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Can subjective data improve inequality measurement? A multidimensional index of economic inequality*

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Abstract

To measure multidimensional inequality by a univariate index, dimensions of inequality need to be weighted. This work addresses the normative and empirical problems by estimating hedonic weights based on German microdata. In contrast to previous works, individuals' perception of inequality is used to estimate a weighting scheme including five dimensions. Aggregating outcomes by a generalized Gini and the hedonic weights, annual multidimensional economic inequality (MDEI) is calculated from 2000 to 2016. The results show that the MDEI is significantly higher in the analyzed period compared to the case of equal weights, but lower than income inequality. Over time, multidimensional inequality in Germany increased at the same pace as income inequality until 2006. Since then, the decreasing trend of MDEI is amplified under the assumption of imperfect substitution elasticity. The decomposition analysis reveals that income contributes more than any other dimension to inequality, but the exceptional reduction in unemployment is the major cause for the decline of the MDEI from 2008 onwards.

Keywords: inequality, multidimensional index, perception, hedonic weights.

JEL Classification: D31, C43, I30.

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1 Introduction

In the current debate on income inequality, numerous works have concluded that income alone is an insufficient indicator to describe human well-being and the distribution thereof (Sen, 1985; Stiglitz *et al.*, 2009). Despite the growing theoretical development and increasing data availability over the last 20 years, the task of selecting and weighting dimension of inequality is still a major issue of debate (Brandolini, 2009; Decancq and Lugo, 2013; OECD, 2011). This work uses Bourdieus capital theory to select relevant dimensions of stratification (Bourdieu, 1983) and subjective social status to weight dimensions of inequality by a hedonic regression (Schokkaert, 2007; Decancq and Neumann, 2014). The result is a composite index of multidimensional economic inequality (MDEI) for Germany.

To evaluate multidimensional inequality and the impact of the weighting scheme, this work draws on a standard functional form to make the normative decisions incorporated in the aggregation process explicit.[1] To account for correlation among dimensions, achievements are first aggregated across individuals by a weighted CES-like function and then across individuals by the Gini index, which can be rewritten as a single step procedure (Decancq and Lugo, 2012). A reverse aggregation would relax the need for micro-data at the individual level, but at the expense of ignoring individual preferences and correlation among dimensions (Aaberge and Brandolini, 2015, 195; Decancq *et al.*, 2015b, 107).

Several methods have been proposed to weight dimensions of inequality. Equal weights, just like any other arbitrary weighting scheme, rest solely on the considerations of a 'social evaluator' and makes any inequality assessment dependent from his perspective on inequality. Statistical weights on the contrary, define the relative importance by the correlation among of dimensions of inequality. Data driven weights have been criticized for carrying out a deliberately normative task by ignoring any normative considerations at all (Brandolini, 2009, 13), because a higher correlation does not imply less relevance per se since a lower correlation could also be interpreted as a sign of higher relevance. Hedonic weights combine the normative selection process of dimensions with a weighting scheme driven by individuals stated preferences. This process is not immune to problems, but has some clear advantages over the other two approaches (Decancq and Lugo, 2013).

This work contributes to the existing literature on hedonic weights in several ways. First, instead of using life satisfaction as the dependent variable of the hedonic regression, subjective social status is used. It is shown that subjective social status points towards the relational aspect of inequality, an aspect missing from applications focusing on well-being and life satisfaction. Second, by pooling individuals at the national level, a consensual weighting scheme is elaborated which yields comparable welfare and inequality measures. Third, the work allows to decompose the overall trend of inequality into changes within dimensions

[1] For recent survey of multidimensional inequality measures see Aaberge and Brandolini (2015) and Chakravarty and Lugo (2016).

and changes by the weights. This allows a reasonable comparison of the MDEI with income inequality. Fourth, by drawing on the ALLBUS dataset the development of multidimensional inequality from 2000 to 2016 in Germany can be investigated.

The results show the annual changes of multidimensional inequality over the last 16 years. According to the MDEI in the preferred specification, inequality increased until the peak in 2006 and declined during the following recession. Since 2008, multidimensional inequality has been gradually decreasing, although the trend of the MDEI in recent years depends critically on the substitution elasticity between dimensions. Assuming lower complementarity, the decline since 2008 is much smaller, but still significant. Among the five dimensions income is by far the most important dimension of the MDEI, as the hedonic regressions reveal. Education, occupational prestige, and employment status are less relevant while the socioeconomic status of the parental household is barely relevant. Moreover, the decomposition into factor shares demonstrates that the variation of hedonic weights over time translates only into marginal changes of multidimensional inequality.

This paper is organized as follows: section 2 explains the methodology of hedonic weights and motivates the choice of subjective social status and the selection of dimensions. Section 3 describes the estimation model, followed by the presentation of the data source and descriptive statistics (section 4). The results are presented and discussed in section 5, before concluding in section 6.

2 Subjective social status and individual preferences

Determining the relative importance of dimensions of inequality by individual preferences aims to circumvent the specific problems that come with normative and statistical weights. However, individual preferences cannot be elicited directly. Therefore, the collection of preferences and the transformation into weights must rely on statistical and methods. Because of this combination, this method has also been named hybrid weights (Decancq and Lugo, 2013).

One solution to elicit individual preferences is to exploit stated preferences of individuals, but stated preferences on different dimensions are rarely available and suffer from two conceptual problems.[2] The first problem is the 'physical-condition neglect'. Individuals might disregard the real influence of physical conditions, for example when they are ill or unsheltered and adopt their desires ''to take pleasure from small mercies'' (Sen, 1985, 21). Second, any subjective assessment is a reflective activity. If personal valuations are not considered, the 'valuation neglect' problem occurs (Sen, 1985, 29).

[2]Empirical application include the OECD *Better Life Index* (BLI) where individuals are asked to weight eleven preselected dimensions (OECD, 2011) and Decancq *et al.* (2013), where different weighting approaches are evaluated against stated preferences.

Hedonic weights

The alternative solution followed in this work, is to use experienced instead of stated preferences by assuming that a subjective well-being measure exists, which represents individuals' preferences consistently. If individual preferences are complete and consistent, they can be elicited by a representative subjective wellbeing (SWB) measure and allow consistent interpretations between different dimensions or outcomes for one person. However, an ordinal SWB measure is not an adequate source for interpersonal comparisons because they depend critically on adaptation and aspirations, framed by reference groups (Decancq *et al.*, 2015a). Only when controlling for such scale effects, SWB measures can be a consistent representation of individual preferences.

Theoretically, an SWB measure should represent all dimensions of life that matter consistently, but the empirical evaluation of this consistency depends critically on the actual selection of dimensions. One could also state vice versa, that all relevant dimensions should be consistently represented by an SWB measure. This acknowledges that the selection the relevant dimensions and an adequate SWB measure are both inherently normative decisions. The consistency criterion only requires that dimensions and the SWB measure complement each other, but does not relieve the 'social evaluator' to define the relevant dimensions.

