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Parental Child Care Time, Income and Subjective Well-Being: A Multidimensional Polarization Approach for Germany

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ABSTRACT

Parental Child Care Time, Income and Subjective Well-Being: A Multidimensional Polarization Approach for Germany*

Neither market income nor consumption expenditure provides an adequate picture of individual standard of living. It is time which enables and restricts individual activities and is a further brick to a more comprehensive picture of individual well-being. In our study we focus on a prominent part of time use in non-market services: it is parental child care which contributes not only to individual but also to societal well-being. Within a novel approach we ask for multidimensional polarization effects of parental child care where compensation/substitution of time for parental child care versus income is interdependently evaluated by panel estimates of society's subjective well-being. The new interdependent 2DGAP measure thereby provides multidimensional polarization intensity information for the poor and the rich and disentangles the single time and income contribution to subjective well-being for targeted policies ensuring at the same time the interdependence of the polarization dimensions. Socio-economic influences on the polarization pole risk and intensity will be quantified by two stage Heckman estimates. The analyses are based on the German Socio-Economic Panel with 21 waves and robust fixed effects estimates as well as the German Time Use Surveys 1991/92 and actual 2012/13 with detailed diary time use data. Prominent result: compensation between parental child care time and income proved to be significant, but there are multidimensional regions with no compensation, where parental child care time deficit is not compensated by income. Interdependent multidimensional polarization by headcount and intensity increased significantly over the twenty years under investigation with remarkable risk and intensity differences.

JEL Classification: I31, I32, J22, D10, D31

Keywords: parental child care, multidimensional polarization of interdependent time and income, subjective well-being, poverty and affluence, minimum multidimensional 2DGAP risk and intensity, German Socio-Economic Panel (SOEP), German Time Use Study (GTUS 1991/92 and 2012/13)

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Parental Child Care Time, Income and Subjective Well-Being – A Multidimensional Polarization Approach for Germany

Joachim Merz and Normen Peters

1 Introduction

Neither market income nor consumption expenditure alone provides an adequate picture of individual standard of living and its distribution. It is time which enables and restricts any individual activity and is a further brick to a more comprehensive picture of individual well-being. In our study we focus on a prominent part of time use in non-market services: it is parental child care which contributes not only to individual but also to societal well-being.

Parental time for child caring primarily is an important factor for the child's emotional, social and intellectual development. More time spent for children can improve their health, diminish risks of social misbehavior, support higher education and improve in general human capital in a broad sense (Cooksey and Fondell 1996, Barnard 2004, Carlson 2006 or Oesterbacka, Merz und Zick 2009). And, parental child care time is an important subjective well-being factor for parents as well: every third father and every fifth mother desire more child care time in Germany (Statistisches Bundesamt 2015).

Beyond time spent on parental child care, individual living conditions require time to achieve income resources. The contest for desirable individual living conditions faces a growing polarization of society accompanied by an erosion of the middle class. This drifting apart of the poor and the rich in many dimensions – and probably for parental child care, too – has far reaching consequences for the individual but also for the economy, society and for the quality of life in general (OECD 2015a,b, 2008, Stiglitz 2015a,b, 2012, Thewissen 2014, Berg and Ostry 2011, Wolfson 1997).

Since public child care with public Kitas ("Kindertagesstätten", public daily child care) provision and labor force participation is of growing importance in the actual economic and social policy discussion, our topic of the family child care situation behind contributes to this policy debate. And, with our focus on parental child care time and income we contribute to the compatibility discussion of a family's time and job circumstances in general.

Our study on parental child care time combines subjective well-being, child care and income by a novel multidimensional polarization approach. Polarization is of particular interest for the parental child care time/income topic since a different material background of being poor or rich allows different uses of external child care and other support. Since time could be spend either for achieving income or for any other activity, we explicitly consider a possible compensation/substitution between income and parental child care time and quantify its substitution via evaluation by subjective well-being. A respective Constant Elasticity Substitution (CES) subjective well-being function is estimated by a robust fixed effects approach with 21 waves of German individual panel data.[1] This empirical based evaluation by German society in a second step based on individual time use diary data then allows the analysis of multidimensional polarization of being poor and affluent under the parental child care and income perspective.

[1] The concept and its subsequent methodology follows our multidimensional analyses of interdependent genuine personal leisure time and income in Merz and Rathjen 2014a,b for poverty and Merz and Scherg 2014 for the poor and the rich by a multidimensional polarization approach.

With our new 2DGAP approach therein we quantify the multidimensional polarization intensity – revealing its dimensional impacts for targeted policies but respecting its interdependence - with reference to both poles of the multidimensional child care time and income distribution. The third step then quantifies socio-economic influences on the 2DGAP risk and intensity of being interdependent multidimensional poor and rich by a two stage Heckman approach. The data bases will be the German Socio-economic Panel from with all waves from 1992 to 2012 and time use diary data from the actual German Time Use Study GTUS 2012/13 with comparisons to about twenty years ago GTUS 1991/92.

Thus our study is a novel empirically based contribution to the parental child care and subjective well-being discussion by

- first: a new multidimensional compensation approach with multidimensional polarization of interdependent parental child care time and income;
- second: The subjective well-being evaluation by German society (via panel data estimation) of the trade-off between time and income reveals empirical based pattern of compensation and no-compensation of parental child care time deficits versus income
- third: a new 2DGAP inspection of the multidimensional pole intensities and their disentangled time and income components for targeted policies, and
- fourth: by quantifying socio-economic influences on the multidimensional pole 2DGAP risk and intensity further supporting economic and social policies.

