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Time, Income and Subjective Well-Being – 20 Years of Interdependent Multidimensional Polarization in Germany

Joachim Merz and Bettina Scherg

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Abstract

Society drifts apart in many dimensions. Economists focus on income of the poor and rich and the distribution of income but a broader spectrum of dimensions is required to draw the picture of multiple facets of individual life. In our study of multidimensional polarization we extend the income dimension by time, a pre-requisite and fundamental resource of any individual activity. In particular, we consider genuine personal time as a pronounced source of social participation in the sense of social inclusion/exclusion and Amartya Sen's capability approach.

With an interdependence approach to multidimensional polarization we allow compensation between time and income, parameters of a CES-type subjective well-being function, where a possible substitution is evaluated empirically by the German population instead of arbitrarily chosen. Beyond subjective well-being indices we propose and apply a new intensity/gap measure to multidimensional polarization, the mean minimum polarization gap 2DGAP. This polarization intensity measure provides transparency with regard to each single attribute, which is important for targeted policies, while at the same time their interdependent relations is respected.

The empirical investigation of interdependent multidimensional polarization incidence and intensity uses the German Socio-Economic Panel (SOEP) and detailed time use diary data from the three German Time Use Surveys (GTUS) 1991/92, 2001/02 and the actual 2012/13. We focus on the working individuals where the working poor requires increasing interest in the economic and social political discussion. The microeconomic two-stage selectivity corrected estimation of interdependent multidimensional risk (incidence) and intensity quantifies socio-economic factors behind.

Four striking results appear: First, genuine personal leisure time additional to income is a significant subjective well-being and polarization dimension. Second, its interdependence, its compensation/substitution, evaluated by the German Society, is of economic and statistical significance. Remarkably, besides compensation regimes, there are interdependent multidimensional polarization regimes where even higher income cannot compensate time deficits. Third, interdependent multidimensional polarization *incidence* (headcount ratio) decreased over those 20 years in Germany, however and in particular, as shown by the new minimum 2DGAP approach, interdependent multidimensional polarization *intensity* increased over those 20 years in Germany. Fourth, there are different multidimensional polarization results and developments for the poverty and affluence poles and regimes, for fulltime self-employed, employees and subsequently for further socio-economic groups. And, polarization also appears with respect to social participation.

JEL: I32, D31, J22

Keywords: *Interdependent multidimensional polarization, time and income poverty and affluence, subjective well-being, life satisfaction, minimum multidimensional polarization intensity gap (2DGAP), extended economic well-being, satisfaction/happiness, social participation, working poor and affluent, middle class, self-employment and employees, CES well-being function, two-stage Heckman estimates of polarization incidence and intensity, German Socio-Economic Panel, German Time Use Surveys 1991/92, 2001/02 and 2012/13.*

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1 Introduction

Individual well-being and its distribution in society is of particular and ongoing interest in the economic and social policy debate, its policies and scientific dispute. Thereby growing polarization is more than ever a rising social problem in society. From an economic perspective growing inequality and polarization, a drifting apart of the income scissor between the poor and the affluent, is seen as the key of lessening well-being and stagnation of standard of living of the middle class and those of the lower part of the income distribution. There is empirical evidence that individuals are less satisfied with life when income inequality is high, and that growing inequality and polarization harms economic growth and endangers social cohesion of society (see background literature).

Inequality and polarization analyses so far mainly focus on the income domain. Though income is the fundamental material resource for living, time is the immaterial companion and as elementary as income for everyday life and individual well-being. Without time there is no activity, neither to generate income, to purchase and consume market goods and services, nor to spend time with the family, to participate on social life or to follow any other activity. Both, time and income therefore are prominent dimensions of subjective well-being in pursuing happiness, the focus of our study under the polarization perspective of the poor and the affluent.

Since time and income involve each other, is there really a dependency, and if, how can we consider and quantify this interaction of time and income? “Time is money”, is compensation/substitution supported by the evaluation of German society’s subjective well-being? Are there regions where compensation won’t cope with the other dimension’s deficit? If there is no compensation, which multidimensional poverty and affluence regions are affected by? Has interdependent multidimensional polarization changed over 20 years in Germany? Who are the multidimensional poor and who are the rich? Is social participation affected by polarization? Questions, we are following in our analyses.

This study contributes to the individual well-being discussion with a methodological and empirical new investigation of interdependent multidimensional polarization with focus on time and income.¹ Time and income are bundled by a subjective well-being function which allows an interdependent compensation of its dimensions. The new contribution is threefold and encompasses in particular:

First, to respect polarization with its economic and social aspects time will be included and specified as genuine personal leisure time in addition to the traditional income measure.

¹ Our study builds on Merz and Scherg 2017, 2014 and extends the latter by the actual GTUS 2012/13 survey, which allows now the analysis of about 20 years of interdependent multidimensional polarization development in Germany, and with a new microeconomic two-stage selectivity corrected estimation of socio-economic factors of risk and intensity of the polarization poles’ poverty and affluence.

Genuine personal leisure time in particular will take care of the social participation aspect in the spirit of social inclusion/exclusion and Amartya Sen's capability approach (e.g. Sen 2008, 1985). The importance of restricted social participation become painful apparent in the recent Corona Covid 19 (Corona) pandemic.

Second, the interdependence of time and income is evaluated by the German society instead of arbitrarily assigning values. Based on a CES-type subjective well-being function, besides multiple well-being measures, a new measure of interdependent multidimensional polarization, the mean minimum polarization gap 2DGAP is proposed. This unique interdependent multidimensional polarization intensity approach ensures its interdependent relations *and* provides transparency with regard to each singular attribute, an important requirement for any targeted polarization policy.

Third, the empirical investigation of interdependent multidimensional polarization incidence and intensity encompasses 20 years and is based on the German Socio-Economic Panel (SOEP) with additional detailed time use diary data from the three available German Time Use Surveys (GTUS) 1991/92, 2001/02 and 2012/13. We focus on the fulltime working individuals with their self-employed and employees as central players in the labor market, where the working poor requires increasing interest in the economic and social political discussion.

Our polarization study is embedded in many changes and disruptions in society worldwide and in Germany after the re-unification in particular over those 20 years of investigation. The results will contribute to show how the individual time and income situation and its polarization developed before that background.

The remainder of the study is organized as follows: Chapter 1 discusses the background of the multidimensional polarization concept and application, its identification, aggregation and the multidimensional CES well-being function to evaluate the interdependence of polarization dimensions. This is the basis for discussing multidimensional polarization well-being measures and the new minimum multidimensional polarization gap (2DGAP). Chapter 2 describes the data base of the three German Time Use Surveys (GTUS) and the German Socio-Economic Panel (SOEP), justifies the time (as genuine personal leisure time) and income concept, quantifies the polarization poverty and affluence thresholds, presents the CES estimation results of subjective well-being, and characterizes the population under the further investigation: fulltime self-employed and employee workers. Chapter 3 comprises the incidence and intensity results of interdependent multidimensional polarization of time and income over 20 years in Germany including polarization headcount ratios in poles and regimes, well-being gap and 2DGAP results. Chapter 4 quantifies socio-economic influence on poverty and affluence incidence (risk/chance) and intensity (2DGAP) by a microeconomic two-stage Heckman approach with corrected selectivity. Chapter 5 concludes.

2 Background: Uni- and Multidimensional Polarization, Methodology and Applications

2.1 Polarization and Inequality

Polarization describes structural shifts so that both the upper and the lower tail of a distribution increase while the middle part decreases. Both, inequality and polarization, consider a distribution where inequality is rather about the entire distribution whereas polarization stresses the importance of both poles. Growing inequality is seen as having far

reaching and harmful consequences for the individual, the economy and society concerning social cohesion and political issues (OECD 2008, Stiglitz 2015, 2012, OECD/Cingano 2014, Thewissen 2014, Osberg 2003): Empirical evidence suggests that individuals are less satisfied with life when income inequality is high (Graafland and Lous 2019, Burkhauser et al 2016, OECD 2015, Ferrer-i-Carbonell and Ramos 2014). New OECD analyses show that income inequality has a negative and statistically significant impact on medium-term growth (“inequality hurts economic growth” OECD 2014). And, greater income inequality is significantly correlated with less cohesion of society (Bertelsmann Stiftung 2014 based on 34 countries, Berg and Ostry 2011).

There are good reasons to have a focus in particular on the lower *and* upper pole of a distribution, the poor and the rich, i.e. to have the focus on polarization. One pole, poverty, receives traditionally particular attention in policy and science. Economic, political and structural consequences of a high fraction of the poor are obvious like social stress, high social costs, lower education, poor health, lower tax revenues etc. (e.g. Mood and Jonsson 2016) and emphasize the relevance to analyze the lower pole of the income distribution. Yet, there are good arguments concerning the other pole, the affluence: different parts of the distribution are mutually dependent, high income allow power and command over multifaceted resources, the affluent have global importance and the possibility of voluntarily isolation (capacity to cop out, private provision of education, health care, gated communities) as well as direct and indirect influence to other groups of society, and, a polarized distribution of income can facilitate a sense of injustice in the population (Atkinson 2015, Atkinson and Piketty 2007, Drewnoski 1978). Both poles therefore require its special attention, at the same time a growing polarization is accompanied with the squeeze of the middle class where the middle class alike is seen as important for the stability and well-being of economy and society (Easterly 2001, Downs 1957).

First pioneering efforts of measuring polarization under the economic perspective regard the decline of the middle class (Foster and Wolfson 1992/2010) or the rise of separated income groups (Esteban and Ray 1994). In the sequence there are a number of unidimensional extensions like Wang and Tsui 2000 and Scheicher 2010 concerning the Foster and Wolfson approach, and concerning the Esteban and Ray approach like Duclos, Esteban and Ray 2004, Esteban, Gradin and Ray 2007 and Gagliarano and Mosler 2009 with a multidimensional concept. Duclos and Taptué 2015 provide a recent overview.

With regard to empirical applications there is a vast number of studies on income inequality and poverty worldwide (see the recent World Inequality Report (Alvaredo et al. 2018), Atkinson and Bourguignon 2015 for evidence, concepts and international approaches). Empirical income inequality analyses in Germany focus mainly on poverty, some on affluence and less on the self-employed.²

Though there is no doubt about the importance of the polarization issue with its many far reaching and multitude consequences for quality of life, there are comparably only a few empirical studies with focus on the poverty *and* the affluence polarization poles. However, for Germany Goebel et al. 2010 and Grabka and Frick 2008 found a growing income polarization since the 1980s with a growing disperse of the “income scissor” where the poor are going to

² Inequality analyses for Germany with focus on poverty provide e.g. Grabka, Goebel and Liebig 2019, Fratzscher 2016, Merz and Rathjen 2014a,b, Hauser and Becker 2003, with focus on the affluent Peichl and Pestel 2013, Merz Hierschel and Zwick 2005, German Federal Poverty and Affluence Report since the beginning of 2000 (Bundesregierung 2002, 2004, 2011, 2013) and with focus on self-employed Merz and Rathjen 2016, Merz 2006.

be poorer and the rich to be richer. Scherg 2014 confirms the result of growing income polarization in Germany since the 1990s even independently of choice of the poverty and affluence thresholds as well as various polarisation measurement indices. Long-term polarization analyses for Germany since the beginning of the 20st century by Dell 2007 with income tax data show, first, that the top income level before the first world war has never been reached after the second world war, and, second, that in the second half of the past century the gap between the top 1% and the following nine percentiles has been much greater as in each other developed country (but with a comparable concentration after 1980 of the anglo-saxon countries). With the perspective of the last 30 years (Socio-Economic Panel 1984-2012) an increase of income polarization appears with a distinctive development concerning liberal professions (free-lancers) as part of the self-employed (Merz and Scherg 2016).

2.2 Multidimensional Well-Being and Polarization

Though income is an important resource for many goods and services, however, there are many further attributes of life which constitute its quality, and are the focus of the multidimensional perspective. Multidimensional polarization started with analyses on poverty and inequality and has proven to be important in various multidimensional poverty studies (see the overview on multidimensional poverty and inequality by Aaberge and Brandolini 2015 and the contributions of Merz and Rathjen 2014b, Alkire and Foster 2011, Atkinson 2003, Bourguignon and Chakravarty 2003, Chakravarty and Silber 2008).

To understand poverty in a broader sense, empirical multidimensional poverty studies incorporate various poverty attributes. An example is the European Union Laeken social inclusion/exclusion indicator set with educational disadvantages, health inequalities, unemployment and worklessness as poverty dimensions (Atkinson 2003) or the UNDP Multidimensional Poverty Index (MPI) based on the Alkire and Foster 2011 proposal.

Multidimensional well-being as developed by many institutions is characterized by a set of living condition indicators which forms dimension-wise well-being indicators (like the OECD's Better Life Index, OECD 2015). The counting and the composite index approaches aggregate with or without weighting the dimensions to bundle the single indicators. Thereby the counting approach summarizes the number of failed minimum standards of those regarded dimensions. The composite approach (as the Human Development Index HDI by the United Nation Development Programme (UNDP)) aggregates proportions of the population below the dimensional minimum standards (Aaberge and Brandolini 2015, Bossert, Chakravarty and D'Ambrosio 2013, Atkinson 2003). See Chakravarty 2018 about multidimensional analyses of well-being in general.

The importance and need to respect the interaction of well-being dimensions to describe well-being intensively emphasized already Sen 1985 with his capacity approach and Stiglitz et al. 2010 with focus on targeted policies. Higher interdependence of dimensions means higher concentration of deprivations which could make overall poverty even be worse, a result of Garcia-Gomez et al. 2021. They analysed the dependencies of single dimensional distributions in a joint well-being distribution with copula functions. Their multidimensional poverty study (with dimensions income, material needs and work intensity) found, that EU countries (2008-2014) "with a high poverty incidence tend to experiment also a higher degree of dependence between the dimensions of poverty" Garcia-Gomez et al. (2021, p. 193). Bayesian Network analysis (Ceriani and Gigliarano 2020) is another recent approach to disentangle the structure of the dependence among the well-being dimensions. Still other approaches focus on the interaction of dimensions within econometric specifications of subjective well-being (Clark 2016), or recently on defining the middle class by

multidimensional quantiles of a well-being index based on a principal component approach (Edo et al. 2021). Respecting the dimensions' interdependence in an explicit functional form of subjective (social) well-being characterizes the multidimensional poverty approaches by Lugo and Maasuomi 2009 and Merz and Rathjen 2014a,b. The Merz and Rathjen approach is the basis we are now following for the multidimensional polarization case in our study. Altogether, there are many studies on multidimensionality with focus on poverty, but only rarely on interdependent multidimensional polarization with focus on the poor and the affluent (but e.g. Gigliarano and Mosler 2009, Merz and Scherg 2014).