Starting with (Schokkaert, 2007), various works have used life satisfaction as a variable for SWB assuming either implicitly or explicitly that this measure adequately reflects individual preferences over various dimensions of well-being. Life sanctification aims to captures an evaluative concept of SWB that is relatively persistent over time because it rests on cognitive evaluations and not emotions (Schokkaert, 2007). Feelings, emotions and other affects as such are only accounted for if individual preferences include them. In empirical applications, life satisfactions has been used to evaluate individual preferences in multidimensional settings to measure job quality (Schokkaert *et al.*, 2009, 2011), well-being (Decancq *et al.*, 2009; Fleurbaey *et al.*, 2009; Decancq *et al.*, 2015a), inequality (Justino, 2012; Maasoumi and Xu, 2015; Decancq, 2015) and deprivation (Haisken-DeNew and Sinning, 2010; Bellani, 2013; Dat *et al.*, 2015).[3] The great variation of topics including different dimensions all weighted by the same SWB measure restates the arbitrary nature of eliciting individual preferences over various dimensions and the need to justify on what grounds consistency between any subjective measure and the selected dimensions is ensured.

Nevertheless, some works using hedonic weights have selected relevant dimensions by regressing them on life satisfaction and judging their relevance by the size of the respective standard errors (Decancq *et al.*, 2013; Haisken-DeNew and Sinning, 2010). These estimations however, rely on the distinction between variables of interest and control variables, which is a normative decision indeed. Education, which has been considered as dimension (Justino, 2012; Maasoumi and Xu, 2015) as well as a control variable (Decancq and Neumann, 2016), shows that

[3] See table A.2 in the appendix for an overview of works using hedonic weights.

such a decision is not trivial. In addition, many of these estimations might suffer from empirical problems such as multicollinearity, which can lead to biased standard errors. Therefore, the only plausible method is to motivate the selection of dimensions and the subjective measure by theoretical means based on the assumed nature of wellbeing or inequality (Aaberge and Brandolini, 2015, 149) and the consistency argument (Decancq *et al.*, 2015a, 1084).

Dimension selection

This work uses Bourdieu's capital theory to select relevant dimensions of multidimensional inequality. In his seminal article, Bourdieu (1983) describes economic, cultural, and social capital as the main determinants of stratification in society. Although cultural and social capital are based on economic capital, their effect on social status is heterogeneous and the possibilities to accumulate and transmit each type of capital are different. Economic capital can always be expressed in monetary values and is usually approximated by income and wealth, but it can also include property rights, that can easily be converted into money. In addition, economic capital can be transmitted at low costs between persons, since it is not incorporated.

Cultural capital is more diverse as it includes institutionalized forms such as educational titles, objects such as art and internalized dispositions including behavioral manners. Cultural capital presupposes not only economic capital to acquire such forms, but also the means to consume such forms. Therefore, it is usually embodied and cannot be transformed easily between individuals. To approximate cultural capital this work uses education (in years), the occupational prestige, and the family background. Decancq *et al.* (2015a) for example, refrain from using occupational prestige and the family background as a dimension of inequality, because they assume that both variables only drive aspirations and consequently use them as control variables. In the light of Bourdieu's theory however, it is reasonable to think of aspirations as an elementary dimension of inequality because they define the habitus and thereby individuals' actions.

The form of social capital is more intangible than the other forms of capital, because it is usually defined as the access to and the recognition within social networks. Continuous efforts are needed to obtain and to preserve social capital because money and time alone are not sufficient to accumulate it. Due to the lack of information on networks connections of respondents, the employment status will be used as a proxy for social status. The underlying assumption is that when controlling for income effects, the additional effect of being unemployed relates to a loss of social networks, skills, and motivation (Sen, 1997).

In accordance with this theoretical foundation, subjective social status is used as the subjective measure to elicit the individual preferences over all three types of capital. From a theoretical perspective, social status describes an individuals' position within society by relative characteristics. Because many individuals agree on the relative position of a given individual, social status manifests in friendships, marriage, and economic decisions (Weiss

and Fershtman, 1998). As such, social status can be described as a shared standard of social stratification (Ridgeway and Walker, 1995). Since the 1980s various household surveys gathered social status as perceived by individuals themselves (Evans *et al.*, 1992; Kelley and Evans, 1995). Subjective social status is usually surveyed by asking the respondent to evaluate his/her position within society on an ordinal ten-point scale from top to bottom. This subjective perspective is especially valuable, because individuals must form an opinion about the overall stratification of society, before they can locate their position within this distribution. Subjective social status thereby links objective criteria with relative evaluations.

Empirically, various works have shown that material factors including income and wealth as well as non-material factors such as education and occupational status have been proven to be highly relevant for subjective social status in the European context (Evans and Kelley, 2004; Lindemann and Saar, 2014; Poppitz, 2016). Therefore, I assume subjective social status to be consistent representation of individual preferences over the three capital types. However, subjective social status lacks the explicit relation to well-being, which makes hedonic weights based on subjective social status more suitable for the case of distributional analyses while works aimed at measuring well-being might prefer a classical SWB variable such as life satisfaction.

Substitution between dimensions

To obtain the multidimensional economic inequality index (MDEI), achievements are aggregated across individuals and dimensions, using a functional form based on the generalized Gini index Decancq and Lugo (2012):

$$MDEI = 1 - \frac{\sum_{i=1}^{n} \left[\left(\frac{r^i}{n} \right)^{\delta} - \left(\frac{r^i - 1}{n} \right)^{\delta} \right] \left(\sum_{j=1}^{m} w_j (x_j^i)^{1-\beta} \right)^{\frac{1}{1-\beta}}}{\left(\sum_{j=1}^{m} w_j \mu (x_j^i)^{1-\beta} \right)^{\frac{1}{1-\beta}}} \tag{1}$$

Aggregating individual outcomes depends on two additional normative parameters, namely the degree of complementary between dimensions (β) and inequality aversion (ϵ). The first parameter defines whether dimensions of inequality are perfect substitutes ($\beta = 0$) and aggregate additively or if they are perfect complements ($\beta \to \infty$) and only the lowest achievement in any dimension determines the overall outcome. The degree of substitution is closely related to the weights, because they jointly determine the marginal rate of substitution (MRS) for any pair of dimensions j_1, j_2 :

$$\text{MRS}_{j1,j2} = \frac{w_{j1}}{w_{j2}} \times \left[\frac{x_i^{j1}}{x_i^{j2}} \right]^{\beta} \tag{2}$$

The first component of equation 2 shows that with an increasing weight of dimension one, individual i is willing to give more of dimension two for an additional unit of dimension

one. If $\beta = 0$, the MRS depends only on the weights, but as β increases the ratio between the achievements in both dimensions becomes more influential.