By asking for the relationship between parental child care time, a rather immaterial dimension, and income, a rather material dimension and resource, the question arises, why should be there any compensation? Isn't parental child care pre-dominant to any other (input) resource, regardless any income situation? Well, the fighting for living condition might restrict this time input either by demanding working hours or other obligations. Circumstances might or not might allow alternative non-parental child care which might influence the individual parental time allocation. Thus, a closer look is required asking for the actual tension between parental child care time and other time consuming activities like working for income in particular; detecting the empirical importance of this tension is the concern of our study.

The reminder of the study is organized as follows: After discussing the background of subjective well-being, parental child care, income and subjective well-being (chapter 2), our analyzing methodology and tools with multidimensional polarization identification, multidimensional CES well-being function and new multidimensional subjective well-being measures are treated (chapter 3). The new multidimensional polarization 2DGAP methodology follows (chapter 4). Data and empirical multidimensional polarization thresholds are provided in chapter 5. Our parental child care results follow in chapter 6 with subjective well-being and 2DGAP intensity measures over twenty years for German society as well as for 2DGAP risk and intensity results for socio-economic groups (chapter 7). Chapter 8 summarizes and concludes.

2 Background

Parental child care time is of long-standing interest in the scientific debate and obviously a continuing topic in the daily life of families. In traditional microeconomics individual time is allocated between labor (with its income/consumption) and leisure. The maximization of the connected utility under time and income constraints result in the respective time allocation equations with either total leisure activities or with subsequent activities like child care. Within the well-known approach of the new home economics by Gary Becker, there are commodities which are decisive parts of the utility function and produced in the household with time and market goods inputs. Again, maximization of utility under time and income constraints delivers the optimal allocation of time and goods. The commodities might be defined in a general sense and might encompass the product of child care

time. Within this microeconomic frame the opportunity costs of achieving income (the market wage rate) is the income leisure (child care) link for the final time use allocation.[2]

Many studies found a negative relation between opportunity costs of labor participation and time for child care, where higher opportunity costs pull to the market to the burden of non-market child care time (Kapteyn and Kooreman 1987, Hill and Stafford 1985, Baydar, Greek and Gritz 1999, Hallberg and Klevmarken 2003, Kalenkoski, Ribar and Stratton 2005, Kimmel and Conelly 2006, Aguiar and Hurst 2006 or Bloemen and Stancanelli 2008).

Other studies are less distinct regarding that negative relation. Ishii-Kuntz and Coltrane 1992, for example, found a positive correlation between labor market involvement and parental engagement for children-oriented activities. Bryant, Zick and Oesterbacka 2001 proved that there is more time spent with children on reading or doing homework if the mother is employed rather staying at home. Guryan, Hurst and Kearney 2008 analyze the impacts of socio-economic factors on parental time use and found almost in every of the 14 countries regarded a positive correlation between income, education and parental time used with their children. With focus on the education impact on child care Craig (2006) found for Australia that mothers with university education do spend more time than others to child care *and* to paid work. Remember, from an economic perspective the positive influence of higher education in child care is not expected given that the opportunity cost of time is higher for higher-educated with higher wages.

Still other scholars do not find any significant impact of opportunity costs on child care. There cultural impacts and individual attitudes are more important. They emphasize behavioral reasons and amplify other aspects (Sayer, Bianchi and Robinson 2004). Bargaining theories, for instance, address the negotiation within the family resulting in the division of domestic tasks including child care (Manser and Brown 1980, McElroy and Horney 1981 or Apps and Rees 1996, Blundell, Chiappori, Magnac and Meghir 1998 or Brett 1998). Further broad discussion of care and child care within family time are provided by Folbre and Bittman 2004.

So, the question about the kind of relationship between child care and income is still open and expect empirical based appropriate answers. In empirical investigations, in general and so far, time use for child caring is analyzed in a single equation or multiple equation time use allocation regression frame to detect the influence of income and other resources to parental child care. Though often not discussed or uncovered, under the microeconomic rational choice perspective – traditional or in Beckerian modelling - behind any allocation modelling with regression equations there is still underlying a utility maximization problem under time and income constraints.

What is missed so far is the explicit consideration of subjective well-being/utility in the parental child care discussion, the concern of our study. With our approach, however, we explicitly do not intend to develop and estimate an optimal time allocation model under a rational choice perspective. We focus rather on the subjective well-being compensation/substitution between parental child care time and income and its consequences in an interdependent multidimensional polarization approach for the child care time and income of the poor and the affluent. Thus our study also is a contribution to the subjective well-being/life satisfaction/happiness discussion which receives increasing political attention [3] with a growing field of research. [4]

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[2] Robbins 1930, Becker 1965, Lancaster 1966, Linder 1970, de Serpa 1971, Evans 1972, Gronau 1977, Hill and Stafford 1985 or Kapteyn and Kooreman 1987, for instance, extend Becker's model in regard to different activities the time is spent for.

[3] See Layard 2006 and his article "Happiness and Public Policy" or the the Enquete Commission of the German Federal Parliament "Growth, Wellbeing and Quality of Life" report 2013.

