inequality is much higher in West Germany, especially among children. Quite interesting regional differences emerge for the size of earnings corresponding to the 50th percentile of the distribution. It is substantially higher in West than in East Germany for fathers and sons whereas it is more or less the same for daughters. This again shows that moving along the income ladder implies different levels of economic resources depending on the region and gender. Also, the higher earnings inequality for daughters, compared to sons, and for West Germany, compared to East Germany, might hint on higher levels of earnings elasticity across generations for women and for West Germany since IEE measures largely depend on the ratio of inequality between children’s and parental earnings distribution.

### 4 Results

In this Section, we first present the estimates of the level of intergenerational mobility in Germany—for the entire country (Sect. 4.1), separately for East and West Germany (Sect. 4.2), and in comparison with other countries (Sect. 4.3)—and then evaluate the robustness of IEE and rank-based measures of mobility to various sample specifications and empirical approaches (Sect. 4.4).
4.1 The degree of intergenerational mobility at the national level

Table 2 presents the estimates of intergenerational mobility—intergenerational rank mobility and intergenerational elasticity in earnings—for the entire sample of children, and separately for sons and daughters. Recall that ranks of children reflect their positions in the earnings distribution of children born in the same year. Similarly, fathers’ ranks are derived based on their positions in the earnings distribution of fathers, who have children born in the same year. For gender sub-samples, ranks of both fathers and children are determined using the earnings distributions within the gender subgroups. Moreover, it is important to note that the slope-coefficients of rank-rank-correlations and IEE estimates are not directly comparable (see Sect. 2 above for more details).

The estimates of intergenerational mobility across generations are statistically significant for both rank- and elasticity-based measures of mobility implying that economic outcomes of children depend on economic outcomes of their parents. The estimates for intergenerational rank mobility show that a child born to a father at the top of the earnings distribution, on average, ranks 24 percentiles higher than a child born to a father at the bottom of the distribution. When looking at the estimates of rank mobility by gender, girls appear more mobile along the earnings ladder than boys do: on average, sons of the top percentile fathers rank 38 percentiles higher than sons of the bottom percentile fathers whereas for daughters the relative advantage is only 15 percentiles.

The estimates of IEE provide further interesting results. In particular, one can see that the gender patterns in intergenerational mobility reverse when we measure intergenerational mobility using earnings elasticity across generations. On average, a 1 percent increase in fathers’ earnings is associated with a 0.42 percent increase in daughters’ earnings and 0.27 percent increase in sons’ earnings. Hence, girls appear much less mobile than boys do as soon as we look at the intergenerational elasticities in earnings. The observed differences in the gender patterns of intergenerational mobility depending on the measure used can be partially explained by the fact that IEE estimates of mobility are sensitive to the difference in the levels of inequality in the distributions of parental and children’s earnings whereas rank-based measures are not. In our sample, inequality is much higher among daughters than among sons, which drives intergenerational elasticity estimates for the former upwards.

However, gender differences in the levels of intergenerational rank mobility should be interpreted with caution. Given that ranks are derived separately for sons and daughters, the same position in the gender specific earnings distributions might be associated with highly different levels of economic resources. In our sample, a daughter occupying the 50th percentile in the daughters’ earnings distribution has annual earnings of 18,643 Euros whereas a son at the same percentile of sons’ earnings distribution earns 40,879 Euros per year (see Table 1 above). Similarly, the difference in economic resources associated with moving from one rank to another is not the same for sons and daughters. For instance, moving from the 5th to the 10th percentile is equivalent to an increase in gross annual earnings by almost 13,000 Euros for sons but only by 3000 Euros for daughters. This evidence implies

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7 Another source of the observed differences in the patterns of intergenerational mobility documented with the IEE and rank-based measures of mobility is related to the difference between correlation coefficients involved in their calculation. Whereas IEE relies on the Pearson correlation in log earnings of fathers and children (Eq. 2), the rank-rank slope relies on correlation of rank variables (Eq. 4).
that even a big upward move along the earnings ladder for daughters might not always bring the same gain in terms of economic resources as a small move for sons.