The Human Development Index (HDI) for example, has previously assumed perfect substitutability ($\beta = 0$) but changed to partial complementarity ($\beta = 1$) in 2010 to recognize the essential differences between dimensions, which are lost when using an arithmetic average (Kovacevic, 2010, 39). In most empirical papers, the degree of substitution has been set arbitrarily while some works include a sensitivity analysis using different β's, usually within the range between 0 and 1. Justino (2012) compares multidimensional inequality of expenditures, education and health between 1992 and 1998. Overall inequality decreased over time, irrespective of β. When the degree of substitution is adjusted from .3 to 1, the magnitude of the inequality change lowers, but not the direction of the trend. Maasoumi and Xu (2015) use an entropy maximization framework to obtain substitutions elasticities for income, housing, wealth, and education. They find a degree of substitution between .5 and .98, with the biggest differences between urban and rural Chinese households. Both examples show that like weights, normative and statistical approaches can be used to determine the degree of substitution.

Another concern is the assumption of equal substitutability between all dimensions. For Bourdieu, one major reason to distinguish between economic, cultural, and social is the fact that ''the different types of capital can be distinguished according to their reproducibility or, more precisely, according to how easily they are transmitted'' (Bourdieu, 1984, 197). In the economic sense, this implicates different marginal rates of substitution, although Bourdieu discusses inter- as well as intra-personal transmission. However, the marginal rate of substitution can vary even if β is hold constant, because of the weights (see equation 2). Since weights are estimated for each dimension, the degree of substitution between the types of capital is assumed to be equal for the sake of simplicity.

3 Estimation of hedonic weights

The hedonic weights are estimated by an OLS model with subjective social status being the depended variable. Using micro-data from individuals, the obtained estimates for the independent variables are interpreted as mutual or unilateral preferences for the respective dimensions.[4] To account for possible nonlinear relationships with subjective social status, a Box-Cox transformation in applied to the continuous independent variables (Fleurbaey *et al.*, 2009). If SSS_i is the subjective social status of individual i, the hedonic weights can be obtained from the regression coefficients ($\beta_{1,\dots,m}$), normalized by the sum of coefficients.[5] This gives the following estimation model including dimension the specific box-cox transformation (Γ_j) for continuous

[4] An ordered probit estimation model was discarded in favor of the more efficient OLS model because the dependent variable includes 10 items and is almost normally distributed. A robustness check confirms virtually similar results.

[5] Which can be described formally by $w_j = \frac{\hat{\beta}^j}{\sum_{j=1}^{m} \hat{\beta}^j}$.

variables, control variables (Z_i) and a time fixed effect (υ_t):

$$SSS_{it} = \alpha + \sum_{j=1}^{m}(\beta^j(\Gamma^j x_{it}^j)) + \gamma' Z_{it} + \upsilon_t + \epsilon_{it} \tag{3}$$

In general, the regression model replicates the aggregation function at the individual level as specified in equation 1, except for the Box-Cox transformation missing from the functional aggregation form. If including the Box-Cox specification in the aggregation, the distribution of all achievements would be transformed. However, In the case of the income dimension, this would limit the comparability to standard estimates of disposable household income inequality to a great extent. To ensure greater comparability with established inequality measures, the aggregation omits the transformation at the expense of consistency.

The issue with hedonic weights is, that they potentially suffer from typical estimation problems resulting in biased estimators and standard errors. Since neither the selection nor the weighting of dimensions relies on the standard errors, multicollinearity does not affect the weights. However, the estimators might be biased due to omitted variables or endogeneity. In addition, the bounded scale requires respondents to rescale their preferences to answer the question, which could lead to measurement errors and add a certain noise to the question (Decancq and Neumann, 2016, 586). If these problems lead to response patterns that are correlated with individuals' characteristics and personal traits, they also lead to biased estimates.

The most common approach to both problems is to control for individual time constant factors by an individual fixed effects model. Lacking panel data, one can only control for age, gender, and personality traits.[6] However, if those individual factors are considered as illegitimate sources of inequality, they would enter the model (3) as dimensions of inequality (X_i) rather than controls (Z_i). To circumvent this problem, Cavapozzi *et al.* (2015) use vignette questions which ask respondents to judge the life satisfaction of two hypothetical households. These vignette questions are then used to control for individual response patterns. They find however, that these additional controls barely change the life satisfaction estimation results. The same problems applies to subjective social status because of a similar answering scheme and the subjective nature of the question. Due to the lack of panel data and information on personal traits the estimation model relies on the control variables age, gender, the structure of the household and political interest. Since estimated coefficients are supposed to yield the importance relative to other covariates, all independent variables are z-standardized to eliminate scaling effects.

[6] Decancq and Neumann (2016) for example include responses about the control over their life, achieved what they deserve and positive attitude toward themselves.

4 Data source and proxy selection

The empirical analysis rests on the cumulation of cross-sectional waves of the German General Social Survey (ALLBUS/GGSS) from 2000 to 2016. The ALLBUS is a bi-annual representative household survey including between 2,800 and 3,900 observations per wave (Wasmer *et al.*, 2014). To get a representative sample of the total German population, sampling weights are used to account for the over-sampling of East Germany. Individuals younger than 18, older than 65 and persons in education are excluded from the sample. After deleting missing values list wise 646 to 1990 annual observations remain.[7] Despite the relatively small number of observations compared to the German socio-economic panel (GSOEP), the Gini coefficients based on both datasets yields no significant differences except for the first two waves (see Figure A.2).

Table 1: Descriptive statistics for subjective social status

	mean	variance	sd	count
2000	5.295	2.26	1.50	730
2002	6.234	2.12	1.46	646
2004	5.457	2.43	1.56	1394
2006	5.309	2.79	1.67	1595
2008	5.667	2.82	1.68	1606
2010	5.778	2.60	1.61	1462
2012	6.361	2.26	1.50	1906
2014	6.367	2.24	1.50	1964
2016	6.430	2.55	1.60	1990
Total	5.938	2.68	1.64	13293

Source: Author's calculation based on ALLBUS (2016).

Subjective social status, the depended variable of the hedonic weights estimation is surveyed by the question: ''In our society there are groups which tend to be towards the top and groups which tend to be towards the bottom. Below is a scale that runs from top to bottom. Where would you put yourself now on this scale?''. Table 1 shows that individuals tend to rank themselves in the middle of the distribution or slightly above (mean = 5.9). The distribution of responses is relatively stable over time, except of a slight increase of average subjective social status since 2012 and an increase in variance during the recession.