4 Diener et al. 1999 with an overview of the last 30 years on subjective welfare, Easterlin 2001 on the relationship of income and subjective well-being; see also Clark and Oswald 1995 and Diener and Biswas-Diener 2002, and recently Clark 2018 about four decades of the economics of happiness.

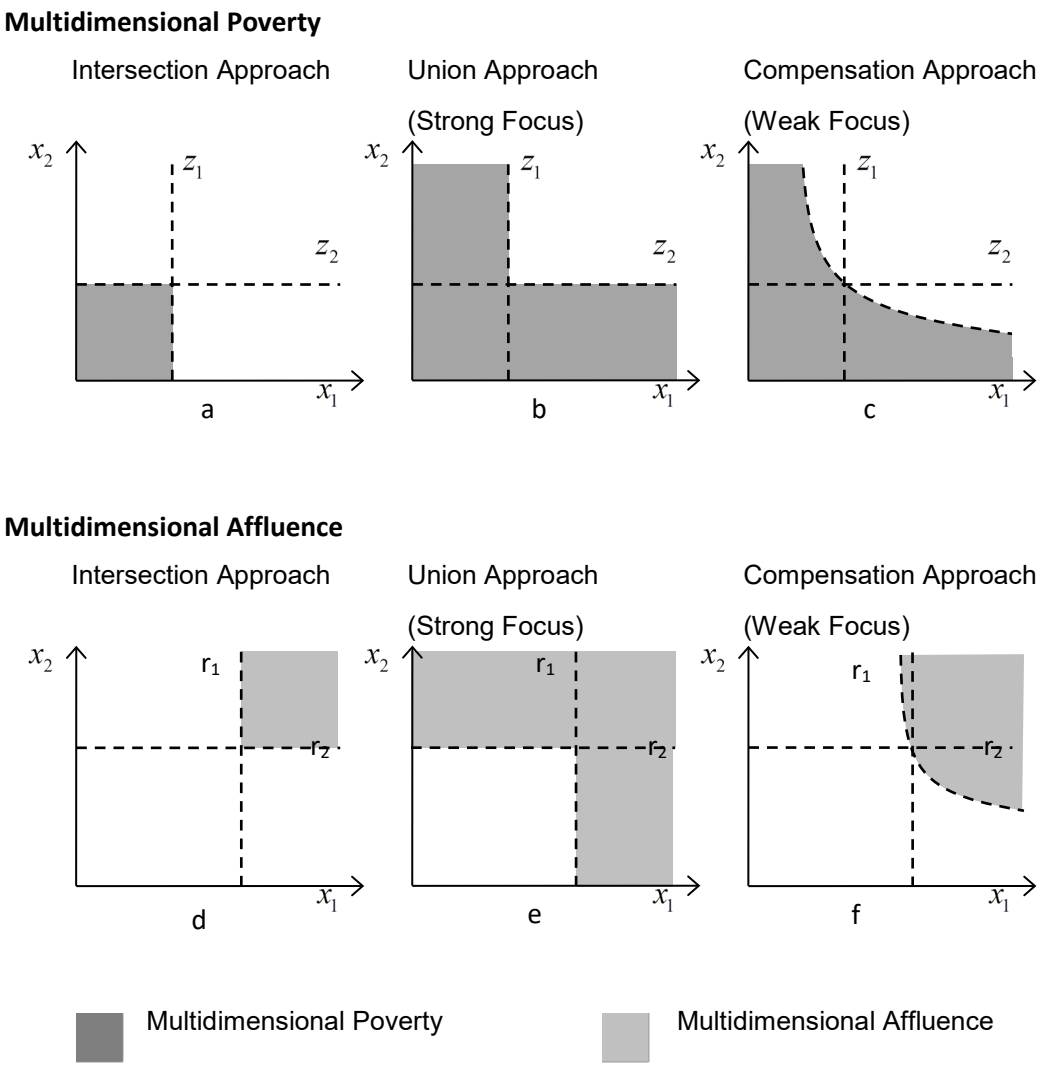
3 Multidimensional Polarization: Identification, Multidimensional CES Well-Being Function and New Well-Being Measures

The multidimensional polarization analysis of a possible compensation/substitution between parental child and income requires the identification of its interdependence followed by an appropriate well-being function, which - with subsequent well-being multidimensional polarization measures - is the concern of the following chapter. [5]

3.1 Interdependent Multidimensional Polarization – Identification

In ***multidimensional poverty identification*** (Kakwani and Silber 2008, Deutsch and Silber 2005, Bourguignon and Chakravarty 2003), there are two identification approaches. 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 1a). Intermediate concepts are conceivable as well.

Figure 1: Identification of Multidimensional Polarization



[5] As mentioned, this study's methodology follows Merz and Rathjen 2014a,b and Merz and Scherg 2014. We use respective paragraphs without further single citation.

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.