4.2 Regional differences in intergenerational mobility: East versus West Germany

Table 3 presents the differences in the level of intergenerational mobility between East and West Germany. To derive these differences, we assign all children to either eastern or western region of Germany taking into account the place where they lived in 1989, when the German Wall fell. The region where the children grew up is in most cases the same as the region where they lived when their earnings were measured. Ranks of fathers and children living in West and East Germany are defined at the regional rather than national level (see below for a sensitivity analysis for ranking within or across regions).

Table 3 shows that rank mobility across generations is lower in East than in West Germany. On average, a child born to a father at the top of the earnings distribution ranks around 34 percentiles higher than a child born to a father at the bottom of the earnings distribution in East Germany whereas in West Germany this advantage constitutes only 24 percentiles. This evidence implies that East Germany provides lower opportunities to move along the earnings ladder than West Germany does. Based on intergenerational earnings elasticities, however, we do not obtain the same conclusion. The estimates of earnings elasticity across generations are statistically significant only in the West German sub-sample. The lack of statistical significance in the model for East Germany is most likely related to a small number of observations since only 66 child-parent pairs come from that part of the country. However, given that we do obtain statistical significant results for rank-correlations based on the very same sample, the statistical insignificance for intergenerational earnings elasticities is probably due to the much larger standard deviation of earnings, as

*In our sample, only one child moved from East to West Germany. For two father-child pairs we also did not have information on where they were living in 1989, hence, we eliminated them from the sample.*
compared to ranks. Moreover, the estimated coefficient is only 0.17, indicating that income mobility based on IEE is, if anything, higher in East than in Western Germany. The gender specific estimates in Table 3 further indicate that regional differences in the degree of intergenerational rank mobility observed in the entire sample of children also hold in gender-specific sub-samples. In particular, rank mobility is always lower in East than in West Germany. For sons, being born to a top rather than a bottom percentile father brings them a 38-percentile higher rank in East Germany as compared to a 33-percentile higher rank in West Germany. Also for daughters, the regional differences are quite small when comparing the estimated coefficients irrespectively of the statistical insignificance of the East-German estimate (which just falls short from the statistical significance with a *p* value of 7%). In contrast, regarding gender-specific results for East- and West-Germany based on intergenerational earnings elasticities, the estimated coefficients vary strongly. Mobility seems to be the smallest for West-German women (with an estimated elasticity of almost 62%) and almost perfect for their East-German counterparts (8%), whereas men range in-between. However, due to the combination of small sample sizes and large earnings variance, the estimates of IEE appear unreliable for combined gender-region sub-samples.

### 4.3 International comparisons of intergenerational mobility

An important question to ask is how Germany compares with other countries in terms of the level of intergenerational mobility. Answering this question, however, presents a challenging exercise given that the literature on intergenerational rank mobility remains scarce and covers only a restricted number of countries (i.e. Canada, Sweden, United States). In addition, to the best of our knowledge, all available studies on intergenerational rank mobility are based on pre-tax household income rather than individual earnings, which makes the comparison of our results with the results in those studies even more challenging. In order to enable such a comparison, we re-estimate rank associations across generations using pre-tax household income as an income measure while following as close as possible sample specifications used in other studies. The results of this exercise are presented in Table 4.
Table 4 shows that intergenerational rank mobility in Germany is higher than in Canada and United States, but somewhat lower than in Sweden, if we consider all children regardless of their gender. In Germany, a child raised by parents at the top of the pre-tax household income distribution, on average, ranks 21 percentiles higher compared to a child raised by parents at the bottom of the distribution. In Canada and the USA, this difference constitutes 24 and 34 percentiles accordingly whereas in Sweden it is around 19 percentiles. This ranking seconds the more recent evidence based on the estimates of intergenerational earnings elasticity (see, among others, Corak, 2006; Schnitzlein, 2016). The ranking of countries, however, differs again if one looks at each gender separately. With no available evidence for Canada, Germany keeps its position in between Sweden and the USA in terms of mobility estimates for daughters. For sons, Germany stands as the most mobile country being followed by Sweden and the United States.