2.3 Multidimensional Polarization: Identification and Aggregation³

Multidimensional polarization identification of those who belongs to the respective poles builds on the multidimensional poverty discussion (Kakwani and Silber 2008, Deutsch and Silber 2005). There are two *multidimensional poverty identification* approaches (Bourguignon and Chakravarty 2003). In the so-called *union approach (strong focus axiom)* a person is judged to be multidimensional poor as soon she or he is deprived in at least one dimension (see Figure 1b for the two-dimension case, the shaded area with the corresponding poverty thresholds z_1 and z_2). The *intersection approach*, by contrast, judges an individual to be multidimensional poor when she is deprived in all dimensions (Figure 1 a). Intermediate concepts are conceivable as well.

Since the union and intersection approaches seem to be too rigid as identification strategies for most cases, an intermediate approach would be most appropriate (Lugo and Maasuomi 2009). It allows compensation (weak focus axiom) for all ranges in one dimension given poverty in the other (Figure 1 c). In the *compensation approach* thus, besides being poor (for instance) in both dimensions (intersection), an individual is multidimensional poor when she cannot compensate poverty in one dimension by the other non-poverty dimension. If a gap in one dimension can be compensated by another's dimension quantity above the dimension threshold, then a person is off poverty (Figure 1 c, unshaded area). Thus, the multidimensional poverty line (threshold) in the two-dimensional case runs through the intersection of the dimension thresholds $z = (z_1, z_2)$ dividing the poor (shaded areas in Figure 1 a,b,c) and the non-poor (unshaded areas in Figure 1 a,b,c).

Following our approach in Merz and Scherg 2014 we extend multidimensional poverty identification to *multidimensional polarization* in a similar way as for poverty, and identify the other pole of the distribution, the affluent, by mirroring the poverty areas along the single affluence thresholds $r = (r_1, r_2)$ (Figure 1 d,e,f). The kind of relationship between dimensions does not change with respect to the intermediate, union and compensation ranges. Figure 1 also allows the identification of unidimensional polarization with regard to the x_1 dimension (poor to the left of z_1 , affluent to the right of r_1) and to the x_2 dimension (poor below z_2 , affluent above r_2).

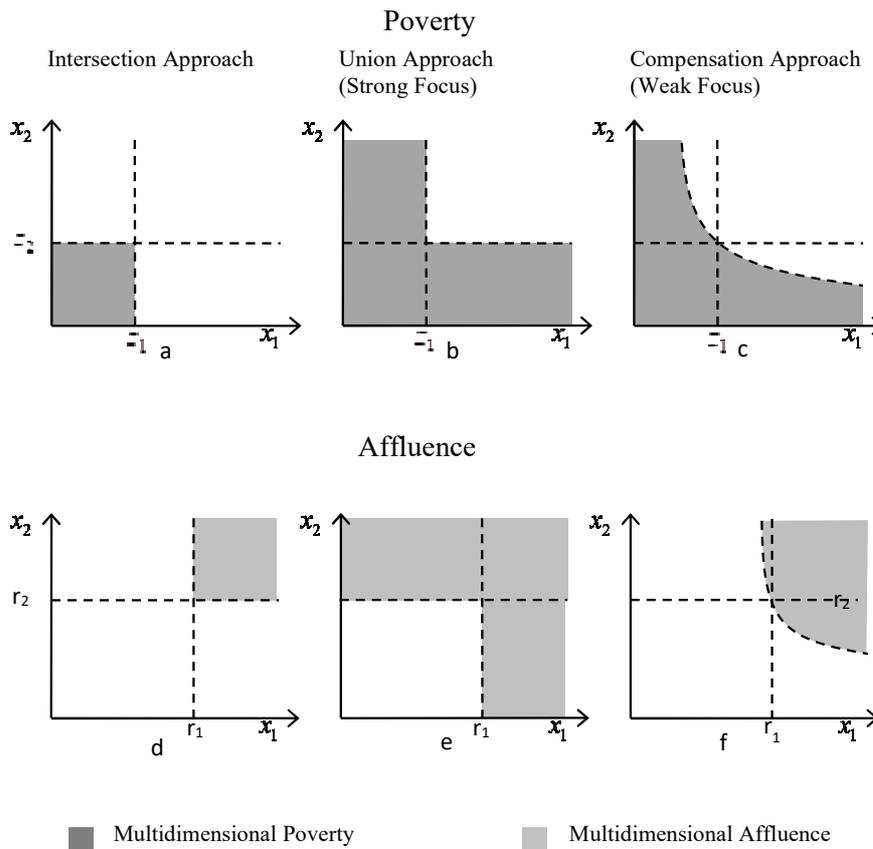
We focus on the compensation approach (weak focus axiom), where the degree of compensation will be evaluated empirically by the German population. For the compensation approach, Figure 2 illustrates the poverty *and* the affluence situation (two-dimensional case). Again, the shaded areas in Figure 2 describe the poor under the poverty line and the affluent

³ To better understand the results of the empirical analysis the main methodological background of multidimensional polarization appears here again without further explicit citation of its introduction in Merz and Scherg 2014.

above the affluence line. With respect to single poverty and affluence lines (thresholds) the two-dimensional presentation in Figure 2 allows interesting insights of compensation and no compensation of the other dimension's deficit. Take for

Figure 1: Identification of Multidimensional Polarization - Multidimensional Poverty and Affluence

Figure 1: Identification of Multidimensional Polarization – Multidimensional Poverty and Affluence



Note: x_1 and x_2 are the quantities of the first and second dimension, z_1 and z_2 are the corresponding poverty and r_1 and r_2 the corresponding affluence dimension thresholds.

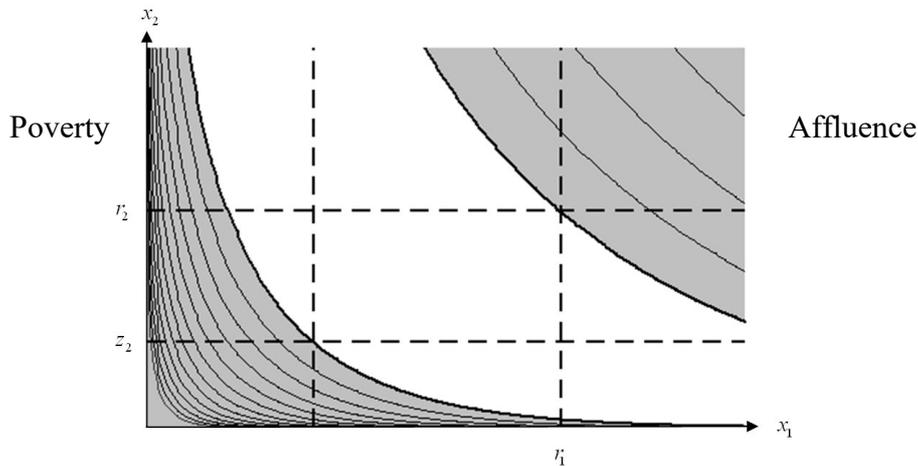
Source: Merz and Scherg 2014.

example the shaded area above the poverty x_1 (e.g. income)-line z_1 : though income is above the poverty line it cannot compensate the time (x_2) deficit to escape multidimensional poverty (Figure 1 c). Or take the affluence compensation above the income threshold (right of r_1 in Figure 1 f). The time deficit (being below the time affluence line r_2) is considered to be compensated by a high income above the multidimensional affluence line to be assigned interdependent multidimensional (IMD) affluent. The time deficit, however, is considered to be not compensated by high income below the multidimensional affluence line; there is no more multidimensional affluence.

The poverty and affluence lines (in the two-dimension case) which delimit the poles (Figure 2) can be interpreted as *interdependent multidimensional (IMD) isopolarization contours*,

which are isoquants of an underlying well-being function, a function which comprises all polarization attributes and

Figure 2: Multidimensional Isopolarization Contours – Compensation Approach (Weak Focus Axiom) in the Two-Dimension Case



Source: Merz and Scherg 2014

evaluates their interdependent relation. This well-being function is specified for our analyses in the next section.

2.4 Multidimensional Polarization: Multidimensional Subjective CES Well-Being Function

The crucial question to delimit the polarization poles is, how can we specify the interaction describing isopolarization contours? With focus on the compensation approach, this section specifies a particular multidimensional subjective well-being function, a Constant Elasticity of Substitution (CES) function, whose multidimensional isopolarization contours, as described above, identifies the individuals in the polarization poles, both the poor and the affluent. The CES well-being function accounts for the interdependence of the polarization attributes and will be the key element in our multidimensional polarization well-being polarization indices (described in the next section) and the foundation for our new minimum 2DGAP polarization approach which follows.

The CES-type well-being function with its individual well-being indicator V_i (weak focus axiom) is based on the multidimensional poverty approach by Merz and Rathjen 2014a (or e.g. used by Bourguignon and Chakravarty 2003) and evaluates the interdependence of dimensions by

$$(1) \quad V_i = \gamma \left[w_1 (x_{1i})^{-\rho} + w_2 (x_{2i})^{-\rho} \right]^{-\frac{\nu}{\rho}}$$

with the substitution elasticity $\sigma = 1/(1 + \rho)$ measuring the curvature of the isoquants, ρ as a substitution parameter of the isopolarization contours with $\rho \neq 0$, γ as a constant, ν as returns to scale, x_{1i} and x_{2i} as the polarization attribute quantities, and the coefficients w_1 and $w_2 = 1 - w_1$ as distribution and weighting parameters describing the skewness of the isopolarization contours.

The degree of substitution between genuine personal leisure time and income is measured by the Hicks' elasticity of substitution as the relative change in the proportion of the two attributes dependent on the relative change of the corresponding marginal rate of substitution. With the CES function, the intersections of all isoquants with a ray from the origin have the same marginal rate of substitution. Substitution/compensation, however, is different between different rays from the origin, which allows different degrees of substitution with different time and income ratios.

Compared to other specifications the CES function has the virtue that the elasticity of substitution/compensation can be estimated empirically and is not predetermined by a certain value, like a value of one as with the Cobb-Douglas function (a special case of the more general CES function). Since in our empirical application we estimate the CES function by a log-Taylor approximation, the results can even be interpreted as being a more flexible specification like a translog one.⁴

Following the CES well-being compensation approach to quantify the interdependence of the polarization attributes, the aggregated *multidimensional poverty line* and the aggregated *multidimensional affluence line* will be defined at their respective thresholds by

$$(2) \quad V_z = \gamma \left[w_1 (z_1)^{-\rho} + w_2 (z_2)^{-\rho} \right]^{-\frac{\nu}{\rho}} \quad \text{and} \quad V_r = \gamma \left[w_1 (r_1)^{-\rho} + w_2 (r_2)^{-\rho} \right]^{-\frac{\nu}{\rho}}$$

resulting in the two isopolarization contours, the isopoverty and the isoaffluence contours, which cross the poverty threshold intersection at $z = (z_1, z_2)$, or respectively the affluence threshold intersection at $r = (r_1, r_2)$. All individuals with their calculated multidimensional well-being $V_x = V(x_{i1}, x_{i2})$ below the isopoverty line are assigned to be poor, above the isoaffluence line to be affluent, and together assigned to be polarized (see Figure 2).

2.5 Multidimensional Polarization Measures Based on a Multidimensional (CES) Well-Being Function

Once the multidimensional poor and affluent are identified as above, for the measurement of multidimensional polarization the individual situation has to be aggregated across the dimensions and individuals of a population. Multidimensional polarization incidence then is characterized by a population headcount ratio and multidimensional polarization intensity by measures based on the mean poverty gap (from $V_z - V_i$) and the mean "affluence gap" (from $V_i - V_r$) (see Merz and Scherg 2014 for such a set of different multidimensional polarization measures).

Here we use two multidimensional polarization well-being measures: P_{median} , which considers broad polarization poles below and above the medians, and P_{poles} , with focus nearer the tails of the distribution which considers the individual polarization gaps to distinct poverty and affluence threshold lines.

P_{median} the *multidimensional well-being polarization index (median)* is defined as

⁴ For a further discussion, reasoning and justification of the CES well-being function with multidimensional poverty application see Merz and Rathjen 2014a.

$$(3) \quad P_{median} = \frac{1}{n} \sum_{i=1}^n \left[\frac{V(x_{i1}, x_{i2}) - V(m_1, m_2)}{V(m_1, m_2)} \right]^\alpha,$$

where $V(\cdot)$ is a (CES) well-being function as in Equation 1, m_i is the median value of the polarization attributes, and n is the population size. The exponents α serves as a polarization aversion coefficient with $\alpha = 1$ as an average relative polarization gap in well-being units, and with $\alpha > 1$ reflecting a higher aversion against strong polarization. The greater the distance from the median well-being to the individual well-being, the greater is this index which is the multidimensional well-being extension of the unidimensional Wang and Tsui 2000 polarization measure.

P_{poles} the *multidimensional well-being polarization index (poverty and affluence threshold lines)* with respect to the isopolarization contours V_z and V_r is defined by

$$(4) \quad P_{poles} = \frac{1}{n_{poor}} \sum_{i \in poor} \left[\frac{V(z_1, z_2) - V(x_{i1}, x_{i2})}{V(z_1, z_2)} \right]^\alpha + \frac{1}{n_{rich}} \sum_{i \in rich} \left[\frac{V(x_{i1}, x_{i2}) - V(r_1, r_2)}{V(x_{i1}, x_{i2})} \right]^\beta$$

with α and β reflecting the aversion against strong polarization. P_{poles} is about well-being units, whereas the correspondent unidimensional Scheicher 2010 polarization index refers to income units. See Merz and Scherg 2014 for further discussion and other absolute and relative multidimensional well-being polarization measures.

The construction principle of this and other indices which mirrors gap measures from poverty analysis to the analysis of the affluent, reveals a general problem of measuring any gap for the affluent. Whereas a poverty gap is restricted to the maximum interval z , the affluence gap would be unbounded if the reference would be the affluence threshold (further implications are discussed e.g. in Peichl et al. 2010). Thus, the second part of our multidimensional polarization index refers to the individual situation $V(x_{i1}, x_{i2})$ and not to the threshold level $V(r_1, r_2)$ ensuring affluence percentage ratios in the interval $[0, 1]$.

2.6 Minimum Multidimensional Polarization Gap (2DGAP)

The virtue of measuring multidimensional well-being and any well-being gap by a CES-type (or other) well-being function, is that it respects and quantifies the interdependence of multiple well-being attributes by a one value well-being index. Such a monovalent well-being index is a good candidate for a number of poverty/affluence/polarization measures like above. However, such an aggregation of dimensions into a one well-being value is criticized and questioned about really measuring “multidimensional” poverty, affluence or polarization. In fact, transparency for each singular attribute within the multidimensional approach is blurred by such a monovalent index. It is blurred because well-being indices based on the well-being gap $V_z - V_i$ respectively $V_i - V_r$ are unaltered for all the individuals with different time (x_{2i}) and income (x_{1i}) combinations but with the same well-being level V_i . However, transparency is desirable for each well-being attribute in a manner which would allow a targeted attribute specific poverty/affluence/polarization policy.