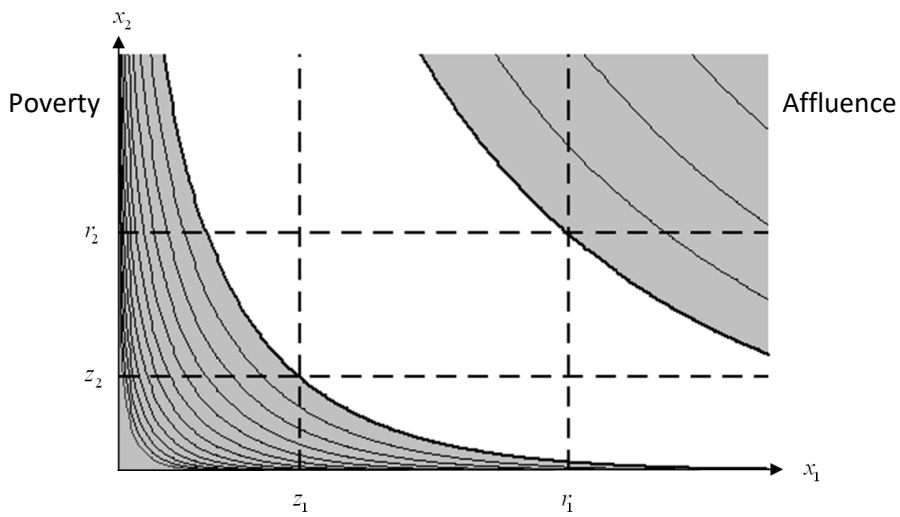
Since the union and intersection approaches seem to be too rigid as identification strategies for most cases, an intermediate approach allows compensation (weak focus axiom) for all ranges in one dimension given poverty in the other (Figure 1c). In the compensation approach thus, besides being poor in both dimensions (intersection), a person is multidimensional poor when she cannot compensate poverty in one dimension by the other non-poverty dimension.

The empirical question is whether and to which extent a poverty gap in one dimension might be compensated for by higher quantities in the other one. 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 1c, unshaded area). Thus, the multidimensional poverty curve 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 1a,b,c) and the non-poor (unshaded areas in Figure 1a,b,c).

We extend multidimensional poverty identification to ***multidimensional polarization identification*** in a similar though not identical way 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 1d,e,f). The kind of relationships then 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).

In the following we focus on the compensation approach (weak focus axiom), where the grade 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, with later analyzed data). Again, the shaded areas in Figure 2 describe the poor under the poverty curve and the affluent above the affluence curve.

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



Source: Merz and Scherg 2014

Take for example the affluence compensation above the income threshold (shaded area right of r_1 in Figure 2). The time deficit (shaded area and being below the time affluence threshold r_2) is considered to be not compensated by a high income above the multidimensional affluence curve to be assigned IMD affluent. The time deficit, however, is considered to be compensated by high income below the multidimensional affluence curve; there is no more multidimensional affluence.

The poverty and affluence curves (in the two-dimension case) can be interpreted as *multidimensional isopolarization contours*, which are isoquants (well-being indifferent curves) of an underlying well-being function, a function which comprises all polarization attributes and evaluates their interdependent relation. This multidimensional well-being function is specified next.

3.2 Multidimensional Polarization - Multidimensional CES Well-Being Function

Following the compensation approach, this section specifies a particular multidimensional 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 the following new multidimensional polarization indices and the foundation for the new minimum 2DGAP polarization approach.

Our CES-type well-being function with its individual well-being indicator V_i (weak focus axiom) evaluates the interdependence of dimensions by

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

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, υ 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. [6]

Compared to other specifications the CES function has the virtue that the elasticity of substitution/compensation can be estimated empirically and is not restricted to 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 by a log-Taylor approximation, the results can even be interpreted as being a more flexible functional specification like a translog one.[7]

The CES indifference curves, which are the contours of the CES well-being function describing the situation in the two-dimensional spaces here for parental child care time as x_{2i}, say, and income as x_{1i}, say, are derived by

[6] The degree of substitution between child care 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.

[7] For a further discussion, reasoning and justification of the CES well-being function with multidimensional poverty application, the reader is referred to Merz and Rathjen 2014a.

(2) $$x_{i2} = \left[\left[\left(V/\gamma\right)^{(-\rho/\nu)} - w_1 x_{i1}^{(-\rho)}\right]/w_2\right]^{(-1/\rho)} \quad .$$

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

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

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 curve are assigned to be poor, above the isoaffluence curve to be affluent, and together assigned to be polarized (see again Figure 2).

3.3 Multidimensional Polarization - Well-Being Measures

We propose a straightforward measurement approach to multidimensional polarization based on individual well-being values. We distinguish between two distances to measure the importance of the multidimensional distribution poles: the first one includes the distance from the individual situation to the median. The second one relies on defined poverty and affluence thresholds and measures the distance from the individual situation to the pole thresholds.

Multidimensional Well-Being Polarization (Median)

The first multidimensional polarization measure is the multidimensional well-being extension of the Wang and Tsui 2000 unidimensional polarization measure which considers polarization poles below and above the respective medians. Our *multidimensional well-being polarization index (median)* (weak focus axiom) measures the well-being polarization intensity as a mean relative well-being gap with respect to the median, and is defined (for the two dimensional case) by

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

where $V(.)$ is a (CES) well-being function as in Equation 1, m_j is the median value of the polarization attributes $(j = 1, 2)$, and n is the population size. The greater the distance from the median well-being to the individual well-being, the greater is this index. In contrast to Wang and Tsui 2000, who relate α to the interval [0.1], we follow the Foster-Greer-Thorbecke (FGT) 1984 idea of α describing here a polarization aversion index, with α = 1 as the relative well-being distance to the median, and α = 2 (or α ≥ 1) for a greater polarization sensitivity with greater weights for larger gaps.