The results in Table 4 are close to Bratberg et al. (2017), who compared intergenerational mobility curves in Germany, Norway, Sweden and the USA also using pre-tax household income. In particular, they found that intergenerational rank mobility is the highest in Nordic countries with Germany standing close to them whereas it is the lowest in the USA. Similar to our study, the authors also document substantial heterogeneity in the country ranking for gender sub-samples: while Germany stands in between Nordic countries and the US regarding the level of intergenerational mobility of women, it outperforms all other countries in terms of intergenerational mobility of men.

4.4 Sensitivity of intergenerational mobility estimates

In order to test the robustness of our findings to different empirical approaches and sample specification choices, we perform a set of additional analyses. In particular, we evaluate the sensitivity of both elasticity-based and rank-based estimates of intergenerational earnings mobility to (1) the mismatch in the stages of the life-cycles at which incomes of parents and children are measured; (2) the number of years used for approximation of permanent income; (3) the treatment of zero values in income variables; (4) the choice of annual

Table 5 Sensitivity analysis for the mismatch in the life-cycle stages at which parental and children’s earnings are measured

| Age of children used for earnings measurement | All children | Intergenerational rank mobility | Intergenerational earnings elasticity | Number of observations |
|----------------------------------------------|-------------|---------------------------------|--------------------------------------|------------------------|
| 30–32                                        |             | 0.207*** (0.042)                | 0.252*** (0.061)                     | 557                    |
| **34–36 (the main sample)**                  |             | **0.242*** (0.045)**            | **0.368*** (0.070)**                 | **447**                |
| 35–37                                        |             | 0.258*** (0.048)                | 0.380*** (0.073)                     | 402                    |
| 36–38                                        |             | 0.244*** (0.051)                | 0.387*** (0.082)                     | 351                    |
| 37–39                                        |             | 0.230*** (0.057)                | 0.448*** (0.101)                     | 297                    |

Authors’ calculations based on the SOEP data. For each specification of the sample, we provide the estimated coefficients from the OLS regression model with standard errors in the parentheses. The full set of estimates (including intercepts) can be provided upon request.

*Means significant at 0.05 level, ** means significant at 0.01 level, and *** means significant at 0.001 level. The results from the baseline model are in bold.
versus hourly earnings, and (5) rank specification at the national versus regional level. The results of this exercise are summarized below.

4.4.1 The mismatch in the stages of the life cycle at which incomes of parents and children are measured

In order to identify the sensitivity of our results to the mismatch in the stages of the life cycle at which incomes of parents and children are measured, we estimate a number of models with alternative specifications of the age at which children’s income is measured. In the first model, we consider earnings of children when they were between 30 and 32. In the subsequent models, we measure earnings of children in the second half of their 30s, i.e. when they were 35–37, 36–38, and 37–39 years old. The results of this exercise are summarized in Table 5.

The estimates reveal that rank-based measures of intergenerational mobility are much more robust to the mismatch in the stages of the life-cycle at which parental and children’s incomes are taken into account. The estimate of relative rank mobility at the age of 30–32 is a bit smaller than the baseline estimate (0.207 versus 0.242) but the difference is small compared to the difference in the estimates of IEE (0.252 versus 0.368). Moreover, the estimates of rank persistence across generations stabilize in our sample after children reach the age of 35 whereas the estimates of intergenerational elasticity of earnings keep increasing.

4.4.2 The number of years used for approximation of the permanent income

To test the sensitivity of the baseline estimates of intergenerational mobility to the number of years used for approximation of permanent income, we run a series of models, where we average earnings of children and parents over different number of years (Table 6).