The following multidimensional gap development unfolds the singular attributes of a well-being gap to obtain a unique interdependent multidimensional (IMD) intensity measure with its transparent singular attributes. This approach is based on our minimum poverty 2DGAP concept proposed in Merz and Rathjen 2014b.

The mapping of the multidimensional well-being to its (two) singular dimensional space allows another appealing integrated approach for describing multidimensional polarization intensity. It consists of a unique distance between the individual situation and the poverty threshold respectively the affluence threshold.

As an illustration consider the two-dimensional case from the compensation approach and its attributes' space as in Figure 3 and regard the poverty situation at $x = (x_1, x_2)$ for an individual. With respect to both dimensions there is a fan of distances from that point $x = (x_1, x_2)$ to the interdependent multidimensional (IMD) isopoverty threshold. Each distance yields the same well-being difference $V_z - V_i$. However, each distance requires that different single attribute intensities need to be overcome in order to escape multidimensional poverty. Thus, a unique distance has to be found.

The *shortest* path between $x = (x_1, x_2)$ and the corresponding point $p = (p_1, p_2)$ at the isopoverty threshold contour is prominent in Figure 3 and is such a unique distance. It requires the minimum input intensities in a sense of a minimum combined input "length" in order to escape multidimensional poverty. A natural measure for that length is the Euclidian distance of the singular attributes $c = [a^2 + b^2]^{0.5}$ with the distances a and b as the singular poverty attribute gap intensities.

The solution for the shortest (or closest) length is characterized by the orthogonal path from the tangent at $p = (p_1, p_2)$ to $x = (x_1, x_2)$ (poverty case) respectively from the tangent at $p^r = (p_1^r, p_2^r)$ to $x^r = (x_{i1}^r, x_{i2}^r)$ (affluence case)

$$(5a) \quad c = \|c\| = \left[(p_1 - x_1)^2 + (p_2 - x_2)^2 \right]^{0.5} \\ = \left[(p_1 - x_1)^2 + (f(p_1) - x_2)^2 \right]^{0.5} = \min!$$

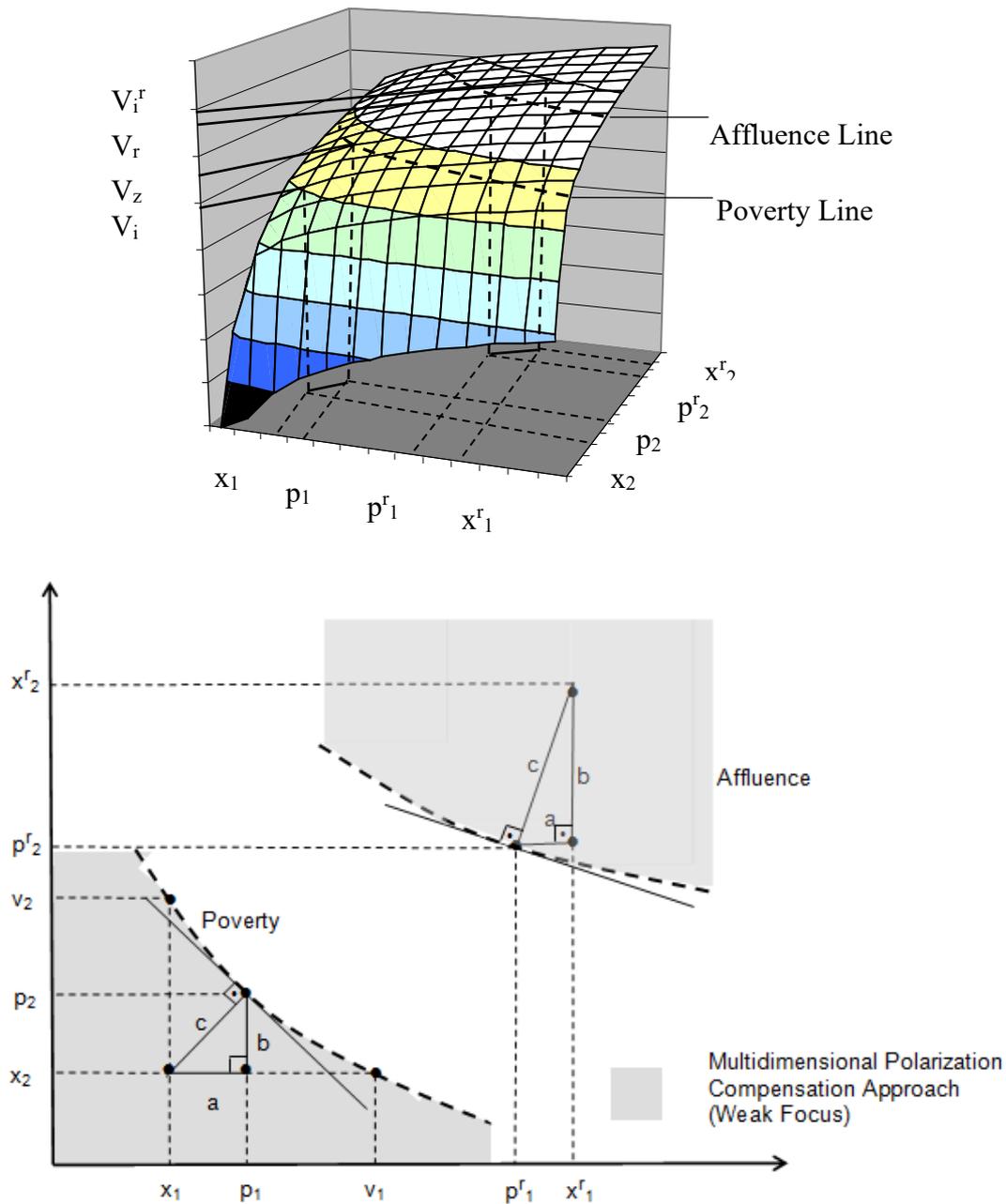
where $f(p_1 | V_z)$ is the isothreshold contour with regard to ordinate values x_2 (time) of the CES multidimensional well-being function (Equation 1)

$$(5b) \quad f(p_1 | V_z) = \left(\left(\left(\frac{V_z}{\gamma} \right)^{\frac{\rho}{\nu}} - w_1 p_1^{-\rho} \right) / w_2 \right)^{\frac{1}{\rho}}.$$

The tangent solution p_1 (respectively p_1^r) of the minimizing problem then allows to calculate c by Equation (5a) for a respective $x = (x_1, x_2)$. Note, because of the quadratic distances, Equation (5a) is the solution for the poverty as well as for the affluence situation. Since the proposed CES well-being function is well behaved, there is always a unique solution for the minimum 2DGAP (distance c).

The distance c is called the **minimum multidimensional poverty respectively affluence 2DGAP** (for two polarization dimensions), which is the measurable two-dimensional minimum mapping of the well-being distance between the individual well-being and the aggregate isopoverty respectively isoaffluence well-being threshold contour.

Figure 3: Multidimensional Polarization: Well-Being Gap and Minimum 2DGAP



Source: Merz and Scherg 2014; top figure is based on our CES estimates with 2001/02 GTUS time and income data.

Once $p = (p_1, p_2 = f(p_1 | V_z))$ is found the singular poverty respective affluence attribute gap intensities can be calculated by

$$(6) \quad a = p_1 - x_1 \quad \text{und} \quad b = f(p_1) - x_2$$

For the *poverty case* the 2DGAP might be defined relative to the maximum 2DGAP distance c_{\max} , which is the distance from the origin $(0,0)$ to the respective orthogonal slope of the IMD isopoverty threshold:

$$(7a) \quad c_{rel} = c / c_{\max} \quad \text{where} \quad c_{\max} = \|c_{\max}\| = \left[(p_1)^2 + (f(p_1, V_z))^2 \right]^{0.5} = \min!$$

with its corresponding **relative singular poverty attribute gap intensities**

$$(7b) \quad a_{rel} = \left[a / p_1 \mid a_{max} \right] \quad \text{and} \quad b_{rel} = \left[b / f(p_1, V_z) \mid b_{max} \right].$$

For the *affluence case*, however and as discussed, there is no comparable genuine maximum distance since any affluence well-being or 2DGAP gap faces the problem of an open top interval.

To retain the population polarization singular attribute contributions in the multidimensional approach we use a straight forward aggregation by the sum of the respective 2DGAP pole means, the mean minimum polarization 2DGAP:

$$(8a) \quad C = \frac{1}{n_{poor}} \sum_{i \in poor} c_i + \frac{1}{n_{rich}} \sum_{i \in rich} c_i$$

with its singular aggregated components

$$(8b) \quad A = \frac{1}{n_{poor}} \sum_{i \in poor} a_i + \frac{1}{n_{rich}} \sum_{i \in rich} a_i, \quad B = \frac{1}{n_{poor}} \sum_{i \in poor} b_i + \frac{1}{n_{rich}} \sum_{i \in rich} b_i.$$

The Benefit: Visibility of Singular Attributes of Interdependent Multidimensional Polarization

The minimum 2DGAP distance c itself measures the shortest multidimensional gap as the length of all dimensional gap intensities in combined attribute units but without direct interpretation in terms of a money or time-space. However, and this is the benefit of our approach, both sides of the right-angled triangle (the distances a and b of Figure 3), are measurable and interpretable in its singular dimension. Thus, beyond the compact interdependent multidimensional polarization description of the minimum 2DGAP, there is an additional singular dimension feature: each singular unidimensional attribute is transparent and visible from the two sides a and b , of the minimum 2DGAP triangles.

In these triangles, with a as the amount of the first attribute, and b as the amount of the second attribute, the path to escape poverty or back to the affluence threshold is minimized while respecting its interdependence with its substitution/compensation.

In our application the singular dimensions behind the two sides a and b of the minimum 2DGAP triangles will be income in money units (EURO) for a , and time in time units (e.g. minutes) for b . This information and transparency then allow singular dimension targeted anti-polarization policies taking into account its multidimensional interdependence. It tells a policy maker how the population evaluates the relative importance of and interdependence among different poverty dimensions to lift an individual out of poverty/affluence. We discuss possible anti-polarization policies in our concluding section.

3 Data Base, Time, Income and Subjective Well-Being Concept and Definition and Population Under Investigation

3.1 Data Base

The German Socio-Economic Panel (SOEP)

The German Socio-Economic Panel (SOEP) provides representative individual longitudinal data for all persons older than 16 years living in German households. The representative panel

study started in 1984 and provides subjective as well as objective information about the individual living conditions in Germany (Goebel et al. 2019).

Since appropriate subjective well-being data are only available within the German Socio-Economic Panel we use SOEP for the CES well-being estimation. Although in principle we could use SOEP for our further analyses we prefer to use in addition time use diary data from all three available German Time Use Surveys (GTUS) (with no appropriate well-being information available) since the time use diaries provide more additional in-depth information. The CES well-being estimation with SOEP 2002 data finally uses 10,831 individuals.

The German Time Use Surveys (GTUS) 1991/92, 2001/02 and 2012/13

The German Federal Statistical Office conducted three large representative time use surveys, the German Time Use Surveys 1991/92, 2001/02 and 2012/13 (Ehling, Holz and Kahle 2001, Ehling 2003, www.forschungsdatenzentrum.de). Therein all respondents older than 11 years in a household note their daily routines in diaries using their own words for two working days and a Saturday or Sunday. Person and household questionnaires provide socio-economic background information. The final available data comprise 1991/92: 6,774 households with 15,366 persons and 30,732 diaries; 2001/02: 5,144 households with 11,908 persons and 35,685 diaries; 2012/13: 4,774 households with 10,705 persons and 32,103 diaries.

3.2 Time, Income and Subjective Well-Being – Concept, Definition and Poverty and Affluence Thresholds

Income and its poverty and affluence thresholds

Income as the material resource is in the focus of traditional well-being analyses and is the central dimension in various poverty studies (see above). Since the affluent are commonly defined in monetary terms and (among others) as controlling a large amount of material resources, in particular income and wealth, income is a natural and our candidate as a polarization dimension for both poles, the poor and the affluent.

Income poverty studies commonly use monthly household net equivalence income with equivalence scales like the OECD scale⁵ and identify a person as income poor if her net equivalence income is below 60% of the median income of all households (Bundesregierung 2004, XV). The 60% median line of the monthly household net equivalence income is therefore adopted in this study as the *income poverty line* (threshold) (Table 1). For the sake of comparison, all subsequent income information for 1991/92 and for 2012/13 is adjusted to 2001/02 price levels.

Whereas there is common agreement about the income poverty line, there is a longstanding and still open discussion about a respective affluence line. The German government explicitly focused for the first time on affluence in addition to poverty in their first “Poverty and Affluence Report” (Bundesregierung 2002). From that period on, top incomes gained increasing attention not only in Germany (Atkinson and Piketty 2007, Dell 2007, Merz, Hirschel and Zwick 2005). Several affluence lines were proposed in this literature, including affluence lines as a multiple of an income fraction, such as 200% or 150% of mean median income, or as a top income percentile. As a pragmatic approach, we are choosing 150% as the cut-off for the median monthly household net equivalence income affluence threshold line.

⁵ With a weight 1 for a household head, a weight of 0.5 for additional household members aged 15 years or older, and a weight of 0.3 for all others.

This affluence threshold is also used by the income polarization studies of Goebel et al. 2010 or Grabka and Frick 2008. Table 1 provides the empirical time, income and subjective well-being thresholds.⁶ Remarkably, the median income behind increases in the first ten years from 1991/92 to 2001/02 and then decreased till 2012/13 but to a higher level than 20 years ago.

Time and its poverty and affluence thresholds

Without time neither income is realised nor spent for consumption and leisure. With intensified labor market conditions as well as squeezed leisure, not income but rather time will be a scarce resource and phenomenon like time stress, time poverty or speed-up of all day living circumstances gain increasing importance (Linder 1970, Rosa 2005)⁷. Time, as mentioned, is the general precondition for any activity and enables and restricts – as well for the poor as to the affluent alike – all desired activities: “Die Zeit ist die formale Bedingung à priori aller Entscheidungen überhaupt (Time is the formal condition à priori of all decisions at all)” (Immanuel Kant 1724-1804). Being important, time – in different specifications – was already the subject in other multidimensional poverty studies like Goodin et al. 2008, Burchardt 2008, Harvey and Mukhopadhyay 2007, Bittman 1999 or Vickery 1977. Recently Masuda et al. 2020 explore the relationship between varying time, income and life satisfaction and identified specific well-being subpopulations.