The independent variables include five proxy variables for the three capital types and several control variables. Income is the only proxy for economic capital since wealth data is only available for the year 2010. The monthly disposable income is surveyed by an open question, equalized by the household structure, deflated by the harmonized consumer price index (European Commission, 2014) and the top 1% incomes are winsorized. Years of schooling and the occupational status serve as proxies for cultural capital. Because years of schooling are not included in the survey, the number is imputed based on the typical length for the highest

[7] In 2000 and 2002 only half of the sample in 2000 and 2002 were asked about their subjective social status. Therefore, the effective number of observations is reduced by half in the first two waves.

educational and occupational degree obtained.[8] This method cannot account for repeated classes and other irregularities. However, differences usually have a minor impact (Pischke and von Wachter, 2008). Occupational prestige is measured by the Standard International Socioeconomic Occupational Status (SIOPS), which transforms ISCO88 occupational codes into an index ranging from 6 (low prestige) to 78 (high prestige).[9] To quantify social capital, the dummy for being employed covers all individuals that are not unemployed including part-time workers and students.[10] Finally, the socioeconomic status of the parents is approximated based on parents' occupation, which are transformed into the International Socio-Economic Index (ISEI). In contrast to SIOPS, ISEI provides a measure of socioeconomic status that considers not only prestige, but also average income and education levels of occupations (Ganzeboom *et al.*, 1992).

To verify that the selected proxies adequately represent the three latent types of capital, a principal component analysis (PCA) has been conducted. Three additional proxies were included covering the highest educational degree instead of years of schooling and the status of the family background measured either by socioeconomic prestige[11] or the highest educational degree of the parents. The PCA confirms that each of the three extracted components represent one of the three capital types (see Appendix A.1).

Before aggregating individual achievements, dimensions are rescaled by a linear transformation to prevent of scale effects. Instead of the common min-max normalization, all variables are divided by their maximum value.[12] The advantage of the latter over the min-max method is that attributes at the bottom of the distribution also get positive values (Decancq, 2015, 45).

5 Results

Weighting dimensions of multidimensional inequality

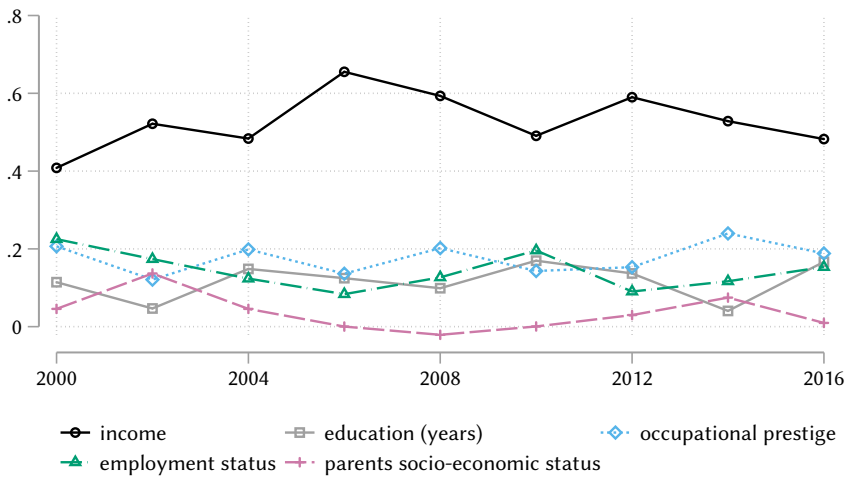
Based on model 3, I estimate hedonic weights using the pooled sample and for each year separately. Before the estimation, box-cox parameters have been determined by a maximum likelihood estimation for the continuous independent variables: income (.217), education in years (.968), occupational prestige (1.11) and parent socio-economic status (.489). In other words, highest decreasing returns for income and smaller, but still significant decreasing returns for parents' socio-economic status while the returns on occupational status and education are linear. Figure 1 shows the estimated coefficients for each wave and the five dimensions, normalized

[8] For the exact imputation methodology see the German country codebook of ISSP (2016).
[9] Based on (Treiman, 1977) and transformed using the conversion tables of Ganzeboom and Treiman (1996).
[10] Further qualitative information about the extend or duration of not being employed is unavailable in ALLBUS.
[11] Socio-economic prestige is measured by the Standard International Socioeconomic Occupational Status (SIOPS), a recode of occupations according to their prestige on a scale from 6 to 78 (Treiman, 1977; Ganzeboom and Treiman, 1996).
[12] The normalization for each outcome x of dimension j can therefore by written as: $x_j^n = \frac{x_j}{\max x_j}$.

to one. Detailed estimation results as well as the pooled sample results can be found in the Appendix (table A.3).

Income is the most important dimensions with an average weight of .53, that varies greatly over time from .40 in 2000 to .65 in 2006. After the peak in 2006, the weight for income declined from 2006 to 2010 and increased again up to .58 in 2012. Education, occupational prestige and being employed are relatively less important as their weights range between 0.11 and .17 on average while the socioeconomic status of the parents is hardly relevant. The relevance of being employed is of similar magnitude (.14) but compared to income the trend is reversed with the lowest weight in 2006.[13] While the variation over time is notable for income, the year to year changes of other dimensions are not significant in most of the years. Overall, the trend of weights during the recession year indicate a shift of individual's focus from income and status to the mere fact of being employed while the relevance of education remained constant. However, to avoid a bias due to spurious volatility between different waves caused by sample selection, the preferred weighting scheme uses pooled weights including year fixed effects as specified in model 3.

Figure 1: Normalized hedonic weights



Source: Author's calculation based on ALLBUS (2016).

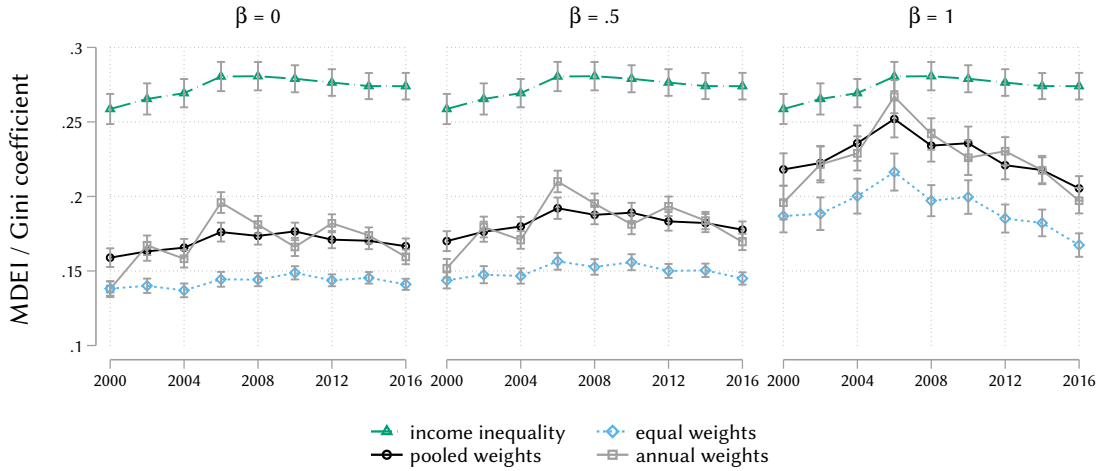
Compared to works which have relied on life satisfaction instead of subjective social status, the high relevance of income stands out. While income is higher correlated with subjective social status than life satisfaction, employment status is more relevant for the latter (Decancq and Neumann, 2016). These differences highlight the subtle but potentially influential differences between subjective measures of well-being and social status (Clark and D'Ambrosio, 2015).