The results show that rank-based measures of intergenerational mobility are quite robust to the number of years used for approximation of permanent earnings. In particular, decreasing the number of years over which parental earnings are averaged results into a decline in the estimates of relative rank mobility but the size of the decline is relatively

Table 6  Sensitivity analysis for the number of years used for approximation of permanent income

| Number of observations used for averaging of earnings | Intergenerational rank mobility | Intergenerational earnings elasticity | Number of observations |
|------------------------------------------------------|---------------------------------|--------------------------------------|------------------------|
| 3 observations for children and 5 for fathers        | 0.242*** (0.045)                | 0.368*** (0.070)                    | 447                    |
| 1 observation for children and 5 for fathers         | 0.251*** (0.047)                | 0.415*** (0.079)                    | 432                    |
| 2 observations for children and 5 for fathers        | 0.234*** (0.044)                | 0.414*** (0.070)                    | 464                    |
| 3 observations for children and 1 for fathers        | 0.227*** (0.047)                | 0.231*** (0.072)                    | 424                    |
| 3 observations for children and 3 for fathers        | 0.218*** (0.044)                | 0.280*** (0.065)                    | 477                    |

Authors’ calculations based on the SOEP data. For each specification of the sample, we present the estimated coefficients from the OLS regression model with standard errors in the parentheses. For the sensitivity analysis based on one observation for children, we took the one when they were 35 years old. The full set of estimates (including intercepts) can be provided upon request.

*Means significant at 0.05 level, ** means significant at 0.01 level, and *** means significant at 0.001 level. The results from the baseline model are in bold.
small. For example, taking parental earnings for only one year yields the estimate of the rank-rank slope of 0.227 against the baseline estimate of 0.242. The estimates of relative rank mobility also do not fluctuate much depending on the number of years used for averaging earnings of children.

The estimates of intergenerational earnings elasticity, in contrast, appear very sensitive to attenuation bias. A decrease in the number of years over which parental earnings are averaged leads to an underestimation of earnings persistence across generations. For example, with only one year of fathers’ earnings taken into account the elasticity of children’s earnings with respect to fathers’ earnings constitutes 0.231, which is 37 percent lower than the baseline estimate of 0.368.

4.4.3 Treatment of zero values in income variables

In our primary analysis, we exclude observations with earnings smaller than 1200 Euros per year. To evaluate the impact of this restriction on the mobility estimates, we perform calculations for two alternative samples (Table 7). In the first alternative sample, we include all observations with positive values of earnings. In the second sample, we also include observations with zero earnings but recode them to one before performing the logarithmic transformation.

In line with other papers in the field (e.g. Dahl and DeLeire 2008; Chetty et al. 2014a, b; Corak 2017), the results of the sensitivity analysis indicate that rank-based measures of intergenerational mobility are more robust to the treatment of zero values in income variables than elasticity-based measures. The estimates of rank mobility remain statistically significant when we include observations with low or zero values in the analysis. They also decrease in size to a much smaller extent than the estimates of IEE. In the sample with low values of earnings, the estimate of relative rank mobility is only 5 percent lower than in the baseline model whereas in the sample with zero values of earnings it is 30 percent lower. In contrast, elasticity-based measures of intergenerational mobility become insignificant as soon as we include observations with zero values in the sample.

| Table 7 | Sensitivity analysis for the treatment of zero values in earnings, all cohorts |
|---------|--------------------------------------------------|
| Sample specification | All children | |
| | Intergenerational rank mobility | Intergenerational earnings elasticity | Number of observations |
| Excluding observations with earnings below 1200 Euros (Main sample) | 0.242*** (0.045) | 0.368*** (0.070) | 447 |
| Excluding observations with zero earnings | 0.230*** (0.045) | 0.354*** (0.074) | 455 |
| Including observations with zero values | 0.167*** (0.043) | 0.093 (0.089) | 536 |

Authors’ calculations based on the SOEP data. For each specification of the sample, we provide the estimated coefficients from the OLS regression model with standard errors in the parenthesis. The full set of estimates (including intercepts) can be provided upon request.