Our study explicitly includes time but instead of a broad leisure time concept we propose *genuine personal leisure time* as being essential to the multidimensional approach (introduced in Merz and Rathjen 2014a,b). Genuine personal leisure time is a last resort of no obligations and personal leisure of freedom and accounts for social participation in particular in the sense of social inclusion/exclusion and the mentioned Amartya Sen’s (Sen 1999, 1985) capacity approach.⁸ We are convinced that social participation is of importance for the poor *and* the affluent and their integrated social life.

Time poverty occurs when genuine leisure time – defined as the time left after all paid and unpaid market and nonmarket commitments have been met – is below a given threshold level and does not allow or limit its social participation in society. Correspondingly, time affluence occurs when genuine personal leisure time is above a given threshold level.

Compared to income the discussion about a time poverty or even time affluence threshold (line) is still at its infancy (Bittman 1999 mentioned not 60% but 50% for the time poverty line). To be comparable to our income poverty and affluence line we chose likewise 60% of the median genuine personal leisure time for poverty and 150% of the median as the time affluence line though such lines are certainly debatable. Table 1 provides the empirical time thresholds. The time median behind increases in Germany over the investigated twenty years 1991/92, 2001/02 and 2012/13.

⁶ The calculation of the time and income thresholds uses the total German population to ensure comparisons with other studies (like the German Federal Poverty and Affluence Report, Bundesregierung 2002) and its thresholds.

⁷ „Harried lifestyle, by hurried time, use more natural resources, generate more waste, and leave less time to care for the Earth we all share“, Gaylord Nelson, Earth Day founder and former U.S. Senator (cited in: de Graaf 2003, backpage).

⁸ Time in our study is genuine personal leisure time which is detailed in the individual GTUS time use diaries and includes activities of the main categories “Contact, Conversations, Sociality” or “Media Use, Free-time Activities” in GTUS 1991/92, the categories “Social Life and Entertainment”, “Participation in Athletic Activities e.g. Outdoor Activities”, “Hobbies and Games“ and “Mass Media“ in GTUS 2001/02, and “Social Life, Conversation and Entertainment”, “Participation at Sport Activities”, “Hobbies and Games” and “Mass Media” (codes 6, 7, 8) in GTUS 2012/13.

Table 1: Income, Time and Multidimensional Well-Being, Poverty and Affluence Lines (Thresholds) – Germany 1991/92, 2001/02, 2012/13

	1991/92	2001/02	2012/13
Median Net Equivalence Income (in € per month and prices 2002)	1,109.64	1,322.58	1,217.42
Median Personal Leisure Time (in minutes per day)	265	310	320
Income Poverty Line (=60% Median Net Equivalence Income)	665.78	793.55	730.45
Time Poverty Line (=60% Median Personal Leisure Time)	159	186	192
Well-Being Poverty $V^{\text{poor}} = f(I^{\text{poor}}, L^{\text{poor}})$	6.704	6.827	6.799
Income Affluence Line (=150% Median)	1,664.46	1,983.97	1,826.13
Time Affluence Line (=150% Median)	397.50	465	480
Well-Being Affluence $V^{\text{rich}} = f(I^{\text{rich}}, L^{\text{rich}})$	7.402	7.538	7.506

Source: GTUS 1991/92, 2001/02 and 2012/13 own calculations in 2002 prices, weighted data. The time and income poverty lines and affluence lines (thresholds) are calculated for median income by total population, for median genuine personal leisure by the available older 11 years population.

Why interdependent time and income polarization?

Time restricts and enables all market and non-market activities. The more time is spent for income activities the less is available for leisure and vice versa. This trade-off is well-known and is central in the microeconomic optimal allocation and Becker's 1965 household production approach. Thus, there are good reasons to suspect compensation/substitution between time and income in principle, the empirical investigation will detect its degree.

Subjective well-being and interdependent time and income polarization

As discussed above, the trade-off will be quantified in our study by a CES well-being (utility) function with interdependent time and income as input factors. Instead of arbitrarily chosen different trade-off weights with different compensation degrees (as in Bourguignon and Chakravarty 2003, Lugo and Maasoumi 2009), we let the individual data from German society identify the degree of interdependence and substitution between income and genuine personal leisure time.

The Socio-Economic Panel (SOEP) is asking for satisfaction with regard to different topics, like income satisfaction as well as a general question about life satisfaction. As common in the happiness/satisfaction literature (e.g. Clark et al. 2008, Frey and Stutzer 2005) we also use the 11-point scale general life satisfaction information of the SOEP questionnaire for our subjective (CES) well-being estimation.

An estimation of individual well-being on such a discrete scale requires rather a type of ordered response modelling. Yet, the Kmenta 1967 Taylor series approach allows a simple OLS estimator of the log transformed non-linear CES well-being function as

$$(9) \quad \ln V = \ln \gamma + \nu \delta \ln I + \nu(1-\delta) \ln L - \frac{1}{2} \rho \nu \delta (1-\delta) [\ln I - \ln L]^2 + \varepsilon ,$$

with $I = x_{i1}$ for income and $L = x_{i2}$ for genuine personal leisure time (ε is the error term) providing efficient estimates.

The estimated CES well-being function (Equation 1)⁹ results in

$$(10) \quad V = f(I, L) = 3.550 \cdot \left(0.519 \cdot I^{0.297} + 0,481 \cdot L^{0.297} \right)^{\frac{0.108}{0.297}}.$$

Significantly estimated coefficients together with fulfilled further consistency rules quantify the relevance of the substitution/compensation between time and income. The population-based evaluation of the substitution/compensation between genuine leisure time and income yields a substitution elasticity of $\sigma = 1.422$, which indicates a slightly higher substitution, a slightly more pronounced substitution, than in the Cobb-Douglas case ($\sigma = 1$)¹⁰.

The estimated input coefficients, the weight $w = 0.519$ for income and $(1 - w)$ for personal leisure, indicate a certain dominance of income. However, the evaluated time contribution is not that far away from a balanced 50% situation, and reflects the importance of time. The SOEP estimated CES parameters then are used to calculate individual well-being levels with the respective individual time and income data of the three GTUS time use diaries for all further analyses. Table 1 provides the multidimensional CES well-being poverty and affluence levels. Subjective well-being poverty and affluence lines, due to changing poverty and affluence thresholds, increase in the first ten years from 1991/92 to 2001/02 and then decreased till 2012/13 to a higher level than 20 years ago.

3.3 Population Under Investigation: Fulltime Working Self-Employed and Employees

The **fulltime working**, the economic active population will be the population under the further investigation because the active population actually experiences work and leisure and therefore, rather than others, are affected by the trade-off between the two dimensions. Moreover, the working poor gained increasing attention at least in Germany. Recent German 2020 data show for them even an 8% risk of poverty of the active population above 18 years, i.e. about 3.1 Mio. working individuals are poor (destatis.de 2021), a remarkable number of being poor despite working. The situation of the other pole, the working affluent is rather unknown. Thus, we will provide results for both distributional poles and focus on fulltime workers, on the full economic active (with more than five working hours a day).

Self-employed and employees are the two main groups in the labor market. Furthermore with respect to the self-employed, because the self-employed in principle have a different time sovereignty with possible different polarization pattern than that of employees' we explicit investigate the situation of these two important population groups. In addition, though there are a multitude of studies about employees, empirical studies about the self-employed are rare. Yet, there are studies of the self-employed: international, e.g. Parker 2004, Hamilton 2000; national, e.g. Merz 2017, 2007, and further studies of our Research Institute on

⁹ To make the evaluation of the polarization situation from 1991/92 until 2012/13 comparable we choose the estimated CES evaluation parameters at the midterm year, the respondents' data of SOEP 2001/02 (all working) for all three analysis years. The CES estimates uses the active population because its working individuals directly experience the trade-off between income and time rather than the total population with its not working individuals.

¹⁰ Perfect substitution: ($\rho = -1, \sigma = \infty$), Cobb-Douglas case with ($\rho = 0, \sigma = 1$), no substitution at all (complementary input factors, $\rho = \infty, \sigma = 0$).

Professions (Forschungsinstitut Freie Berufe, FFB, Leuphana University Lüneburg, www.leuphana.de/ffb) with its research results about the self-employed, freelancer and entrepreneurs.

4 Interdependent Multidimensional Time and Income Polarization Incidence and Intensity: Headcount Ratios, Well-Being Gap and Minimum 2DGAP Results – 20 Years in Germany

The development of interdependent multidimensional (IMD) time and income polarization over 20 years in Germany is now analyzed. Two kinds of information are of prominent interest in distributional analyses to describe the extent of polarization, of being poor or affluent: the incidence (who is affected by) and its intensity (how large is its magnitude (severity, deepness)). We start with the incidence of IMD polarization (with headcount ratios in poles and regimes) followed by the analysis of its intensity (with well-being gap and minimum 2DGAP). All results refer to fulltime (>5 hours a day) workers.

4.1 IMD Polarization Incidence – Headcount Ratios in Poles and Regimes

The picture of all individual fulltime workers data in the actual GTUS 2012/13 is presented in the scatter plot Figure 4a together with its multidimensional poverty and affluence lines (thresholds) based on its CES population evaluation. As discussed, the crossing of the presented single time and income poverty and affluence lines define the IMD poverty and IMD affluence lines, the two-dimensional projection of the respective CES subjective well-being contours. Figure 4a and quantified in Figure 4b provide headcount ratios in single interesting polarization regimes of time and income compensation and no compensation with Figure 4b for all three years of the analysis.

2012/13: As the overall data scatter plot 2012/13 shows the majority of individuals belongs to the “middle class”, the area between both IMD lines. However, and with the numbers of Figure 4b, almost one every five (19.1%) belongs to the IMD poles. The majority of the IMD polarization individuals are IMD poor: 11.6% of all with 7.5% IMD affluent.

Distinct IMD polarization differences are obvious between the self-employed and employees in 2012/13 (Table 2 and Appendix Table 2a with measures for all three survey years): the IMD polarization incidence (headcount ratio) of the self-employed (32.77%) is about twice as much as that of the employees (16.84%) in 2012/13. That is, almost every third fulltime working self-employed is assigned to be in both IMD poles. In other words, for employees the “middle class” is more pronounced than for the self-employed. The higher polarization incidence of the self-employed compared to the dependent fulltime workers is also given in both single poles (Figure 4b, Table 2, 2012/13).

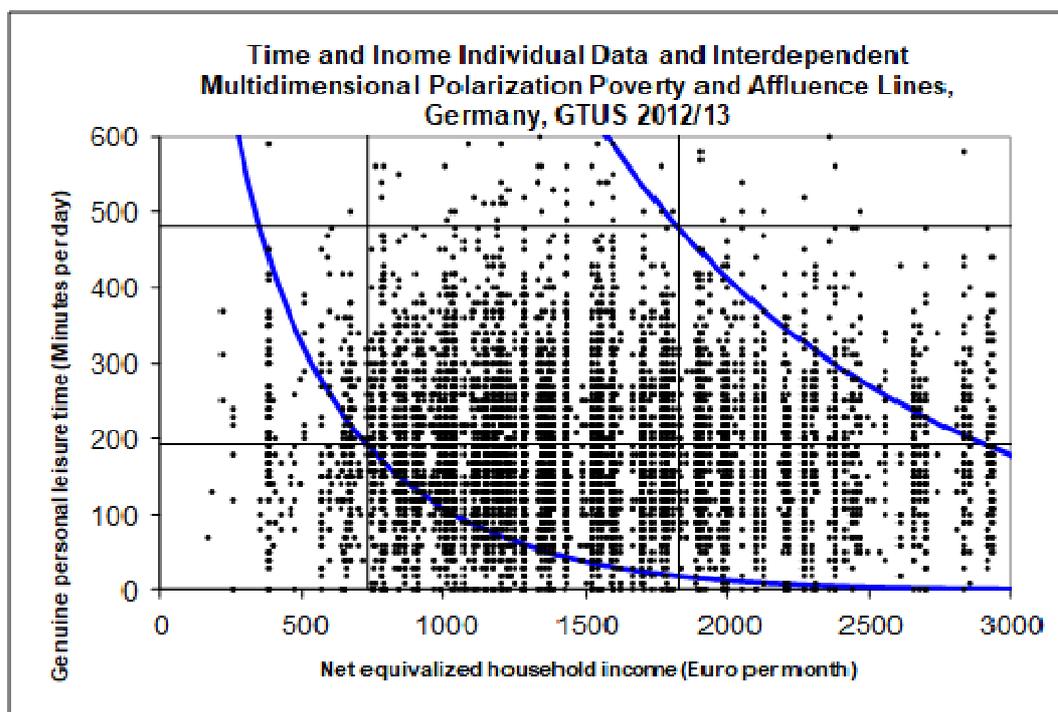
In all three survey years there is a similar picture (Appendix Table 2a): a remarkable higher IMD polarization incidence of the self-employed compared to that of the employees in both IMD poles as well as with respect to the majority of unidimensional time and income dimensions.¹¹

Over 20 years, IMD polarization incidence decreases from 20.74% to 19.04%, a slight decrease only, however, a decrease of high significance (Table 2, Figure 4c). Yet, it is not a steady decrease, from 2001/02 IMD incidence increased showing some u-shaped development over 20 years (Figure 4c and Appendix Table 2a). More distinct IMD

¹¹ The exception is unidimensional time 2001/02 and 2012/13 of the affluent.

polarization differences are visible for subgroups: The incidence of poverty and affluence not only is remarkably higher for the self-employed than the employees in all three survey years (roughly twice as much higher), but the *IMD polarization development* in the respective poles is remarkably different as well: Whereas employee poverty decreases by 20% (index 79.5, 1991/92=100, Table 2) self-employed poverty even increased by 47% (index=147, 1991/92=100), an eminent rise of self-employed poverty. The IMD affluence fraction decreases for both groups, however, by far more pronounced for the self-employed with 44% against 2% for employees.

Figure 4a: Survey Time and Income Individual Fulltime Workers Data and Interdependent Multidimensional (IMD) Polarization Lines – Germany 2012/13



Source: GTUS 2012/13, fulltime workers survey data and estimated CES well-being contours, own representation.