Multidimensional Well-Being Polarization (Poverty and Affluence Thresholds)

Whereas the last index comprises all gaps below and above the well-being median, *multidimensional well-being polarization index (poverty and affluence thresholds)* P_{all} considers the individual gaps with respect to explicit poverty and affluence thresholds:[8]

[8] It is an extension of the Scheicher 2010 index, which for each individual gap only sums up attribute values without any compensation possibilities.

(5) $$P_{all} = \frac{1}{n}\sum_{i=1}^{n}\left[max\left(\frac{V(z_1,z_2)-V(x_{1i},x_{2i})}{V(z_1,z_2)},0\right)\right]^{\alpha} + \frac{1}{n}\sum_{i=1}^{n}\left[max\left(\frac{V(x_{i1},x_{i2})-V(r_1,r_2)}{V(x_{i1},x_{i2})},0\right)\right]^{\beta}$$

The exponents α and β serve as polarization aversion coefficients, with $\alpha = 0$ and $\beta = 0$ delivering the multidimensional polarization headcount ratios. With $\alpha = 1$ and $\beta = 1$ an average relative polarization gap in well-being units is measured, and with $\alpha > 1$ and $\beta > 1$ a higher aversion against strong polarization (which may be different for the poor and the affluent) is reflected. The proposed polarization index (5) has its origins in a multidimensional Foster-Greer-Thorbecke 1984 poverty index under the weak focus axiom according to well-being.

The construction principle of this index – which transfers 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 affluence part were specified in the same manner as the poverty part, then a reference to the affluence threshold $V(r_1,r_2)$ might deliver values greater than one (further implications are discussed e.g. in Peichl et al. 2010). Therefore, the second part of our multidimensional polarization index refers to the individual situation $V(x_{i1},x_{i2})$ and not to the affluence threshold situation $V(r_{i1},r_{i2})$ ti ensure affluence percentage ratios in the interval [0, 1].

Though both parts have a different reference, for both parts a larger index characterizes an increasing polarization as increasing mean relative gaps within the multidimensional poles.

Since in both parts of the multidimensional polarization index (Equation 5), the average is related to the whole population (n), relatively small values have to be expected in an empirical application. A more intuitively appropriate average would be related to only the poor or affluent population numbers. The *multidimensional well-being polarization index (poverty and affluence thresholds)* P_{poles} then is defined by

(5) $$P_{poles} = \frac{1}{n_{poor}}\sum_{i\in poor}^{n_{poor}}\left[\frac{V(z_1,z_2)-V(x_{i1},x_{12})}{V(z_1,z_2)}\right]^{\alpha} + \frac{1}{n_{rich}}\sum_{i\in rich}^{n_{rich}}\left[\frac{V(x_{i1},x_{i2})-V(r_1,r_2)}{V(x_{i1},x_{i2})}\right]^{\beta}$$

with exponents α and β greater or equal one. Our polarization index (Equation 5) respects well-being units, whereas the unidimensional Scheicher 2010 polarization index refers to income units.

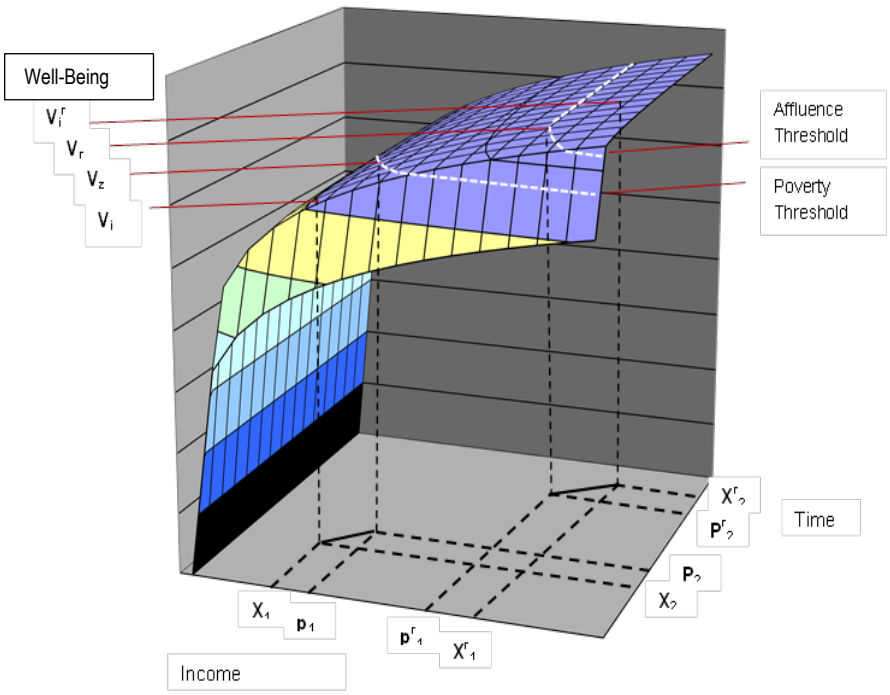
4 Minimum Multidimensional Polarization Gap (2DGAP)

The virtue of measuring multidimensional well-being is that it respects and quantifies the interdependence of multiple well-being attributes by a one-value well-being index. However, such an aggregation of dimensions into a single well-being value is questionable if it is still measuring "multidimensional" poverty, affluence or polarization, since the single attributes are no longer transparent. Transparency for the single attributes in the multidimensional approach, however, is desirable in a manner which allows a targeted policy aimed at the transparent specific attributes of poverty, affluence or polarization.