*Means significant at 0.05 level, ** means significant at 0.01 level, and *** means significant at 0.001 level.
Table 8  Sensitivity analysis for the intensity of labor supply

| Income measure     | All children | Only sons | Only daughters |
|--------------------|--------------|-----------|---------------|
|                    | Annual earnings | Hourly earnings | Annual earnings | Hourly earnings | Annual earnings | Hourly earnings |
| Rank mobility      | 0.242***     | 0.272***   | 0.380***     | 0.327***     | 0.154**        | 0.185**        |
|                    | (0.045)      | (0.046)    | (0.059)      | (0.061)      | (0.068)        | (0.071)        |
| Earnings elasticity| 0.368***     | 0.259***   | 0.265***     | 0.238**      | 0.420***       | 0.270***       |
|                    | (0.070)      | (0.057)    | (0.071)      | (0.081)      | (0.130)        | (0.074)        |
| Number of observations | 447         | 433       | 246          | 236          | 201            | 197            |

Authors’ calculations based on the SOEP data. For each specification of the sample, we present the estimated coefficients from the OLS regression model with standard errors in the parentheses. The full set of estimates (including intercepts) can be provided upon request. * means significant at 0.05 level, ** means significant at 0.01 level, and *** means significant at 0.001 level.
4.4.4 Annual versus hourly earnings

The annual measure of earnings does not account for the intensity of labor supply at the individual level, i.e. the choice of the number of hours to work. As a consequence, one might end up comparing annual earnings of a full-time employed father with annual earnings of a part-time employed child, or the other way around. This is especially relevant for women, who are more likely than men to work part time. In order to test the sensitivity of our estimates to this issue, we repeat the analysis using hourly wages as a measure of income. The results of this exercise are provided in Table 8.

The main conclusion of this exercise is that both elasticity- and rank-based measures of mobility are sensitive to the type of earnings used but the level of sensitivity is smaller in rank-based measures. For all children together, we find relative rank mobility being 12 percent lower for hourly than for annual earnings. For IEE estimates, the difference is 30 percent and it goes in the opposite direction – we find higher mobility of children’s earnings with respect to parental earnings. This is largely due to the fact that annual earnings are more unequally distributed than hourly earnings and IEE estimates are sensitive to inequality in the earnings distribution.

4.4.5 Rank specification at the national versus regional level

In our analysis in Sect. 4.1 we defined individual ranks within the national distribution of earnings (either for all children together, or separately by gender). One may argue, however, that a given level of earnings can correspond to a relatively high rank in East Germany and to a relatively low rank in West Germany. In order to test the sensitivity of our main results to the different ways of computing individual ranks, we re-estimate the level of intergenerational rank mobility using ranks specified within regional distributions of earnings. The results of this exercise are presented in Table 9 below.

The main message from Table 9 is that the estimates of relative rank mobility across generations are not sensitive to the geographical level at which ranks are defined in the sample where all children are pooled together (0.242 versus 0.251). The estimates, however, differ somewhat depending on the geographical level used for definition of ranks in the gender-specific subsamples. For boys, the degree of intergenerational rank mobility increases if we define their ranks and the ranks of their fathers at the regional level. For girls, it is the other way around – defining ranks at the regional rather than national level leads to higher estimates of rank persistence across generations. Most importantly, the gender differences in intergenerational rank mobility do not change much: regardless of the definition of ranks, sons appear always less mobile than daughters do. One should keep in mind, however, that this might be a German case, which does not necessarily hold for other countries.

5 Conclusions

Using SOEP data, the paper provides new evidence on intergenerational earnings mobility in Germany (at both national and regional levels). Apart from the conventional measures of intergenerational mobility (the elasticity of children’s earnings with respect to fathers’ earnings), we also estimate the association between the positions (ranks) which children
| Geographical level at which ranks are defined | All children | Only sons | Only daughters |
|-----------------------------------------------|-------------|----------|---------------|
| National                                      | 0.242*** (0.045) | 0.251*** (0.046) | 0.154** (0.068) |
| Regional                                      | 0.380*** (0.059) | 0.334*** (0.061) | 0.222** (0.069) |
| Number of observations                        | 447         | 445      | 201           |
|                                               | 246         | 244      |               |
|                                               | 201         |          |               |

Authors’ calculations based on the SOEP data, all cohorts pulled together. For each specification of the sample, we provide regression model, with standard errors in the parentheses. The full set of estimates (including intercepts) can be provided upon request. * means significant at 0.05 level, ** means significant at 0.01 level, and *** means significant at 0.001 level.
and parents occupy in the earnings distributions of their own generations. As a next step, we compare the sensitivity of the estimated elasticity-based and rank-based measures of intergenerational mobility to different empirical approaches and sample specification choices. We perform the analysis for all children together and for each gender separately.