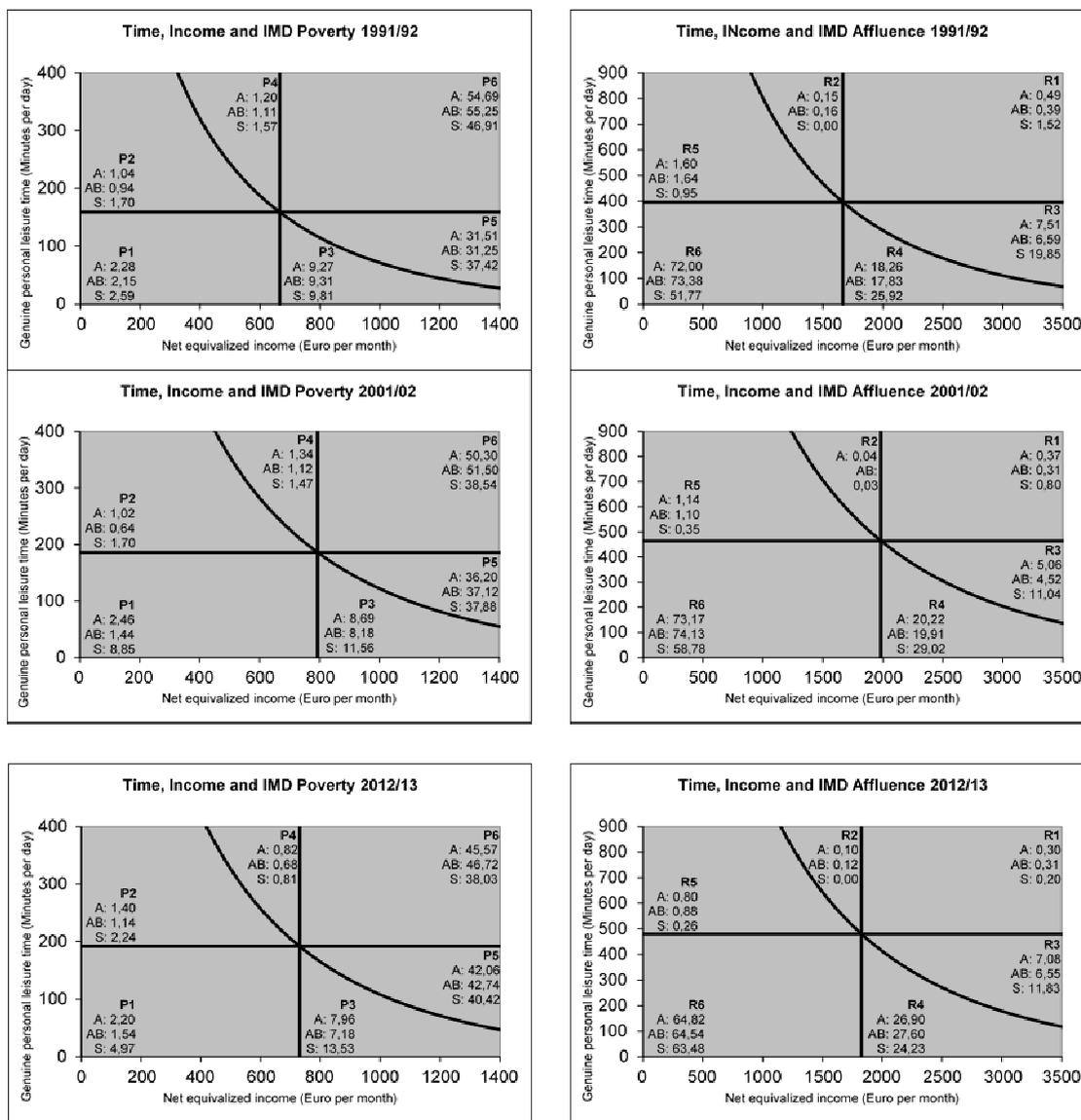
So, over 20 years in Germany IMD polarization incidence declines slightly but significantly, i.e. we face a slightly rising share of the fulltime working middle class (stronger for employees than self-employed). In particular, the self-employed show a strong and eminent incidence tendency to the lower end of the distribution, from a strong diminished affluence pole to the middle class, and from the middle class to a strong growing poverty pole.

Whereas *multidimensional* polarization incidence decreased the *unidimensional time* and *unidimensional income* polarization incidence increased – in other words, the unidimensional middle class declined, the multidimensional middle class increased– over those 20 years with a pronounced level of time poor headcount ratios (Table 2).¹² Yet, the unidimensional result is

¹² The headcount ratio of the unidimensional time poor is quite high (2012/13: 53.42%) and naturally depends on the debatable activity basket respected (see footnote 7). A time poverty threshold of 50%, instead of the chosen 60%, would reduce that incidence to 35.78. In fact, this is quite a difference (16%), which is characterized by a practically change between poverty regime P5 (time poor but above IMD poverty) to regime P6 (no deficits at all). However, the multidimensional IMD poverty incidence will virtually remain at

not always different to the multidimensional evidence: e.g. self-employment income decreases which corresponds to an IMD incidence decrease over 20 years.

Figure 4b: Multidimensional Polarization Incidence: Headcount Ratios in Poverty and Affluence Regimes – All Fulltime Workers (A), Employees (AB) and Self-employed (S) – Germany 1991/92, 2001/02, 2012/13



Source: GTUS 1991/92, 2001/02 and 2012/13, A=all, AB=employees, S=self-employed, own presentation.

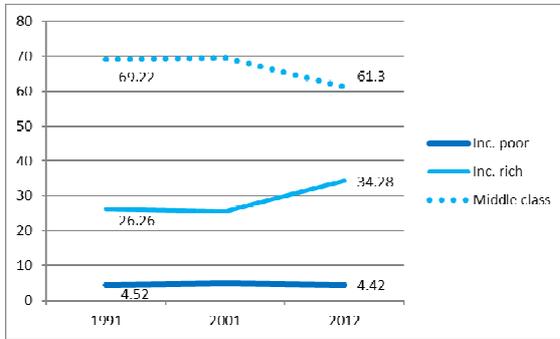
The lesson so far: respecting the interdependence of polarization dimensions strengthens the polarization incidence (self-employed development: IMD poor (+) and unidimensional time and income poor (+)) and lessens or even changes the polarization picture (employees' development: diminishing IMD incidence (-) vs. increasing unidimensional time and income

11.6% (difference 0.19% only) and thus support the robustness of our multidimensional results concerning time deficits.

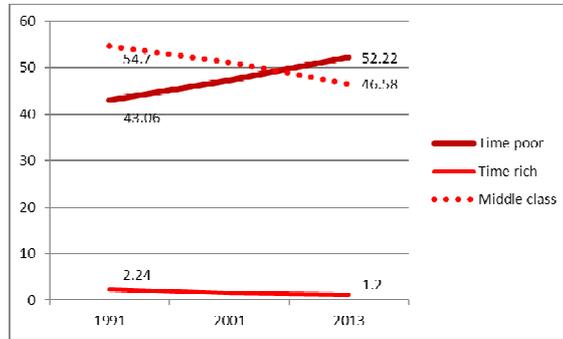
incidence (+)). Neglecting the interaction of polarization dimensions thus would deliver a misleading polarization picture with respective ineffective economic and social policies.

Figure 4c: Multidimensional Polarization Incidence: Headcount Ratios – Germany 1991/92, 2001/02, 2012/13

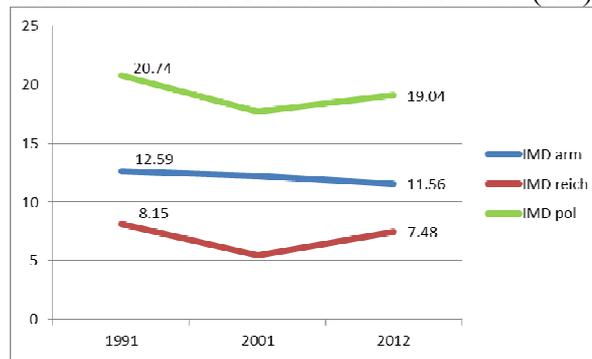
Unidimensional Polarization Incidence: Income



Unidimensional Polarization Incidence: Time



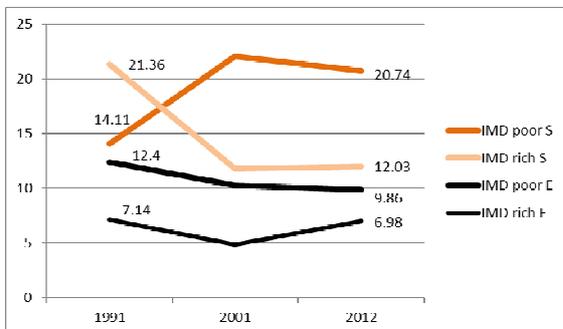
Multidimensional Polarization Incidence (All)



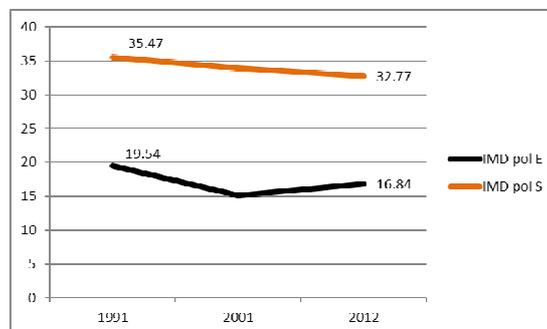
Multidimensional Polarization Incidence: Headcount Ratios – Self-employed and Employees – Germany 1991/92, 2001/02, 2012/13

Self-employed and Employees

IMD poor, IMD rich



IMD polarization (All)



Source: GTUS 1991/92, 2001/02, 2012/13, IMD=interdependent multidimensional; own calculations, fulltime working (working hours > 5 hours per day), weighted data.

Headcount ratios in poles and regimes: Poverty

Summarizing both poles of a distribution naturally hide the relative importance of the single poverty and affluence poles. In addition, single poverty and affluence regimes of different compensation remain undiscovered, which, however, provide interesting and striking results and developments in the single poles for both labor market groups (Figure 4b). We start with the poverty pole and its compensation situation.

Poverty regime P1: A regime of particular interest within the poverty pole at first is the regime where individuals are time as well as income poor: About 2.2% of all fulltime workers are poor in both dimensions, the “hardcore” IMD poor (2012/13, regime P1, Figure 4b). The IMD headcount ratios of the two labor market groups therein develop over the 20 years with opposite direction: employees’ headcount ratio dropped from 2.15% to 1.54%, the headcount ratio of the self-employed, however, almost doubled from 2.59% to 4.97%, a remarkable difference.

Nota bene, fulltime workers (more than 5 working hours the day) are behind that number who despite working are poor (“the working poor”). The picture is even more striking when the unidimensional time and income development is regarded (Table 2): the self-employed headcount ratio of the income poor increased from 5.86% to 8.01% (regimes P1, P2, P4); the headcount ratio of the time poor self-employed increased alike from 49.8% to 58.9% within the 20 years (time poor employees from 42.7% to 51.5%). The high incidence of time poor individuals, self-employed and employees, emphasizes the time dimension as being a particular important dimension of multidimensional poverty.

Poverty regime P3: Poverty regime P3 is of particular importance: here income even above its poverty line does not compensate time poverty to leave IMD poverty. Again, the self-employed are affected by in particular. The respected self-employed of being not income poor but with a time deficit not compensated increased from 9.81% to 13.53%, but decreased for employees from 9.13% to 7.18% in 20 years. This reveals in particular a growing not compensated time pressure of the IMD poor self-employed and again a diametral development between self-employed and dependent workers over those 20 years in Germany.

Different factors will be behind the increased number of those IMD poor self-employed with not compensated time deficits, like an increased outsourcing of certain services linked with a growing pressure to perform, a growing number of “independent” contractors (“Scheinselbstständigkeit”) and just work pressure of the self-employed in particular through a growing globalization and pressure of competition.

Poverty regime P5 detects another situation of time poverty. Here income above its poverty line compensates time poverty, yet still being time poor but not IMD poor. The headcount ratio in this regime increased from about 32 to 42% in 20 years.

Taking together the situation of those who are not income poor but time poor (P3 IMD poor and P5 IMD not poor): in 2012/13 remarkably 50%, half of the fulltime working population, are time poor even earning an income above the poverty line. And, the increase of that group by 22% over 20 years indeed stresses the growing importance of genuine personal leisure time for subjective well-being and the measurement of interdependent multidimensional polarization.

Headcount ratios in poles and regimes: Affluence

Are those differences between the two labor market groups also visible in the affluence pole? First, compared to the IMD poverty pole only a relatively small fraction of the self-employed and of the employees are time as well income affluent (affluence regime R1). Second, the self-employed headcount ratio in the affluence R1 regime (the “hard core” IMD affluent) decreased stronger than that of the employees supporting the discussed tendency to the lower tail of the distribution.

Affluence regime R4: One regime concerning the compensation situation of the affluent is of particular interest: Affluence regime R4. In this regime a higher income (above the affluence income line) does not succeed to compensate the time rich deficit to achieve IMD affluence. This applies to a quarter of the self-employed 1991/92 and 2012/13 and even more in between (2001/02). Though the R4 incidence of self-employed remains over 20 years, employees in contrast increased from 18% to 28%, a remarkable result of growing time pressure of the income rich dependent workers.

Affluence regime R3: The fraction of income affluent self-employed who, however, compensated their time rich deficit to be assigned IMD affluent decreased from about 20% to 12% (employees remains about 6%); another brick to the importance of time and the tendency to poverty of the self-employed. Figure 4b and Table 2 show further details in other time and income regimes.

A word about “compensation”: compensation is an assignment according the population revealed evaluation of time and income via the estimated CES subjective well-being function. Such an assignment corresponds to assignments as common in the poverty literature and is not necessarily an expression of an individual actual or possible compensation.

4.2 IMD Polarization Intensity – Well-Being Gap and Minimum 2DGAP

The chapter above was about the incidence of IMD polarization. This chapter provides information about the intensity, the magnitude of interdependent multidimensional polarization. In principle, polarization intensity measures the distance an individual is below the poverty line respectively is above the affluence line. The longer this distance, the deeper is polarization. In other words, the broader the gap, the nearer is the tail end of the distribution, the more intensive then is polarization. The proposed two intensity measures, which takes into account the interdependent multidimensional case, the well-being gap indices and the new minimum 2DGAP, are applied now (Table 2 and Appendix 2a with measures for all three survey years).

IMD polarization intensity - well-being gap

The CES well-being function unifies time and income (or more dimensions) in a monovalent well-being index. A respective gap simply measures the distance between well-being value at the IMD polarization line and well-being at a multidimensional poverty or affluence situation. Out of many conceivable approaches to measure such a distance (see e.g. Scherg 2014) we discussed two interdependent multidimensional polarization indices which refer to the median well-being P_{median} and to the IMD pole well-being lines P_{poles} via the respective CES well-being indices $V(.)$. Table 2 shows the values 2012/13 and its development from 1991/92, Table 2a for all three survey years.

First, both well-being polarization measures refer to a stronger polarization of the self-employed as compared to the employees (2012/13). Second, interestingly, measured polarization intensity development over those 20 years differs according its reference: For employees there is a significant decrease only with respect to the median (P_{median}), but for the self-employed there is a significant decrease only with respect to the multidimensional poverty and affluence lines. Because the pole well-being measure P_{poles} accentuates the farther ends of the distribution, the results indicate that multidimensional polarization in 20 years changes the self-employed pole position more distinct than that of the employees. Taking both groups together the two polarization well-being indices change only marginally and not significantly.