The main motivation for developing the multidimensional polarization 2DGAP (introduced by Merz and Rathjen 2014b for poverty analyses) is thus to "disentangle" the single attributes of a well-being gap to obtain a unique multidimensional intensity measure with transparent single attributes. We follow the extended minimum poverty 2DGAP concept for the multidimensional polarization case as in Merz and Scherg 2014.

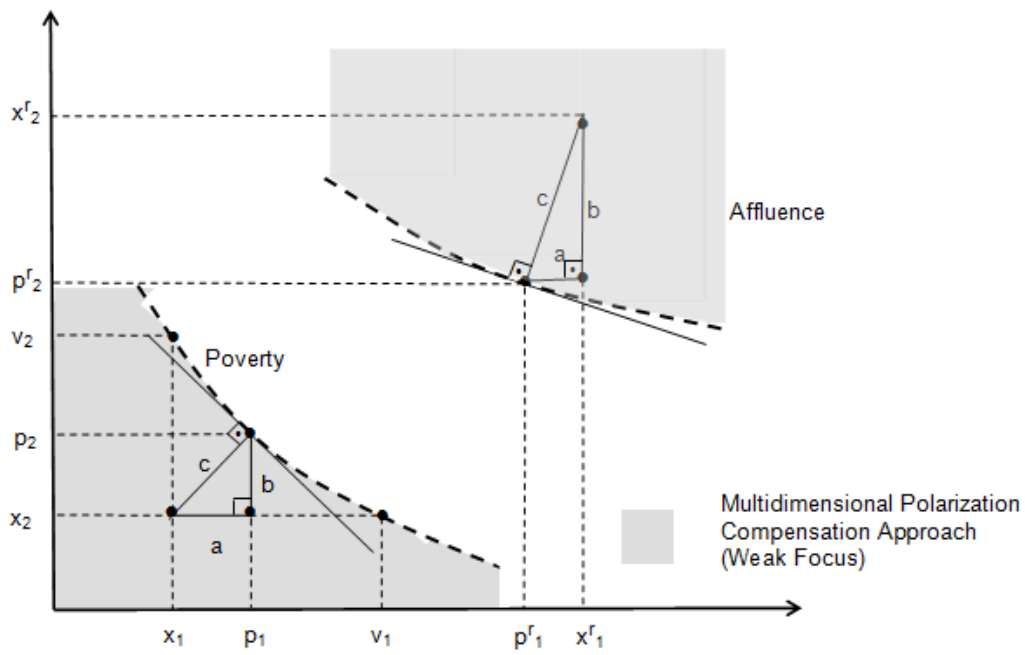
In the polarization case, both poles of a distribution with their respective poverty threshold and affluence threshold contours are of interest. Figure 3 (top) shows the CES well-being graph and

Figure 3a: Multidimensional Polarization: Subjective Well-Being Gap



Source: Well-Being Gap ($V_z - V_i$) , ($V_r - V^r_i$), SOEP panel estimates 1984 – 2013, own illustration

Figure 3b: Multidimensional Polarization: Minimum 2DGAP



Source: Merz and Scherg 2014

describes the two-dimensional poverty and affluence case: $V_z = V(z_1, z_2)$ is the well-being contour at the poverty threshold $z = (z_1, z_2)$, $V_i = V(x_{1i}, x_{2i})$ is the individual well-being contour at $x_i = (x_{i1}, x_{i2})$. The difference $V_z - V_i$ is the multidimensional poverty well-being gap. In an analogous way $V_i^r - V_r$ defines the multidimensional affluence well-being gap for a rich person with $V_i^r = V(x_{i1}^r, x_{i2}^r)$ and $V_r = V(r_1, r_2)$ as the affluence threshold.

The mapping of the multidimensional well-being on its (two) single dimensional input space now allows for another attractive integrated approach for describing multidimensional polarization intensity while disentangling the single attribute contributions. It consists of a unique distance between an individual situation and the poverty or, respectively, the affluence threshold.

As an illustration, consider the two-dimensional case from the compensation approach (Figure 3a subjective well-being function as in our later empirical application) and its attribute space as in Figure 3b and regard first 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 IMD isopoverty threshold. Indeed, each distance yields the same well-being difference $V_z - V_i$. However, each distance requires that different single attribute input mixtures need to be overcome in order to escape multidimensional poverty.

The *shortest* and thus a *unique* path between $x = (x_1, x_2)$ and the corresponding point $p = (p_1, p_2)$ at the isopoverty threshold contour is shown in Figure 3. It requires a minimum input mixture in the sense of an optimized compensation intensity, a minimum combined input "length", in order to escape multidimensional poverty. A natural measure for that length is the Euclidian distance of the single attributes $c = \left[a^2 + b^2\right]^{0.5}$ with their components a and b as the single poverty attribute gap intensities (for further details see Merz and Rathjen 2014b).