The main results reveal that—regardless of the measure used—economic outcomes of children depend on economic outcomes of their parents. For rank-based measures of mobility, we find that children born to fathers at the top the earnings distribution, on average, score 24 percentiles higher than children born to fathers at the bottom of the distribution. For IEE, the estimates show that the elasticity of children’s’ earnings with respect to earnings of their fathers is equal to 0.368 implying that a 1-percent increase in fathers’ earnings is, on average, associated with a 0.368-percent increase in the earnings of children.

While looking at the gender differences in intergenerational rank mobility we find that daughters are almost two times more mobile than sons are: the estimates of the rank association across generations are 0.154 and 0.380 accordingly. This implies that daughters are more likely than sons to move up and down the income ladder compared to their fathers. The gender pattern, however, is the opposite with the elasticity-based measures of mobility revealing that the elasticity of individual earnings with respect to fathers’ earnings is higher for daughters than for sons. Albeit the two types of measures represent different concepts of intergenerational mobility—rank mobility versus earnings elasticity—there is also a mechanical explanation behind the observed differences. Whereas IEE measures are directly influenced by the differences in the degree of inequality in the earnings distributions of parents and children, rank-based measures of mobility are free from this influence. Given that inequality is much higher in daughters’ earnings distribution than in the earnings distribution of sons it is not surprising that elasticity in individual earnings with respect to fathers’ earnings is also much higher for daughters than for sons. The same applies to regional differences between East and West Germany, with lower earnings inequality and, consequentially, lower IEE in the East. However, when combining regional and gender differences, the IEE estimates for gender-region-subsamples become blurry, whereas the rank-based mobility estimates appear robust.

From the comparative perspective, intergenerational rank mobility in Germany is higher than in Canada and the United States but lower than in Sweden. This also comes in line with previous rankings based on intergenerational elasticity estimates. With respect to gender specific patterns of intergenerational mobility, Germany holds its position between Sweden and in the United States for daughters’ mobility but it appears to be the most mobile country out of three when we look at the rank mobility of sons.

An important finding in the paper is that rank-based measures of mobility are more robust to methodological approaches and sample specification choices than the conventional IEE measures. Previous research has demonstrated it on large administrative datasets. We demonstrate that this evidence also holds for relatively small samples drawn from survey data. In line with Dahl and DeLeire (2008), Chetty et al. (2014a), and Nybom and Stuhler (2017), we find that rank-based measures of intergenerational mobility are less sensitive than elasticity-based measures to the mismatch in the stages of the life cycle when
incomes of children and parents are measured, the number of years for which incomes are considered, and treatment of zero values in income variables. We also find that rank-based measures of mobility are more robust to the use of annual rather than hourly earnings due to their insensitivity to the levels of inequality present in the parental and children’s earnings distributions. Coupled with the results for gender and regional comparisons, these findings suggest that rank-based measures yield more reliable evidence on the level of intergenerational mobility than conventional IEE measures when only survey data is available. This, in turn, makes them better candidates for studying trends in intergenerational mobility over time and across countries.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