[13] Alternative specifications of the employment dummy including the employment status of the spouse or partner yield similar results.

Multidimensional Inequality in Germany

Using pooled, annual and equal weights I calculate three series of composite inequality measures. Figure 2 compares these series with income inequality including bootstrapped standard errors (2000 replications). To account for different degrees of substitution, results are shown for perfect substitution ($\beta = 0$), a high degree of complementarity ($\beta = 1$), which is the standard choice for the IHDI, and an intermediate+ value ($\beta = .5$).[14]

Figure 2: Absolute development of the MDEI



Note: Development of the MDEI with annual and pooled hedonic weights, equal weights, and the Gini coefficient for disposable income. Gray whiskers show 95% confidence intervals, based on bootstrapped standard errors. *Source:* Author's calculation based on ALLBUS (2016).

Figure 2 shows that income inequality provides an upper bound of inequality with an average Gini coefficient of .273. The MDEI using pooled hedonic weights is significantly lower with an average of .225 ($\beta = 1$) whereas the equal weights index provides a lower bound of inequality estimates with .191 ($\beta = 1$). This result is not surprising since the hedonic weights reduce the MRS between dimensions (see equation 2) leading to an overall increase in inequality compared to equal weights. Using annual weights, the variation of the MDEI increases, but remains within the confidence intervals of the MDEI based on pooled weights in all years except 2006. This suggests that distributional changes within dimensions are more important to inequality changes over time than weights changes.

Of similar importance for the development over time is the degree of substitution and therefore the correlation between dimensions of the MDEI. The MRS exemplifies the relationship between correlation and weights (see equation 2). As β increases, the ratio between outcomes at the individual level dominates the effect of the ratio between weights. Assuming perfect substitution ($\beta = 0$), income inequality and the composite indexes follow a similar trend over time. Whether uni- or multidimensional, inequality has increased until 2006. Since then income inequality decreased slightly if $\beta \leq .5$, but in relation to the 95% confidence intervals,

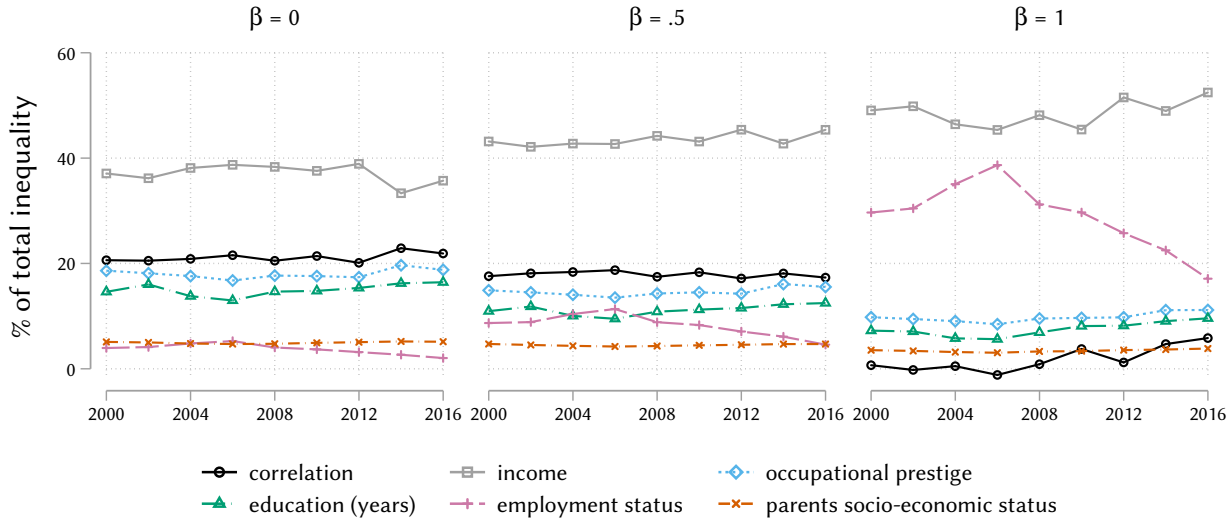
[14] The theoretically feasible minimum of substitution is $\beta = 2$, limited by the functional form. However, the interpretation of results for $\beta > 1$ does not change significantly and have therefore been omitted.

the decline is modest. Assuming imperfect substitution however, the strong increase was followed by an even greater surge in multidimensional inequality. If $\beta \geq 1$ the decrease of the MDEI since 2008 is severe, regardless of the weights used. Given the relevance of the degree of substitution, the question is, if lower correlation between dimensions or lower inequality within dimensions is causing the trend change of the MDEI.

Decomposition by correlation and dimension

To answer this question, the MDEI is decomposed using counter-factual distributions to distinguish the effects of distributional changes within each dimension from the effect of a changing correlation between dimensions. Decancq (2017) decomposes total multidimensional inequality into four components: correlation between individual preferences, variation in individual preferences, correlation among outcomes and variation in outcomes. Since this work relies on unilateral preferences, the decomposition boils down to the latter two components. Therefore, the decomposition first reshuffles individual outcomes among individuals repeatedly. Mean and standard deviation over all inequality estimates then provide total inequality minus the effect of correlation among achievements. Second, outcomes in each dimension are replaced by their respective mean, starting with the highest weighted dimension. Compared to Shorrocks (1982) factor decomposition method, this method allows decomposing factors which are aggregated non-additively, at the expense making the decomposition path dependent. However, a robustness check using the reverse decomposition path shows equivalent results.[15]