Table 2: Uni- and Multidimensional Polarization Incidence and Intensity: Headcount Ratios, Well-Being Index and Minimum 2DGAP – All Fulltime Workers (A), Employees (E) and Self-employed (S) – Germany 2012/13 and its development from 1991/92

	All			Employees			Self-employed		
	Measure 2013	Index 1992 =100	sig.	Measure 2013	Index 1992 =100	sig.	Measure 2013	Index 1992 =100	sig.
Unidimensional Income Polarization Headcount Ratio									
Income poor	4.42	97.79		3.37	80.24		8.01	136.69	*
Income rich	34.28	130.54	***	34.46	138.84	***	36.26	76.69	***
Income	38.7	125.73	***	37.83	130.36	***	44.27	83.31	***
Unidimensional Time Polarization Headcount Ratio									
Time poor	52.22	121.27	***	51.46	120.49	***	58.82	118.27	***
Time rich	1.2	53.57	***	1.31	59.82	**	0.46	18.7	***
Time	53.42	117.92	***	52.77	117.53	***	59.38	113.58	**
Multidimensional Polarization Headcount Ratio									
IMD poor	11.56	91.8	***	9.86	79.5	***	20.74	147	***
IMD rich	7.48	91.8	***	6.98	97.8	***	12.03	56.3	***
IMD	19.04	91.8	***	16.84	86.2	***	32.77	92.4	***
Multidimensional Polarization Well-Being Index									
P _{median} (%)	3.23	98.4		3.07	96	***	4.17	96.3	
P _{poles} (%)	5.04	101.9		4.79	103.3		5.84	86.4	***
Multidimensional Polarization Minimum 2DGAP									
Income Component									
A _{poor} (€)	33.99	191.8	***	30.2	185.9	***	38.97	153	***
A _{rich} (€)	12.79	110.8	*	13.44	114.6	**	9.95	99.1	
A (€)	46.78	159.8	***	43.64	156	***	48.92	137.8	***
Time Component									
B _{poor} (Minutes)	64.31	142.5	***	60.19	138.9	***	70.59	127.9	***
B _{rich} (Minutes)	97.15	106.9		93.39	112.8	**	113.69	92.4	
B (Minutes)	161.45	118.7	***	153.58	121.8	***	184.27	103.4	
IMD 2DGAP									
C _{poor}	74.65	151.2	***	69.22	147.1	***	82.2	132	***
C _{rich}	98.37	107		94.72	112.9	**	114.45	92.5	
C	173.02	122.4	***	163.94	125.2	***	196.64	105.8	

¹ Two samples mean test with variance inhomogeneity; Significance (sig.): * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; IMD = interdependent multidimensional.

Source: GTUS 1991/92, 2001/02 und 2012/13; own computation, weighted data.

IMD polarization intensity - minimum 2DGAP

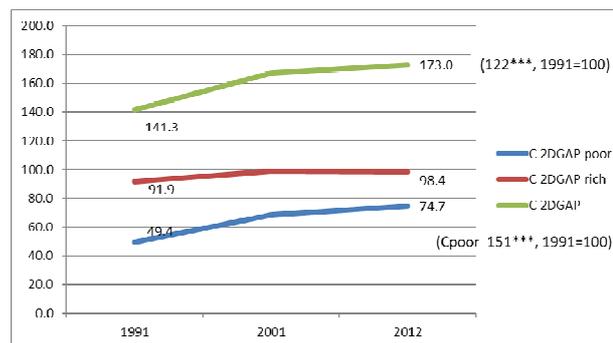
The results of IMD polarization intensity measured by the above well-being gaps has the virtue to summarize the polarization degree with a monovalent index. However, and in particular for targeted policy analysis, the contribution of the single polarization attributes is getting lost. Our proposed multidimensional polarization 2DGAP measure in fact provides

such a single time and income polarization contribution while respecting the assigned attribute compensations.

The polarization results as *mean minimum multidimensional polarization gaps* (2DGAP) (Equation 8a) show Table 2 and Figure 5, with its disentangled income and genuine personal leisure time components (Equation 8b) for 2012/13 and the development over 20 years. Table 2 also provides results overall and for respective poverty and affluence regimes for self-employed and employees.

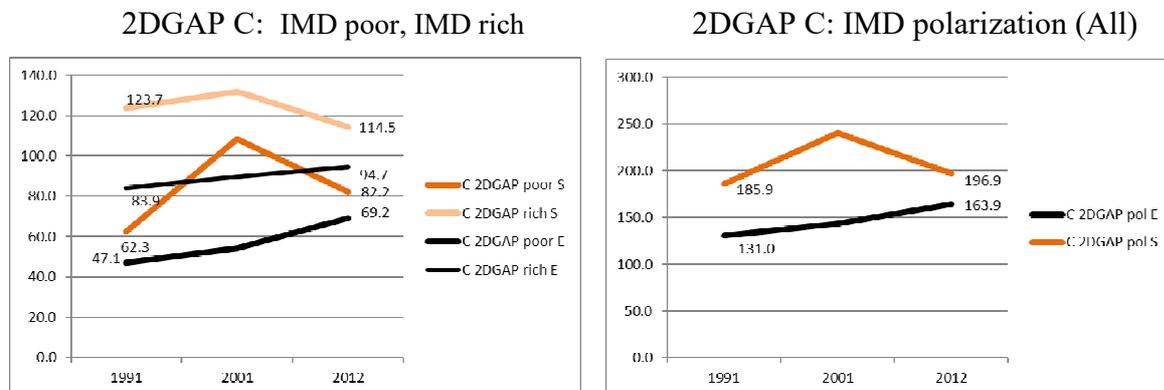
Figure 5: IMD Multidimensional Polarization Intensity: Mean 2DGAP C (Polarization Gap) – Germany 1991/92, 2001/02, 2012/13

C (IMD poor), C (IMD rich) and C (IMD pole (poor + rich))



IMD Multidimensional Polarization Intensity: Mean 2DGAP C – Self-Employed (S) and Employees (E) – Germany 1991/92, 2001/02, 2012

Self-employed and Employees



*** Significance < 0,1% Two-sample mean difference test

Source: GTUS 1991/92, 2001/02, 2012/13, own calculations, fulltime working (working hours > 5 hours per day), weighted data.

2DGAP overall (C): Over 20 years interdependent multidimensional polarization intensity (2DGAP C) increased from the early nineties significantly by 22.4%, a distinct result for an intensity drift to the poles of interdependent multidimensional polarization. Overall multidimensional polarization intensity is more pronounced for the rich (C_{rich}) than the poor (C_{poor}) for both, employees and self-employed (in all three years). In other words, polarization is deeper in the upper pole compared to the lower pole of the multidimensional distribution.

The multidimensional intensity scissor opened asymmetrically with a particular worsening of the poor (increase by 51.2%), for poor employees (increase by 47.1%) and poor self-employed (increase by 32%). We find a significant polarization intensity increase for

employees by 25.2% but only a slight (5.8%) and not significant one for the self-employed over 20 years.

Yet, and again, both groups face a strong and significant increase of the poverty pole (C_{poor}) intensity over 20 years. However, whereas there is a “steady” increase of IMD polarization intensity for employees, the intensity for self-employed first increase from 1991/92 to 2001/02 but then decreases till 2012/13 (inverse u-shaped with still a higher level than 20 years ago (Figure 5).

Of specific further interest are the 2DGAP single income (in €) and time (in minutes) components (A and B of Equation 8b) linked with the mean 2DGAP C measure just discussed. They detect the single components’ contribution at the mean intensity gap with respect to its interdependence. Remember, their relation and temporal development provide valuable information for targeted economic and social policies.

2DGAP income component (A): The summarized mean minimum *2DGAP income component* (€46.78) is dominated in 2012/13 by the income component of the poor (A_{poor}). The monetary component increases significantly by remarkable almost 60% (employees 56%, self-employed 38%). There is an asymmetry (for both, employees and self-employed) with a stronger poverty than affluence income component intensity growth.

2DGAP time component (B): The mean minimum *2DGAP summarized time component* (161.45 minutes) is dominated in 2012/13 by the time component of the rich (B_{rich}) (in contrast to the income component dominance for the poor (A_{poor})). The time component increases by about 19% but not as strong as that of the income component by 60%. Remarkably, the time as well as the income component of the poor grows stronger than that of the rich. This holds for both, employees and self-employed.

Which component, time or income, is responsible in particular for the combined development (1991/92 to 2012/13) of multidimensional intensity polarization? For both labor market groups it is mainly the income dimension (2DGAP A, employees +56%, self-employed +37.8%) and therein *the particular growth of the income poverty component*.

Differences between the two labor market groups concern the affluence gap: whereas the polarization intensity growth of the self-employed time and income components did not change significantly over the 20 years (2DGAP A_{rich} , 2DGAP B_{rich}), the time and income components of employees increased significantly.

What would be the policy lesson? Twofold, first the particular growth of the income poverty component asks for an anti-polarization income policy with focus on the poor. Second, though the income component growth is prominent, the significant time component growth of the poor nevertheless requires time specific policy support as well.

IMD polarization well-being and minimum 2DGAP intensity results compared

The mean minimum polarization gaps (2DGAP) indicated a significant increase in multi-dimensional time and income polarization, whereas the well-being polarization gaps indicated overall no significant change. How can this difference result between well-being and minimum 2DGAP intensity be explained?

One explanation is the following: Any individual well-being difference (the core of the well-being indices) is the difference between two values: one isoquant value with respect to the individual situation and one value of the polarization line well-being. However, between the individual situation and the polarization well-being threshold a fan of multitude gaps describes the differences from the individual situation to the isopoverty or the isoaffluence threshold. Yet, the monovalent well-being measure provides only a one valued well-being gap for the entire fan. The indefinite possibilities from all income and time combinations on both

contours result in a fuzzy all over well-being picture. The minimum 2DGAP approach, however, builds on a unique well-defined multidimensional distance with interpretable components. So, the “fuzziness” of the well-being gap will be the reason for different well-being gap and minimum 2DGAP results and argues in favor for the 2DGAP approach in measuring interdependent multidimensional polarization.

To summarize the 2DGAP interdependent multidimensional polarization results: With highly significant results we face a strong case for an increased interdependent multidimensional time and income polarization intensity for Germany between 1991/92 and 2012/13.

IMD polarization intensity – polarization centers and compensation

The IMD 2DGAP approach allows another meaningful insight into the centers of IMD polarization and the mean time/income compensation.

Polarization centers: We characterize polarization centers with regard to polarization intensity via the mean minimal IMD polarization gap (2DGAP C) which shows the shortest multidimensional way to escape the poverty or to leave the affluence pole. We call the starting coordinates (x_{1c}, x_{2c}) of the mean 2DGAP C_{poor} and C_{rich} distance a *polarization center*. As a measure of a polarization “deepness” they characterize the gravity of interdependent multidimensional poverty respective affluence.

Figure 6 (with Appendix Table 3a) summarizes and illustrates the development of IMD polarization from 1991/92 to 2012/13 for fulltime workers with polarization centers, mean 2DGAP C intensities and mean IMD income and mean IMD time (Table Appendix 4a provides the numbers¹³, Table Appendix 3b shows poverty 2DGAPs and its components as fractions of the maximum poverty 2DGAP¹⁴). Four results emerge and illustrates the numerical findings:

First, the IMD polarization 2DGAPs are relatively smaller in the poverty pole (1991/92 poverty: 9.73%, 2012/13 poverty: 12.9% of max 2DGAP). The polarization centers are relatively near to their polarization lines, in other words, the majority of the individuals - within their poles - are relatively far away from the lower and upper pole boundary.

Second, the poverty polarization center is located in the area of time as well income poverty (hardcore poverty, regime P1) which stresses the particular polarization in both, the time as well the income dimension. The affluence polarization center in the contrary is located in the area of high income but no compensated rich time deficits (regime R3).

Third, there is a particular move of the mean affluence gap to higher income over the two decades.

Fourth, relatively steep ascending 2DGAP C lines refer to the prominent importance of time for the pole intensity situation (with relatively large time components in the affluent pole).

Compensation: The 2DGAP components A (time) and income (B) can be used to illustrate the empirical compensation and to validate time to answer the question how “expensive” time is to leave the poles.

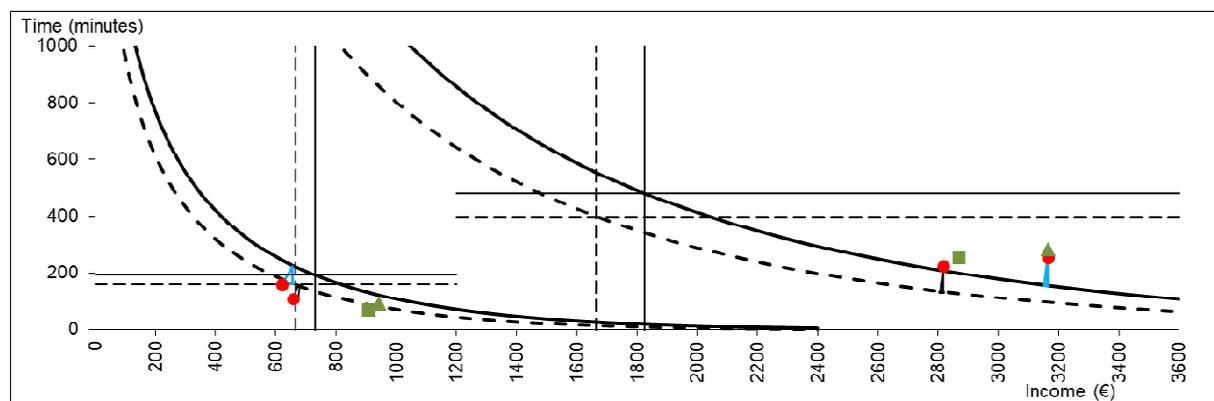
At the polarization center the time/income relation B/A of the 2DGAP poverty intensity components defines the slope of 2DGAP C ($c' = B/A$) and its compensation there. The slope at the orthogonal isopoverty line, where C is crossing, is the marginal rate of substitution $c'_{\perp} = -A/B$). With a 1991/92 value of $c'_{\perp} = -A/B = -17.72/45.12 = -0.39$ the

¹³ The mean 2DGAP starting coordinates are found by an iterative procedure with their mean components and the orthogonality property; the program is available by the authors.

¹⁴ Because of the open affluence interval a maximum 2DGAP is only computable for the poverty 2DGAP.

assigned amount of income (€) to compensate one minute locally (mean minimum 2DGAP) is about 0.39 Euro for the poor and for the affluent 0.13 Euro (Appendix Table 3a).

Figure 6: Multidimensional Polarization: Polarization Centers and Mean Minimal Polarization Intensity (2DGAP C) of Fulltime Workers, Germany 1991/92 (Dashed Line) and 2012/13 (Full Line)



Round points: starting coordinates (x_c , y_c) of mean IMD polarization intensity (2DGAP C); square points: mean IMD income and mean IMD time 1991/92; triangles: mean IMD income and mean IMD time 2012/13.