The similar approach will be used for a shortest path from a multidimensional affluent individual situation to the isoaffluence curve. It is the minimum combined input length necessary to lose multidimensional affluence. We call this shortest distance *c* the *minimum multidimensional poverty/affluence 2DGAP* (for two polarization dimensions).

The *minimum multidimensional poverty/affluence 2DGAP* c, again and summarized delivers transparency of the single dimensions by the components a (say income) and b (say time). It will be transparent for each individual, how much time (b) and how much income (a), say, is minimally needed to overcome poverty respectively not to be affluent any more.

Aggregation and Mean Minimum Polarization 2DGAP

To retain the polarization single attribute contributions in the multidimensional approach, we propose a straightforward aggregation and measure by the sum of the respective minimum 2DGAP pole means, the *mean minimum polarization 2DGAP*:

(6) $$C = \frac{1}{n_{poor}} \sum_{i \in poor}^{n} c_i + \frac{1}{n_{rich}} \sum_{i \in rich}^{n} c_i ,$$

and its single aggregated components[9]

[9] The aggregation of the single poverty attributes *a* and *b* and of the 2DGAP c over all individuals might not result in the joint aggregate condition $c = (a^2 + b^2)^{0.5}$. With two degrees of freedom one remaining

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

5 Multidimensional Parental Child Care Time and Income Polarization in Germany – Data and Empirical Thresholds

This chapter characterizes our two data bases and discusses the threshold concept and its empirical implementation.

5.1 Data: GSOEP 2002 and GTUS 1991/92 and 2001/02

The German Socio-Economic Panel (GSOEP)

The German Socio-Economic Panel (GSOEP) provides representative individual longitudinal data for all persons older than 16 years living in German households. The representative panel study started in 1984 and encompasses annual objective as well as subjective information about individual living conditions in Germany (for details, see Wagner, Frick and Schupp 2007). In particular, the GSOEP asks about satisfaction with regard to different topics, such as income, as well as general questions about life satisfaction. The 11-point scale regarding general life satisfaction information is used for our subjective well-being measure and the CES well-being estimation and refers to the recent happiness/satisfaction literature (Clark et al. 2008, Frey and Stutzer 2005).

Since appropriate subjective well-being data are only available in the German Socio-Economic Panel, we use all the single GSOEP waves 1992 until 2013 for the CES well-being panel estimation (covering the further GTUS data survey periods). Although in principle we could use the GSOEP for further analyses, we prefer to use time use diary data from the German Time Use Surveys (GTUS) from 1991/92 and 2012/13 (with no appropriate well-being information) since the time use diaries provide more in-depth information of parental child care time.

Within SOEP child care is one activity among others (paid and unpaid working hours, leisure etc.) for which time "normally" used in hours are available.[10] Obviously this restricts a daily expressiveness but allows to capturing a more long termed time use importance. Other SOEP information characterize our further bricks: being a parent and defining an appropriate household income.

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

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). In these surveys all respondents in a household older than 11 years noted their everyday routines in diaries in their own words for two working days and a Saturday or Sunday. Personal and household questionnaires also provide socio-economic background information. We focus on the 1991/92 and 2012/13 GTUS data[11] to characterize the start and the end of an about twenty years long development.

Within GTUS coded activities for each time slot (1991/92 five minutes slots; 2012/13 ten minutes slots) over three time diary days are available of more than 30.000 respective person respondents.

component (*a*, *b* or *c*) is computable from the other aggregates. In our application, alternative computations of the respective remaining components have shown close accordance with the orthogonal condition.

[10] SOEP 2013:" What is a typical day like for you? How many hours do you spend on the following activities on a typical weekday, Saturday, and Sunday? ☐ Please give only whole hours. Use zero if the activity does not apply!" one of 8 activities: child care

[11] Federal Statistical Office, Zeitbudgeterhebung 1991/1992 (GTUS 1991/92), Scientific Use File (SUF), DOI: 10.21242/63911.1992.00.00.3.1.0; Zeitverwendungserhebung 2012/2013, Scientific Use File (SUF), DOI: 10.21242/63911.2013.00.00.3.1.0

Our samples focus on parents with children only. Child care for our study encompasses the code areas (GTUS 2012/13): “47 child care in the household” (with seven sub codes) and “947 Travel time child care” with comparable codes for GTUS 1991/92. Further personal and household information describe the parent and other household situation.

5.2 Income, Time, and Multidimensional Poverty and Affluence Threshold Concept

Single poverty thresholds z_i and single affluence lines r_i $(i = 1, 2)$ identify the poor and the affluent respectively, the respective multidimensional well-being thresholds and the polarization individuals in our analysis. Yet, the empirical analysis requires concrete values.

Income: Poverty and Affluence Threshold Concept

Income poverty studies commonly use monthly household net equivalence income with equivalence scales like the OECD scale[12]. Conventional income-based poverty studies in the European Union identify a person as income poor if the net equivalence income is below 60% of the median income of all households (Bundesregierung 2005, XV). As a result, the 60% median line of the monthly household net equivalence income is adopted in this study as the *income poverty line*. For the sake of comparison, all subsequent income information for 1991/92 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 2001), which was followed by four further government reports (Bundesregierung 2005, 2008, 2013, 2017). During that period, top incomes gained increasing attention not only in Germany (Atkinson and Piketty 2007, Dell 2007 with German income tax microdata from 1891-1998, Merz, Hirschel and Zwick 2007 with German income tax microdata from 1992-2003). Several affluence lines were proposed in this literature, including an affluence line 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. Tthis threshold is supported, for example, by the polarization threshold in Goebel et al. 2010 or Grabka and Frick 2008 from the German Economic Institute.