Figure 3: MDEI decomposition by correlation and outcomes



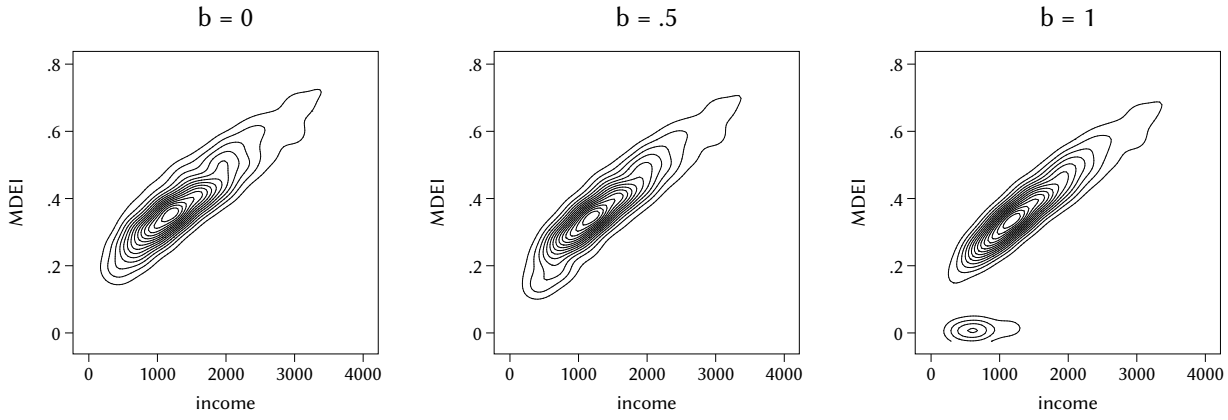
Note: Relative contribution of each dimension and the correlation between dimensions to MDEI, estimated by (1) reshuffling achievements by random and (2) eliminating stepwise the influence of one dimension. *Source:* Author's calculation based on ALLBUS (2016).

[15] Results available upon request.

Figure 3 shows the decomposition results in percentages.[16] The contribution of the correlation between dimensions to total inequality is moderate and steady at 20%. If $\beta \geq 1$, however, the contribution is significantly smaller and increasing over time meaning that the downward trend of the MDEI is cushioned by a decreasing correlation between dimensions. Of all dimensions, the highest absolute contribution comes from the income dimension with 36% on average ($\beta = 0$). Occupational prestige and education also contribute with a stable share of ~16% to overall inequality. As complementarity increases however, the relative contributions of all dimensions decrease at the expense of income (47%) and the employment status (28%). If complementarity is high ($\beta = 1$), the employment status becomes not only the second most important dimension but also the major factor of the MDEI trend with a relative contribution going down from 38% in 2006 to 17% in 2016.

Comparing the rank changes between income and MDEI also highlights the relevance of the employment dimension. Instead of using a transition matrix, which tabulates rank affiliation across percentiles, I analyze rank changes by a stochastic kernel (Quah, 1997). This non-parametric method avoids the otherwise necessary assumption of a normal distribution within each percentile and therefore allows to describe the distribution more accurately. Figure 4 shows contour plots of the bivariate density distributions over the income and MDEI distribution in 2010. The great concentration along an imaginary 45°line shows that for most of the of individuals the rank in the income distribution translates into a similar rank within the multidimensional distribution. However, as complementarity increases, several low-income individuals at the bottom of the MDEI distribution are separated. These individuals are unemployed and cannot substitute the lack of employment by outcomes in other dimensions. Only if $\beta > .5$ the segregation between employed and unemployed individuals manifests in the MDEI distribution, but also at lower degrees of complementarity, the segregation is already visible.

Figure 4: Stochastic kernel plot for the year 2010



Note: Kernel-smoothed bivariate density distribution of income and MDEI in 2010 using a Gaussian kernel and pooled weights. *Source:* Author's calculation based on ALLBUS (2016)

[16] Absolute contributions to total inequality can be found in appendix A.3.

6 Conclusion

Prior works have used life satisfaction as a benchmark variable to estimate weights for multidimensional inequality indexes by a hedonic regression. Life satisfaction is an established subjective well-being measure, but an arbitrary choice whose efficacy depends on the dimensions of inequality which have been deemed relevant. This work used subjective social status to estimate hedonic weights, which is more closely related to the topic of inequality and consistently represents the dimensions selected in this work. Compared to income inequality, the results show distinct levels and trends of multidimensional inequality in Germany.

The selection of dimensions was motivated by Bourdieu's distinction between economic, cultural and social capital. Based on his theory this work identified five relevant proxies for the three dimensions of inequality: income, education, occupational prestige, employment status and parents' socio-economic status. Using the German household survey ALLBUS, estimations indicate that income is the single most important dimension with an average weight of .52. Education, occupational prestige and the employment status together are equally important while parents' status is irrelevant.

Subsequently, the composite index of multidimensional economic inequality (MDEI) is constructed using the estimated weights and individual achievements. According to the MDEI, inequality continuously increased until 2006 and declined afterwards. In the 2000 - 2016 period average MDEI was .225, while the Gini index of disposable income was .273. Until 2006 the development of the MDEI is relatively similar for different degrees of substitution, but since 2008 substitution is a critical factor for evaluating the trend of the MDEI. When assuming high substitution between dimensions, multidimensional inequality has stagnated or slightly declined, similar to the trend of income inequality. Assuming greater complementary however, the MDEI shows a continuous and significant reduction of inequality since 2006. This result indicates that the disparity between achievements in different dimensions, especially because of the employment dimension, has decreased in recent years. The margin between income inequality and the MDEI is, among other things, related to the use of unilateral preferences since heterogeneous individual preferences would contribute to higher multidimensional inequality Decancq *et al.* (2017).

The contribution of individual dimensions is further investigated by a decomposition based on counterfactual distributions. The decomposition reveals, that the correlation among dimension contributes steadily to overall inequality while the changes over time are mainly driven by the employment status dimension. The contribution of the employment dimension remains stable at $< 6\%$ under perfect substitution, but with greater complementarity increases up to 38% in 2006 to decrease gradually to 16% in 2016. These empirical findings prove the decisive role of the degree of substitution in combination with the employment dimension and suggest that a composite index is needed to understand the contradicting developments within and between dimensions. At the same time, the high relevance of the employment

status dummy call for a more detailed investigation about the relevance and variation of social capital as a dimension of inequality.

However, two reasons limit the empirical results of this work. First, the ALLBUS data set does not allow controlling for the effect of personal traits on subjective social status sufficiently, because it lacks the panel structure to control for individual fixed effects and the choice of proxies for personal traits is limited. In addition, the estimated weights could be biased due to omitted variables, but previous studies aimed to explore the determinants of subjective social status indicate that the predictive power of the proxies, selected in this work is robust (Evans and Kelley, 2004; Lindemann and Saar, 2014; Poppitz, 2016). Finally, the ALLBUS survey lacks data for one frequently included dimension: health. While the relevance of health for life satisfaction is undoubted, this can be disputed for subjective social status. At least in Bourdieus' discussion of different types of capital health does not play a role. Therefore, I assume that the lack of health as one dimension of inequality is negligible.