Source: GTUS 1991/92, 2001/02 und 2012/13; own presentation, weighted data.

The price of time for the poor increased to 0.53 Euro per minute but remains to 0.13 for the rich over the entire 20 years till 2012/13. This picture of greater and increased compensation figures of the poor and constant figures for the rich is valid for employees and self-employed over 20 years (out of Table 2).

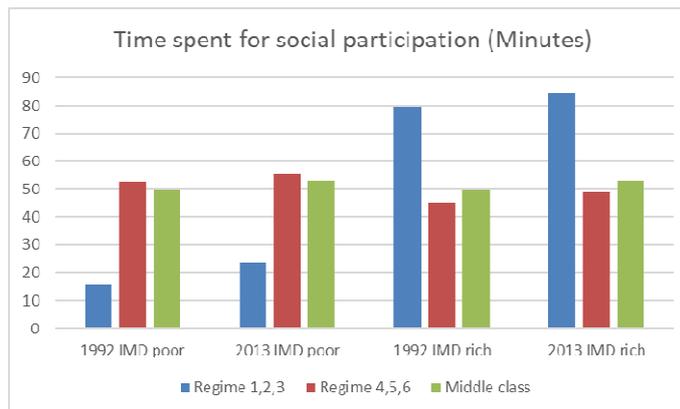
Time at the mean situation of the poverty polarization center thus is more “expensive” than at the respective affluence center in both years for employees as well as for self-employed, which highlights the stronger importance of time for the poor than for the rich. Or in other words, time compensation at the polarization centers is more valuable for the poor and is even going to be more valuable over those 20 years.

This corresponds to the found importance of the poverty pole with regard to the 2DGAP time and income component findings.

Social participation and genuine personal leisure time

We argued that genuine personal leisure time allows and restricts social participation, a relevant dimension of an enhanced poverty perspective and important for the poverty capability approach by Amartya Sen. As to our results (Figure 7), when social participation is measured by average time spent in social life (social contacts with others, visiting neighbour/friends, cultural participation etc.) as well when measured as time spent with others beside household members (social companions) then social participation indeed is considerably lower among the IMD poor compared to the non-IMD poor and compared to the middle class (non-poor minus IMD rich). This picture holds over those 20 years with a slightly diminishing difference between IMD poor and non-IMD poor, and, it holds for general genuine leisure time poor compared to non-time poor and as well as to the middle class (absolute and relative).

Figure 7: Time Spent for Social Participation: Mean Genuine Personal Leisure Time (Minutes) – Germany 1991/92, 2012/13



Source: GTUS 1991/92, 2012/13, Regimes as in Figure 4b: 1,2,3 for IMD poor or rich and 4,5,6 for non IMD poor or rich, middle class without the poles, own calculations, fulltime working (working hours > 5 hours per day), weighted data.

Thus, time poverty among the fulltime working - either with respecting compensation by income (IMD) or time not compensated – indeed reduces societal involvements and social participation.

Time affluence mirrors the situation with higher time involvement in social life for the IMD rich compared to the non IMD rich with a rising difference over those 20 years.

Taking together, polarization appears also with respect to social participation. Time spent for social participation is different in both poles of the distribution compared to the non-pole and middle class situation: social time is restricted for the poor and is enabling for the rich; a remarkable result having in mind the investigated fulltime working situation of both, the pole and non pole individuals.

5 Microeconometric Analysis of IMD Polarization - Incidence and 2DGAP Intensity

It is to be expected that different individual resources and limitations will result in a different polarization picture for different socio-economic groups. To quantify competitive socio-economic explanatory factors behind the IMD polarization incidence and intensity of the 2DGAP approach we apply the two-stage Heckman 1976 procedure to account for the expected selectivity. A selectivity bias is possible because the poor and affluent are expected not to be random subgroups of the entire population, respectively of the working population. In the first stage the incidence probability (polarization risk, participation, probit estimation) and in the second stage the polarization intensity is estimated corrected for a self-selection bias (COLS). This procedure is separately applied 2012/13 for the poor and the affluent.

Hypotheses and variables to explain IMD polarization in the following refer to manifold poverty and labor supply research results. Regarding income, human capital variables are recommended. Moreover, household and family variables contribute in many labor supply studies.¹⁵ Regarding time, the focus unabatedly is on labor supply of paid work. However, with the extension to Becker's household production approach unpaid work and other nonmarket activities are incorporated. This holds also for various leisure time activities which corresponds to our genuine personal leisure time.

¹⁵ Polachek and Siebert 1999 or Merz, Böhm and Burgert 2009 and the references therein.

The estimated IMD polarization 2012/13 results of incidence (stage 1) and intensity (stage 2) of 2DGAP C are presented in Table 4. Appendix Table 5 provides the descriptive statistics behind. The respective reference category will be a person expected not to be poor. To be brief we pinpoint only some prominent results.

The two-stage estimation result all over: the model goodness of fit measured by the Chi²-Wald test is highly significant and supports our modelling strategy.

IMD Polarization Incidence

IMD Polarization incidence is estimated by a probit approach as the probability to be a member of the respective polarization pole (polarization risk). The general result: remarkably, the polarization incidence can be explained predominantly by highly significant personal, educational, occupational and job variables, and family/household and regional variables. This applies to the poverty as well as to the affluent pole, however with differences.

Personal situation: The poverty risk (the risk to be a member in the IMD poverty pole) for women is higher than that of men. To be older increase the poverty risk and reduces the affluence chance. Foreigners have a higher poverty risk.

Education: As expected, higher education reduces IMD poverty and result in a higher probability to be multidimensional rich.

Occupation/Job: As above discussed and shown, self-employed compared to employees (the reference group) have a significant higher IMD poverty risk but not a higher affluence chance. This is a remarkable result since belief tells that the self-employed would be rich by money and, because of their independence and principal time sovereignty, would be rich by time, too.

Daily working hours is a further significant polarization incidence factor for both poles: a longer working day (measured the same day as genuine personal leisure time) cannot diminish the risk of IMD poverty but rather increase that risk; there seems to be no positive correlation between the length of working hours and its income. Longer working hours in contrast reduce the affluence chance. This might talk for the importance of their non-labor income.

Family/Household: As expected, compared to singles the poverty risk is reduced for couples (without children) whereas the probability to be affluent is increased, probably because of multiple income of both partners. Couples with one child show a reduced poverty risk (with a lower significance), too. The situation changes with an increased number of children. Couples with more than two children have a higher poverty risk. The poverty risk also increases for single parents with more than one child.

The family situation also plays an important role for the IMD affluence pole. Whereas couples without children show a higher probability to be rich, a growing number of children reduces this probability. Together with the IMD poverty result a growing number of children in the family thus has the tendency to be in the lower pole of the distribution, the probability to be affluent decreases and that of poverty increases.

Unpaid child care hours even raise the multidimensional poverty risk and points to a particular temporal burden of families with children. Weekend activities correlates with the chance of multidimensional affluence.

Region: Spatial agglomeration measured by county types/population density show no particular influence. However, living in East Germany more than 20 years after the reunification still increases the IMD poverty risk and decreases the IMD affluence chance significantly.

Table 4: Multidimensional Polarization of Time and Income – IMD Incidence and IMD 2DGAP C Intensity: Two-stage Heckman Estimates for IMD Poor and IMD Rich – Germany 2012/13

	IMD Polarization Incidence		IMD Polarization Intensity	
	Probit IMD ¹ poor	Probit IMD rich	COLS IMD poor	COLS IMD rich
Personal				
Female	0.0926 *	-0.0113	-10.72 *	-0.496
Age	0.0576 ***	-0.0451 **	-0.052	-6.808 **
Age**2/100	-0.0601 ***	0.0409 *	0.0318	6.666 **
Married	-0.0274	-0.361 ***	-7.852	-8.939
German	-0.499 ***	0.0627	-8.985	-6.833
Education				
Junior high	-0.192 ***	0.228 *		
A level	-0.217 ***	0.447 ***		
School years			-0.825	-70.33
School years ²			0.0732	3.123
Occupation				
Self-employed	0.285 ***	0.152	1.73	5.792
Job				
Working hours (min. day)	0.00213 ***	-0.00131 ***	-0.0857	-0.1 *
Wage	-0.0758 ***	0.0781 ***	-1.714	3.71 ***
Family/Household				
Household size	-0.0975 **	0.0483	-2.172	-7.38
Couple 0 kids	-0.614 ***	0.621 ***	-22.04	21.48
Couple 1 kid	-0.149 *	-0.109	-9.921	-27.78
Couple 2 kids	0.0646	-0.591 ***	-11.99	-3.562
Couple > 2 kids	0.574 ***	-0.919 ***	-6.02	-12.86
Single parent	0.316 ***	-0.913 ***	-11.22	-43.65
Single > 1 kids	0.511 ***	-1.096 ***	-17.69	-44.6
Child care hours, paid ⁽²⁾	-0.00506	-0.00181	0.163	-0.539
Child care hours, unpaid ⁽²⁾	0.0184 **	-0.0346 *	-0.305	-4.024
Saturday	-0.00225	0.343 ***	-9.772	25.92 *
Sunday	0.0717	0.268 *	-17.22	51.74 **
Region				
County type ⁽³⁾	0.0157	-0.0297	0.506	-6.13
East Germany	0.302 ***	-0.177 *	-14.08	-8.561
Constant	-2.143 ***	-1.011 *	229.2 *	610.7
Mills' Lambda			-40.82	35.09
<i>n</i>	7 721	7 721	7 721	7 721
<i>Censored n</i>	6 772	7 285	6 772	7 285
<i>Uncensored n</i>	949	434	949	434
<i>Wald Chi(23)²</i>	91.81 ***	47.62 **	91.81	47.62 **

¹ IMD=interdependent multidimensional; ² Paid resp. unpaid child care of other individuals in mean hours per week; ³ County type/population density: 1 = county free cities ... 4 = thin populated rural counties; Significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: GTUS 2012/13; own presentation, weighted data, fulltime workers.

IMD Polarization 2DGAP Intensity

Whereas the polarization incidence could be explained by many significant personal, occupation/job, household/family and regional variables the polarization intensity, the pole gaps measured by the multidimensional minimum 2DGAP can only hardly explained in a comparable manner. Gender only is influencing 2DGAP poverty polarization intensity. The 2DGAP affluence polarization intensity in contrast is significantly reduced by age (nonlinear) and by working hours. As expected, a higher wage rate will raise income and allows to reduce working hours in the affluence pole. Weekend activities, either direct or indirect, yield an increase of the affluence gap.

To summarize: Whereas a profound set of explanatory market-oriented factors as well as non-market household/family factors could be detected in the concurring multivariate analysis of interdependent multidimensional polarization risk, the set of significant explanatory variables for multidimensional poverty intensity, however, is remarkably smaller. Many personal and human capital variables, daily working hour arrangements, the children situation, and the region are no more significant. Further background variables are needed to better explain the deepness, the intensity of multidimensional poverty and affluence.

6 Concluding Remarks

Interdependent multidimensional (IMD) polarization of time and income of fulltime workers over 20 years in Germany is the topic of this study. Beyond the methodological 2DGAP contribution four striking general substantive results appear:

- First, genuine personal leisure time additional to income is a significant subjective well-being and polarization dimension.
- Second, the interdependence of time and income, its compensation/substitution, evaluated by the German Society, is of economic and statistical significance. Remarkably, there are interdependent multidimensional (IMD) polarization regimes where even higher income cannot compensate time deficits.
- Third, IMD polarization *incidence* (headcount ratio) decreased slightly but significantly, however, IMD polarization *intensity* (2DGAP) increased significantly over those 20 years in Germany. So, interdependent multidimensional polarization increased not by risk but rather by “burden” particular for the poor.
- Fourth, there are different multidimensional polarization results and developments for the poverty and affluence poles and regimes, for fulltime self-employed, employees and for further socio-economic groups. And, polarization also appears with respect to social participation.

Results in particular:

Interdependence of Genuine Personal Leisure Time and Income

The interdependence of time and income yields a different group specific polarization picture than the unidimensional time and unidimensional income results. It strengthens, lessens or even changed the polarization evidence depending on polarization poles, regimes and socio-economic groups. So, the findings strength the importance of dimensions interaction, a result found also by the mentioned Garcia-Gomez et al. 2021 study. Hence, neglecting the interaction of polarization dimensions would deliver misleading polarization pictures and respective economic and social policies.

Incidence of Interdependent Multidimensional Polarization of Time and Income

The *incidence* of IMD polarization (headcount ratio) result: almost every fifth individual (about 20% in all three survey years) belongs to the IMD polarization poles. IMD polarization is asymmetric: the majority of the polarized fulltime workers are IMD poor.

Over 20 years in Germany IMD polarization incidence declines slightly but significantly. In other words, we find a slight rising share of the fulltime working middle class. In particular, the self-employed show a strong incidence tendency to the lower end of the distribution, from a strong diminished affluence pole to the middle class, and from the middle class to a strong growing poverty pole. And, IMD polarization incidence in all three survey years is by far more pronounced (twice as much) for self-employed than for employees.

The projection of subjective well-being to the two-dimensional time and income presentation reveals regimes of time deficits which are assigned not to be compensated even by above threshold income for both IMD polarization poles: time poverty is even not compensated by above threshold poverty income to leave IMD poverty (Regime P3, more distinct for self-employed, Figure 4b), and time deficit is not compensated even by above affluence income to achieve IMD affluence (Regime R4, more distinct for employees).

These interaction results of not compensated time deficits by above poverty and affluent threshold income are remarkable and missed in the time poverty discussion so far. The statement “time is money”, meaning time can be compensated by income, a core assumption in microeconomics, thus holds only limited. A result, which accentuates the particular relevance of the time dimension to be respected in a multidimensional polarization analysis.

In addition, and with regard to time poverty in particular: in 2012/13 remarkably half of the fulltime working population are time poor even earning an income above the income poverty line (P3 IMD poor *and* P5 IMD not poor). And, the increase of that group by 22% over 20 years indeed stresses the growing importance of genuine personal leisure time for subjective well-being and multidimensional polarization.

Intensity of Interdependent Multidimensional Polarization of Time and Income (2DGAP)

Multidimensional polarization *intensity* is measured by the two-dimensional 2DGAP, the gap from the IMD poverty respective affluence line to the time/income starting point of the shortest path to leave individual poverty respective affluence. The larger this gap, the deeper, more intensive, is poverty respective affluence.

The result: IMD polarization intensity significantly increased over 20 years by more than 22%, a distinct result for an intensity drift to the tail ends of interdependent multidimensional polarization. Increased polarization incidence, however for the unidimensional income case, in Germany was detected alike by Goebel et al. 2010 and Scherg 2014.