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**Appendix 1**

See Table. 10.
| Study                        | The period used for income measurement | Age when child’s income is measured                             | Age when father’s income is measured | Elasticity estimate |
|-----------------------------|----------------------------------------|----------------------------------------------------------------|-------------------------------------|---------------------|
| **Father-son pairs**        |                                        |                                                                  |                                     |                     |
| Couch and Dunn (1997)       | 1984–1989                              | Annual earnings, multiyear average (up to six years) when sons were 18 years old and more | Annual earnings, multiyear average (up to six years) | 0.112               |
| Lillard (2001)              | 1984–1998                              | Annual earnings, multiyear average (up to six years) when sons were 18 years old and more | Annual earnings, multiyear average (up to six years) when fathers were up to 65 years old | 0.109               |
| Vogel (2006)                | 1984–2005                              | Annual earnings, multiyear average (at least over five years) when sons were 25 years and older | Annual earnings, multiyear average (at least over five years) when fathers were up to 60 years old | 0.235               |
| Eisenhauer and Pfeiffer (2008) | 1984–2006                             | Monthly earnings when sons were between 30 and 50 years old | Monthly earnings, multiyear average (at least over five years) when fathers were between 30 and 50 years old | 0.282 |
| Schnitzlein (2009)          | 1984–2004                              | Annual earnings, multiyear average over the period between 2000 and 2004, when sons were 30–40 years old | Annual earnings, multiyear average (at least over five years between 1984–2004) when fathers were 30–55 years old | 0.263               |
| Schnitzlein (2016)          | 1984–2011                              | Annual earnings, multiyear average over the period between 1997 and 2011, when sons were 35–42 years old | Annual earnings, multiyear average (at least over five years between 1984–1993) when fathers were 30–55 years old | 0.318               |
| **Father-daughter pairs**   |                                        |                                                                  |                                     |                     |
| Schnitzlein (2009)          | 1984–2004                              | Annual earnings, multiyear average over the period between 2000 and 2004, when daughters were 30–40 years old | Annual earnings, multiyear average (at least over five years) when fathers were 30–55 years old | 0.361               |

All estimates listed in the table are based on data from the German socio-economic panel.
### Appendix 2

See Table 11.

| Name of the sample            | Year of collection | Description                                                                                                                                                                                                 | Size  |
|-------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Sample A “ Residents in the FRG” | 1984               | Includes people living in private households in the Federal Republic of Germany (FRG), where the head of the household does not belong to one of the main groups of foreigners (Turkish, Greek, Yugoslavian, Spanish or Italian) | 4528  |
| Sample B “Foreigners in the FRG” | 1984               | Includes people living in private households in the FRG, where the head of the household is of Turkish, Greek, Yugoslavian, Spanish or Italian origin                                                           | 1393  |
| Sample C “German residents in the GDR” | 1990       | Includes people living in private households where the head of the household is a citizen of the German Democratic Republic (GDR)                                                                               | 2179  |
| Sample D “Immigrants”          | 1994/1995          | Includes households in West Germany, in which at least one household member has moved from abroad after 1984                                                                                                   | 531   |
| Sample E “Refreshment”         | 1998               | Includes people living in private households in Germany without any restrictions to their origin                                                                                                             | 1060  |
| Sample F “Refreshment”         | 2000               | Includes people living in private households in Germany without any restrictions to their origin but with a slightly higher selection probability for households with a non-German than with a German head | 6043  |
| Sample G “High income”         | 2002               | Includes private households with a monthly income of at least 3835 Euros                                                                                                                                 | 1224  |
| Sample H “Refreshment”         | 2006               | Includes people living in private households in Germany without any restrictions to their origin                                                                                                             | 1506  |
| Sample I “Incentive sample”    | 2009               | Includes people living in private households in Germany without any restrictions to their origin                                                                                                             | 1531  |
| Sample J “Refreshment sample”  | 2011               | Includes people living in private households in Germany without any restrictions to their origin                                                                                                             | 3136  |
| Sample K “Refreshment sample”  | 2012               | Includes people living in private households in Germany without any restrictions to their origin                                                                                                             | 1526  |
| Migration sample               | 2013               | Includes immigrants using register information of the German Federal Employment Agency                                                                                                                    | 2700  |

**Source** Composed by the authors using Haisken-DeNew and Frick (2005) and on-line SOEP Desktop Compendium (https://about.paneldata.org/soep/dtc/sample.html)
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