By combining the subjective perspective on inequality with the factual distribution of relevant dimensions, this work provides an empirical solution to unify both aspects of inequality in a single univariate measure. This is especially relevant since numerous works in recent years have found that perceptions of inequality might be better suited to explain attitudes towards redistribution (Cruces *et al.*, 2013; Clark and D'Ambrosio, 2015) and political mobilization (Justino and Martorano, 2016). However, a strong focus on individual perceptions ignoring the distribution of other domains faces the dilemma of a ''physical condition neglect''. By combining the subjective viewpoint with factual distributions, the MDEI provides a fair middle ground to analyze in future works how changes in the perception of inequality and the actual distribution in different domains might affect economic and political developments. Future works using subjective social status could also review the impact of heterogeneous preferences compared to unilateral preferences empirically and investigate how the MDEI developed in other European countries that experienced a different evolution of labor markets during the financial and European crisis.

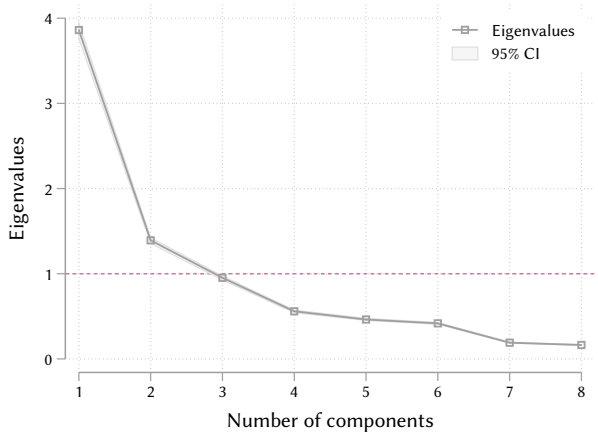
A Appendix

A.1 Principal components analysis

The principal components analysis aims to verify, if the available proxy variables share similar features, equivalent to the theoretically defined dimensions. The similarity between proxies for the same dimension should verify their quality while the dissimilarity between proxies of different dimensions should rule out multicollinearity problems in the hedonic regression. The PCA uses the total sample of non-missing observations over all waves.

With an average $KMO > .7$, all variables are sufficiently correlated to qualify for an PCA analysis (Dziuban and Shirkey, 1974). According to the scree plot two to three components should be extracted (figure A.1). The unrotated PCA results of the first component show that all variables except working status (unemployment) point towards the same direction thereby reproducing the regression results (table A.1a). After rotating the factor loadings, the "Einfachstuktur" is evident and confirms that the selected proxies adequately represent economic cultural and social capital (table A.1b).

Figure A.1: Scree plot of eigenvalues after PCA



Note: Author's calculation based on ALLBUS (2016).

Table A.1: Factor loadings of PCA

(a) Unrotated loadings

	Comp1	Comp2	Comp3
winc	0.289	-0.423	-0.289
educyrs	0.421	-0.152	0.319
isced97	0.408	-0.242	0.331
siops	0.357	-0.254	0.346
rwrkst	-0.176	0.422	0.708
pisei	0.385	0.436	-0.185
psiops	0.369	0.453	-0.187
pedu	0.361	0.319	-0.124

Source: Factor loadings after extracting three components out of eight variables by principal components analysis. *Source*: Author's calculation based on ALLBUS (2016).

(b) Rotated loadings

	Comp1	Comp2	Comp3	Unexplained
winc			-0.540	0.349
educyrs	0.543			0.188
isced97	0.578			0.172
siops	0.555			0.303
rwrkst			0.839	0.154
pisei		0.610		0.131
psiops		0.613		0.155
pedu		0.493		0.341

Note: Based on an oblimin rotation with $\delta = 0$. For better readability, lower factor loadings ($< \pm.3$) have been omitted. *Source*: Author's calculation based on ALLBUS (2016).

Table A.2: Survey of empirical applications of hedonic weights

authors	topic (Inequality measure)	weights	estimation model	data (Region)	dimensions	ord./ bin.	normalization	β	controls
Schokkaert *et al.* (2011)	job inequality (equivalent incomes)	hedonic (life sat.)	ordered logit	SONAR (Flanders)	8 job characteristics incl. log(wage)	+ / -	$\frac{x-min}{max-min}$	1	
Haisken-DeNew and Sinning (2010)	deprivation	stated preferences	ols fixed effects	GSOEP (Germany)	finance, house, consumption, health, social	- / +	by p-values	-	age, children
Justino (2012)	inequality (Theil)	arbitrary variation	-	VLSS (Vietnam)	consumption, education, health	+ / -	$\frac{x-min}{max-min}$, z-sd. + 10	$.3-1$	
Bellani (2013)	deprivation	stated preferences		SILC (Europe)	19 (finance, basics, housing, durables)	- / +	-	-	
Decancq *et al.* (2013)	preferred weights	voting		LEVO (Flanders)	8 subjective indicators	+ / -	-	1	age, sex, nationality, personality
Decancq and Neumann (2014, 2016)	well-being (equivalent incomes)	hedonic (life sat.)	box-cox, interactions	GSOEP (Germany)	income, health, (un)employment	+ / +	$\frac{x-min}{max-min}$	-	age, sex, edu, married, personality
Decancq *et al.* (2015a); Fleurbaey *et al.* (2009)	well-being (equivalent incomes)	hedonic (life sat.)	ordered logit, interactions	RLMS-HSE (Russia)	log(consumption), house, health, unemployment	+ / -	$\frac{x-min}{max-min}$	-	
Decancq *et al.* (2015c)	poverty	hedonic (life sat.)	box-cox, interactions	RLMS-HSE (Russia)	consumption, health, housing, unemployment	+ / +	-	< 1	age, sex, edu, minority
Maasoumi and Xu (2015)	inequality (entropy measure)	hedonic (happiness)	entropy min-imization	CHIOPS (China)	income, wealth, housing, health, education	+ / -	$\frac{x-min}{max-min}$	$.4-.9$ (est.)	marital status
Cavapozzi *et al.* (2015)	poverty	hedonic (life sat.)	ordinal probit, hobit	SHARE (Europe)	6 (income, housing, health)	- / +	-	-	vignette question
Dat *et al.* (2015)	child deprivation	hedonic (life sat.)	ordered logit, f.e.	YL (Vietnam)	education, health, shelter, water, work, inclusion	-	-	-	sex, rural, ethnicity, religion

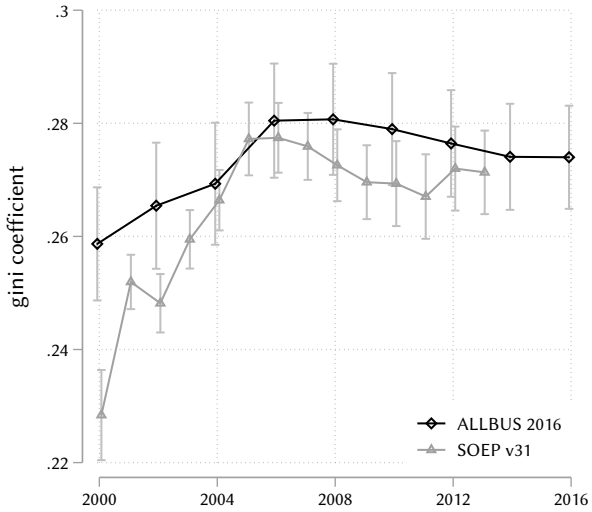
Note: Survey of empirical works which use hedonic weights to obtain a multidimensional measure of inequality or deprivation. Abbreviations: life sat: life satisfaction, ord: ordinal scaled variables, bin: binary variables, β: degree of substitution as in CES function, defined in Decancq and Lugo (2012).