IMD polarization intensity is more pronounced for the rich than the poor (in all three years), which refers to a respective larger spread of higher time and income. The multidimensional intensity scissor opened asymmetrically with a particular strong worsening of the poor compared to that of the rich. That means, it is going to be relatively harder to leave the poverty pole, a remarkable result.

We find a significant polarization *intensity increase* for employees but only a slight and not significant one for the self-employed over 20 years. Yet, and again, both groups face a strong and significant increase of the poverty pole intensity over 20 years, in particular for employees (yet, remember the stronger self-employed *incidence* drift to the poverty pole).

Disentangling IMD polarization dimensions: 2DGAP components detect the single components' contribution at the mean intensity gap respecting its interdependence. Both, the *time and income components* increased stronger for the poor than the rich (employees and

self-employed). However, it is the *income component (A)* (employees stronger increase) to be responsible for the combined 2DGAP intensity growth though the *time component (B)* still grew by remarkably (again employees stronger).

Polarization centers, the starting point of the mean minimum 2DGAP distances, characterizes a kind of a gravity center and marks a particular point of action for an effective anti-polarization policy. The result: the *polarization center of the affluent*, compared to the poor farer away from its pole, is located in the above affluence income but below rich time deficit threshold regime (regime R3, increasingly pronounced over 20 years) and would ask rather for a time policy consideration. The *poverty polarization center* is located in the area of time *as well* income poverty (hardcore IMD poverty, regime P1 over 20 years) which stresses the particular polarization in both, the time as well the income dimension in the lower tail of the distribution. Thus, an effective anti-polarization policy should focus on the “hardcore” multidimensional time *and* income poor.

Compensation, the price of time (marginal rate of substitution by 2DGAP component relation A/B): Time at the poverty polarization center is more “expensive” than at the respective affluence pole, which highlights the stronger importance of time for the poor. Or in other words, time at the polarization centers is more valuable for the poor and is even going to be more valuable over 20 years for employees as well as for the self-employed.

Social participation and genuine personal leisure time

Beyond the result of increasing interdependent multidimensional polarization of time and income intensity, polarization appears also with respect to social participation. Time spent for social participation – compensated or not compensated – is different in both poles of the distribution compared to the respective non pole and middle class situation: social time is restricted for the poor and is enabling for the rich (fulltime workers) over those 20 years. A remarkable result, since fulltime working for all pole and non pole individuals leave only limited time for social life.

Socio-economic influences, microeconomic results

Multidimensional polarization proved to be different for different socio-economic groups. In addition to the mentioned results for self-employed and employees, the microeconomic estimation detects further concurring socio-economic influences. The 2012/13 estimates show additional significant impacts of personal variables (gender, age), education, job (working hours, wage), and region (East, West Germany). A higher *polarization risk* is given in particular for single parents and couples with children, the more the more children live in the household. Whereas the polarization risk could be better explained by many socio-economic factors behind, the *polarization intensity*, however, needs a broader set of background variables. Nevertheless, with different results of the situation and development for self-employed and employees together with the further microeconomic results, which pinpoint the relevance of the family situation, our results provide relevant starting points for a broad spectrum of anti-polarization policies.

Some policy lessons

What can we learn for targeted policies? Polarization is multidimensional and should respect in particular the interdependence of time and income: The asymmetric IMD polarization incidence with a larger poverty pole, and the emerging strong growth of poverty incidence (in particular for self-employed) with a dominant growth of poverty intensity asks in particular for an active economic and social anti-polarization policy with focus on the poor and both, time and income. And, different IMD polarization pictures of self-employed and employees require different policy considerations.

As an example, beyond rather traditional income-oriented tax and transfer policies, with for instance decreasing taxes or transfer policies in favor of the poor and increasing taxes for the rich, the policy inclusion of time aspects – directly or indirectly – should be necessary in any extended anti-polarization policy. As only one example is the support of the infrastructure for families. Because multidimensional poverty risk is increasing with more children of couples and single parents, more “KiTa, Kindertagesstätten, daily Kindergarten” places could not only allow changes in the individual labor force participation and income situation but also could allow more genuine personal time with its social participation perspectives.

Economic and social policy will deal differently according to the poverty and affluence pole when a decline in polarization is aspired. Yet, targeted policy needs detailed polarization information for which our study will be a contribution. A lot more could be discussed here like the synchronizing of time dependent processes (public traffic and services) etc. to enable more time for personal activities. We refer to the German Association for Time Policy (www.zeitpolitik.de) for further ideas and discussion.

Again, and to emphasize our findings: the results stress the relevance of genuine personal leisure time with its social participation aspect as an important polarization dimension and an important dimension for individual and society well-being.

The detected polarization development over 20 years since the 1990s is embedded in many changes and disruptions in society worldwide and in Germany in particular. Worldwide globalization increased working pressure and intensified inequality of income, wealth and individual chances. Financial crises, the “dotcom” break of the new IT economy bubble in the beginning of the 2000s, the Lehman brother crisis 2007/08, terror attacks (9/11 in 2001 in New York, USA, 2004 in Madrid, Spain and 2005 London, UK)), atomic disasters (Tschernobyl 2006, Fukushima 2011), increased war conflicts, political transformation and upheavals (“cold war”, Perestroika and the breakdown of the Soviet Republic), growing populism and right-wing extremism; they all destabilized the economic and political situation in society with growing polarization in a multitude perspective. Germany in addition, since the re-unification of East and West Germany 1990, faces an ongoing extraordinary transformation process in economic and societal terms. The years after 2012/13, the end of our 20 years analysis period, then with a growing awareness of the climate change (Paris 2015 agreement) and the recent Covid 19 pandemic even sharpened the social life situation and intensified the multitude polarization impacts on society and the individual living conditions.¹⁶

Individual time and income polarization thus is definitively only a part, yet an important part which makes visible individual economic and social cohesion effects of the general economic, societal and cultural drifting apart.

¹⁶ See for instance Oxfam 2021, The Inequality Virus, and the IMF paper Shibata 2020 on distributional impacts of the recent pandemic recession and the 2008 global financial crisis.

Appendix

Table 2a: Uni- and Multidimensional Polarization Incidence and Intensity: Headcount Ratios, Well-Being Index and Minimum 2DGAP – All Fulltime Workers (A), Employees (E) and Self-employed (S), Germany 1991/92, 2001/02 and 2012/13

	All			Employees			Self-employed		
	Measure 1991/92	Measure 2001/02	Measure 2012/13	Measure 1991/92	Measure 2001/02	Measure 2012/13	Measure 1991/92	Measure 2001/02	Measure 2012/13
Unidimensional Income Polarization Headcount Ratio									
Income poor	4.52	4.82	4.42	4.2	3.2	3.37	5.86	12.02	8.01
Income rich	26.26	25.65	34.28	24.82	24.74	34.46	47.28	40.87	36.26
Income	30.78	30.47	38.7	29.02	27.94	37.83	53.14	52.89	44.27
Unidimensional Time Polarization Headcount Ratio									
Time poor	43.06	47.35	52.22	42.71	46.74	51.46	49.82	58.92	58.92
Time rich	2.24	1.55	1.2	2.19	1.45	1.31	2.46	1.16	0.46
Time	45.3	48.9	53.42	44.9	48.19	52.77	52.28	60.08	59.38
Multidimensional Polarization Headcount Ratio									
IMD poor	12.59	12.17	11.56	12.4	10.26	9.86	14.11	22.11	20.74
IMD rich	8.15	5.47	7.48	7.14	4.87	6.98	21.36	11.84	12.03
IMD	20.74	17.64	19.04	19.54	15.13	16.84	35.47	33.95	32.77
Multidimensional Polarization Well-Being Index									
P _{median} (%)	3.28	3.09	3.23	3.2	2.89	3.07	4.33	4.37	4.17
P _{poles} (%)	5.2	4.87	5.04	4.63	4.11	4.79	6.76	6.4	5.84
Multidimensional Polarization Minimum 2DGAP									
Income Component									
A _{poor} (€)	17.72	26.11	33.99	16.24	17.96	30.2	25.47	46.24	38.97
A _{rich} (€)	11.55	12.09	12.79	11.73	11.52	13.44	10.04	13.35	9.95
A (€)	29.27	38.56	46.78	27.97	29.48	43.64	35.51	59.59	48.92
Time Component									
B _{poor} (Minutes)	45.11	62.2	64.31	43.35	50.2	60.19	55.17	96.6	70.59
B _{rich} (Minutes)	90.87	97.69	97.15	82.78	88.55	93.39	122.98	131.12	113.69
B (Minutes)	135.98	159.89	161.5	126.13	138.75	153.6	178.15	227.72	184.27
IMD 2DGAP									
C _{poor}	49.38	68.5	74.65	47.07	54.04	69.22	62.25	108.23	82.2
C _{rich}	91.92	98.73	98.37	83.91	89.59	94.72	123.68	131.99	114.45
C	141.30	167.23	173.02	130.98	143.63	163.94	185.93	240.22	196.64

IMD = interdependent multidimensional.

Source: GTUS 1991/92, 2001/02 und 2012/13; own computation, weighted data.

Table 3a: Multidimensional Polarization Intensity – Polarization Centers and Compensation of Time and Income – Fulltime Workers, Germany 1991/92 and 2012/13

IMD ¹	1991/92		2012/13	
	Poor	Rich	Poor	Rich
Income (€) (x_c)²	656.72	2818.95	622.09	3164.39
Mean IMD Income (€)	906.45	2867.36	944.39	3207.45
Income Line (€)	665.72	1664.46	730.45	1826.13
Time (Minutes) (y_c)	109.3	224.49	160.38	254.75
Mean IMD Time (Minutes)	69.04	253.83	93.88	285.45
Time Line (Minutes)	159	397.5	192	480
Well-Being IMD Mean	6.488	7.533	6.553	7.629
Well-Being (x_c, y_c)	6.6	7.525	6.676	7.623
Well-Being line	6.704	7.402	6.799	7.506
Compensation				
2DGAP Components				
<i>Income A (€)</i>	<i>17.72</i>	<i>11.55</i>	<i>33.99</i>	<i>12.79</i>
<i>Time B (Minutes)</i>	<i>45.12</i>	<i>90.87</i>	<i>64.31</i>	<i>97.15</i>
<i>A/B</i>	<i>0.39</i>	<i>0.13</i>	<i>0.53</i>	<i>0.13</i>
<i>B/A</i>	<i>2.55</i>	<i>7.87</i>	<i>1.89</i>	<i>7.60</i>

¹ IMD=Interdependent Multidimensional Polarization; ² x_c, y_c starting coordinates of mean IMD 2DGAP intensity

Source: GTUS 1991/92, 2012/13; own computation, weighted data.

Table 3b: Multidimensional Polarization 2DGAP Intensity – Mean 2DGAP Components and Maximum Polarization 2DGAP, Fulltime Workers, Germany 1991/92 and 2012/13

2DGAP Components	Poverty 1991/92			Poverty 2012/13		
	Absolute	% of max	max	Absolute	% of max	max
Income A_{poor} [€]	17.80	4.85	366.97	33.99	8.13	418.18
Time B_{poor} [Minutes]	45.14	12.86	350.93	64.31	16.08	399.90
IMD 2DGAP C_{poor}	49.41	9.73	507.76	74.65	12.90	578.61

Source: GTUS 1991/92, 2012/13; own computation, weighted data.

Table 5: Multidimensional Polarization of Time and Income: Descriptive Statistics – Germany 2012/13

	All		Working all		IMD poor		IMD rich	
	Mean	Std.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Personal								
Female	0.5094	0.4999	0.4122	0.4923	0.4289	0.4952	0.3641	0.4817
Age	46.6	19.4	42.0	12.6	41.2	13.0	45.1	12.5
Married	0.4964	0.5000	0.5023	0.5000	0.3692	0.4828	0.5223	0.5001
German	0.9824	0.1313	0.9833	0.1281	0.9769	0.1503	0.9832	0.1288
Education								
Junior high	0.3413	0.4742	0.3692	0.4826	0.4049	0.4911	0.2354	0.4247
A level	0.3667	0.4819	0.4619	0.4986	0.3522	0.4779	0.7068	0.4557
School years	10.12	3.34	11.13	2.00	10.63	2.26	12.06	1.49
Occupation								
Self-employed	0.1110	0.3142	0.1162	0.3205	0.2097	0.4073	0.1862	0.3897
Job								
Working hours (daily hours) ⁽¹⁾	2.71	4.1474	9.04	2.0029	9.79	2.8086	8.71	1.7726
Wage	6.53	8.64	10.98	6.30	7.09	4.45	17.86	9.82
Family/Household								
Household Size	2.54	1.23	2.60	1.24	2.46	1.40	2.21	0.94
Couple 0 kids	0.3113	0.4630	0.2540	0.4353	0.1193	0.3243	0.5151	0.5003
Couple 1 kid	0.1198	0.3248	0.1467	0.3538	0.1171	0.3217	0.0968	0.2960
Couple 2 kids	0.1550	0.3619	0.1751	0.3801	0.1358	0.3427	0.0726	0.2598
Couple >=2 kids	0.0730	0.2602	0.0664	0.2491	0.0978	0.2972	0.0144	0.1194
Single parent	0.0368	0.1883	0.0392	0.1941	0.0634	0.2438	0.0081	0.0897
Single > 1 kids	0.0213	0.1445	0.0176	0.1315	0.0232	0.1505	0.0036	0.0596
Child care hours, paid ⁽²⁾	0.4487	3.7840	0.5825	4.3655	0.4543	3.4926	0.2350	2.1406
Child care hours, unpaid ⁽²⁾	0.4520	2.4573	0.5507	2.5901	0.7315	3.4426	0.1207	0.9259
Saturday	0.1397	0.3467	0.1718	0.3772	0.1640	0.3705	0.2473	0.4319
Sunday	0.1479	0.3550	0.0401	0.1962	0.0564	0.2308	0.0409	0.1983
Region								
County type ⁽³⁾	2.14	0.98	2.16	1.00	2.25	1.09	1.93	0.87
East Germany	0.1999	0.3999	0.2123	0.4089	0.3430	0.4750	0.1052	0.3072
Income⁽⁴⁾ (€)								
	1 503.14	732.32	1 673.70	758.96	944.39	476.85	3 207.45	901.85
Time⁽⁵⁾ (minutes)								
	333.02	172.20	198.72	104.47	93.88	84.83	285.45	112.31
n⁽⁶⁾								
	32 103		7791		964		439	
N⁽⁶⁾								
	222 815 028		61 960 352		7 163 002		4 635 595	

IMD=interdependent multidimensional; ¹ Main or secondary job, diary day ² Paid resp. unpaid child care of other individuals in mean hours per week; ³ County type/population density: 1 = county free cities ... 4 = thin populated rural counties 4) Equivalized monthly household net income in 2002 prices ⁵ Genuine personal leisure time, diary day ⁶ Persondays

Source: GTUS 2012/13; own presentation, weighted data, fulltime workers.

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