Table A.3: Annual regressions for hedonic weights

dependent variable	subjective social status									
	2000	2002	2004	2006	2008	2010	2012	2014	2016	total
income	0.403	0.479	0.519	0.729	0.631	0.536	0.518	0.475	0.482	0.537
	(0.065)***	(0.063)***	(0.050)***	(0.044)***	(0.049)***	(0.051)***	(0.040)***	(0.041)***	(0.045)***	(0.017)***
education (years)	0.113	0.043	0.159	0.139	0.105	0.185	0.120	0.036	0.167	0.118
	(0.065)+	(0.068)	(0.048)***	(0.049)**	(0.049)*	(0.055)***	(0.042)**	(0.042)	(0.045)***	(0.017)***
occupational prestige	0.204	0.111	0.213	0.151	0.215	0.156	0.134	0.215	0.188	0.178
	(0.066)**	(0.074)	(0.048)***	(0.049)**	(0.049)***	(0.054)**	(0.044)**	(0.046)***	(0.044)***	(0.017)***
parents social status (ISEI)	0.045	0.126	0.049	0.000	-0.022	0.001	0.026	0.067	0.010	0.028
	(0.058)	(0.055)*	(0.043)	(0.041)	(0.043)	(0.046)	(0.036)	(0.036)+	(0.037)	(0.014)+
employed (dummy)	0.222	0.160	0.133	0.093	0.135	0.214	0.079	0.105	0.153	0.144
	(0.056)***	(0.073)*	(0.044)**	(0.043)*	(0.047)**	(0.051)***	(0.038)*	(0.040)**	(0.048)**	(0.016)***
age	-0.009	-0.059	0.061	0.016	-0.110	-0.037	-0.022	0.004	-0.069	-0.029
	(0.059)	(0.062)	(0.045)	(0.041)	(0.045)*	(0.044)	(0.037)	(0.037)	(0.038)+	(0.015)+
age^2	0.072	0.017	0.109	0.080	0.098	0.010	0.086	0.093	0.055	0.073
	(0.058)	(0.064)	(0.047)*	(0.043)+	(0.045)*	(0.048)	(0.040)*	(0.041)*	(0.045)	(0.015)***
female	0.033	0.039	0.087	0.068	0.107	-0.018	-0.014	0.057	0.021	0.043
	(0.050)	(0.050)	(0.038)*	(0.036)+	(0.037)**	(0.038)	(0.032)	(0.031)+	(0.032)	(0.013)***
no political interest	-0.158	-0.022	-0.082	-0.138	-0.108	-0.030	-0.022	-0.121	-0.120	-0.092
	(0.054)**	(0.062)	(0.041)*	(0.039)***	(0.040)**	(0.043)	(0.036)	(0.035)***	(0.037)**	(0.014)***
hh composition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
r^2	0.244	0.272	0.261	0.334	0.277	0.259	0.218	0.232	0.248	0.301
N	730	646	1394	1595	1606	1462	1906	1964	1990	13293

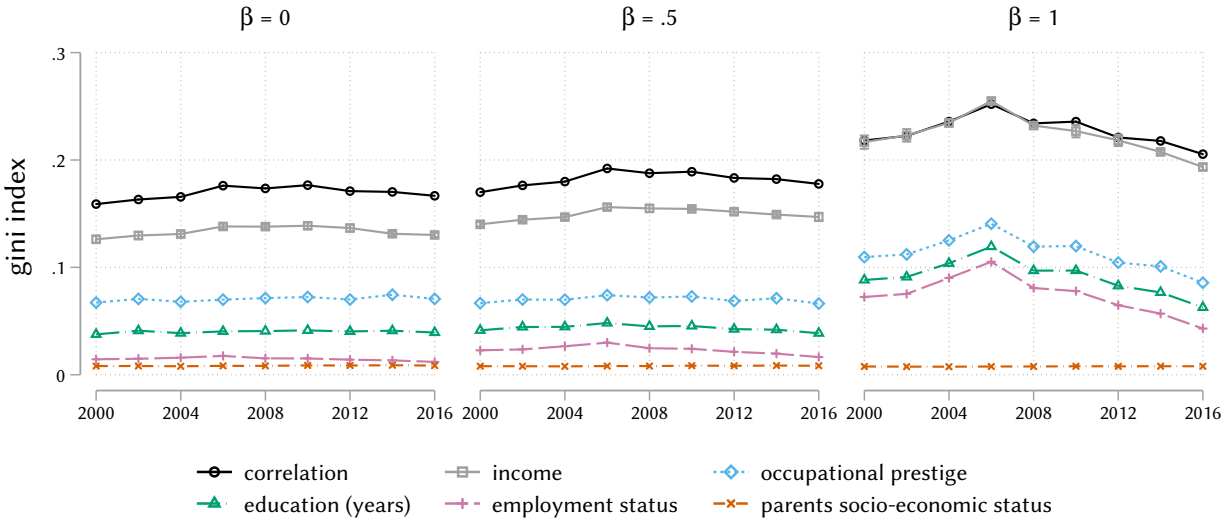
Note: + p<0.10, * p<0.05, ** p<0.01, *** p<0.001. S.E.'s in parentheses. All regressors are z-standardized. *Source:* Author's calculation based on ALLBUS (2016).

Figure A.2: Income inequality compared



Note: Gini coefficient with 95% confidence intervals based on jackknife estimates. Sample: 18 - 65 year old individuals not in education. *Source*: Author's calculation based on ALLBUS (2016) and SOEP (2016).

Figure A.3: Absolute MDEI decomposition by correlation and outcomes



Note: Absolute contribution of each dimension and the correlation between dimensions to MDEI, estimated by (1) reshuffling achievements by random and (2) eliminating stepwise the influence of one dimension. *Source:* Author's calculation based on ALLBUS (2016).

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