Time: Poverty and Affluence Threshold Concept

Compared to income, the discussion about time poverty or even time affluence is still in its infancy. Bittman 1999 mentions a 50% time poverty line. To be consistent to our income poverty and affluence line, we chose 60% of the median parental child care leisure time as defining an individual which is time poor, and 150% of the median as the time affluence threshold. Admittedly, such thresholds are certainly debatable.

5.3 Empirical Multidimensional Poverty and Affluence Thresholds, Germany 1991/92 and 2012/13

The empirical based parental child care time and income poverty and affluence thresholds are summarized in Table 1. As mentioned, all income data are adjusted for price inflation.

[12] With a weight of 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.

CES well-being estimates: Fixed effects robust panel estimates 1992-2013

Concerning the empirical subjective well-being and isopolarization thresholds we do not follow any expert setting but rely on society's evaluation with a panel data based estimation of the CES subjective well-being function. With the GSOEP-reported general life satisfaction data on an 11-point scale[13], any estimation of individual well-being using this data requires a type of ordered response non-linear modelling. The Kmenta 1967 Taylor series approach, however, is a linear polynomial specification as a log-transformed non-linear CES well-being function (see Merz and Rathjen 2014a).

To capture a rather longstanding evaluation by the German society we then use individual panel data from 1992 (after the German re-unification and the period of the first GTUS) to 2012 (period of the last GTUS) for estimating a fixed effect robust regression with 21 waves which results in the following CES well-being function

(8) $$V = f(I, L) = 3.970 \cdot \left(0.912 \cdot I^{0.062} + 0.082 \cdot C^{0.062}\right)^{\frac{0.077}{0.062}}$$

with $I = x_{i1}$ for income and $C = x_{i2}$ for parental child care time. Significantly estimated coefficients (p-value < 0.01%) together with the fulfilment of further consistency rules quantify the relevance of substitution/compensation between parental child care time and income. The population-based evaluation[14] of the substitution/compensation between parental child care time and income yields a substitution elasticity of $\sigma = 1.066$, which shows an easier substitution than in the Cobb-Douglas type ($\sigma = 1$) situation[15]. Remarkably, given a significant substitution, income is the dominant subjective well-being predictor within income and parental child care time influencing interdependent multidimensional well-being. Figure 3a shows the estimated CES well-being mountain of equation 8.

To provide a comparable evaluation scheme this CES well-being estimates will further evaluates both the 1991/92 and 2012/13 situation.

Parental child care time and income

Median (net equivalence) income, and as a result the income poverty and affluence thresholds, increased by 10.9% to 1,217.42 Euros in the about twenty years period between 1991/92 and 2012/13 (Table 1).

Median parental child care time, and in the same manner its time poverty and affluence thresholds, shows a much stronger increase from 95 to 130 minutes per day, a remarkable increase by 36.8%.

Given the parental child care time and net equivalence income thresholds and the estimated CES-well-being function (Table 1), both, a respective assigned individual multidimensional subjective well-being and the multidimensional threshold to be compared with form the empirical basis for the following analysis.

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[13] GSOEP 2012/13 question in the personal questionnaire: "How satisfied are you today with the following areas of your life? ☐ Please answer on a scale from 0 to 10, where 0 means completely dissatisfied and 10 means completely satisfied. How satisfied are you with your … standard of living".

[14] Our CES well-being function estimates are based on parents with children and therefore its judgment of the trade-off between the two dimensions is probably more appropriate than respecting a broader population.

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

Table 1: Child Care Time, Income and Well-Being Multidimensional Poverty and Affluence Lines, Germany 1991/92 and 2012/13

	1991/92	2012/13
Median Net Equivalence Income (in euros per month and 2002 prices)	1,097.45	1,217.42
Median Parental Child Care Time (in minutes per day)	95	130
Well-Being Median $V^{median} = f(I^{median}, C^{median})$	6.702	6.764
Income Poverty Line (=60% median net equivalence income)	658.47	730.45
Time Poverty Line (=60% median personal leisure time)	57	78
Well-Being Poor $V^{poor} = f(I^{poor}, C^{poor})$	6.443	6.503
Income Affluence Line (=150% of median)	1,646.18	1,826.13
Time Affluence Line (=150% of median)	142.50	195
Well-Being Rich $V^{rich} = f(I^{rich}, C^{rich})$	6.914	6.978

Source: GTUS 1991/92 and 2012/13, weighted data, own calculations.

6 Parental Child Care Time and Income - Multidimensional Polarization in Germany – Headcount Ratios, Well-Being Indicators and Minimum 2DGAP Results

We provide results on the incidence and intensity of multidimensional parental child care time and income by three sets of indicators: first, by headcount ratios, which shows how many parents are characterized by their poverty and affluence poles and both poles together; second, by multidimensional polarization CES-well-being indicators, and third, by the Minimum 2DGAP intensity results which describes unique poverty and affluence gaps together with their transparent child care time and income contributions in the interdependent setting.

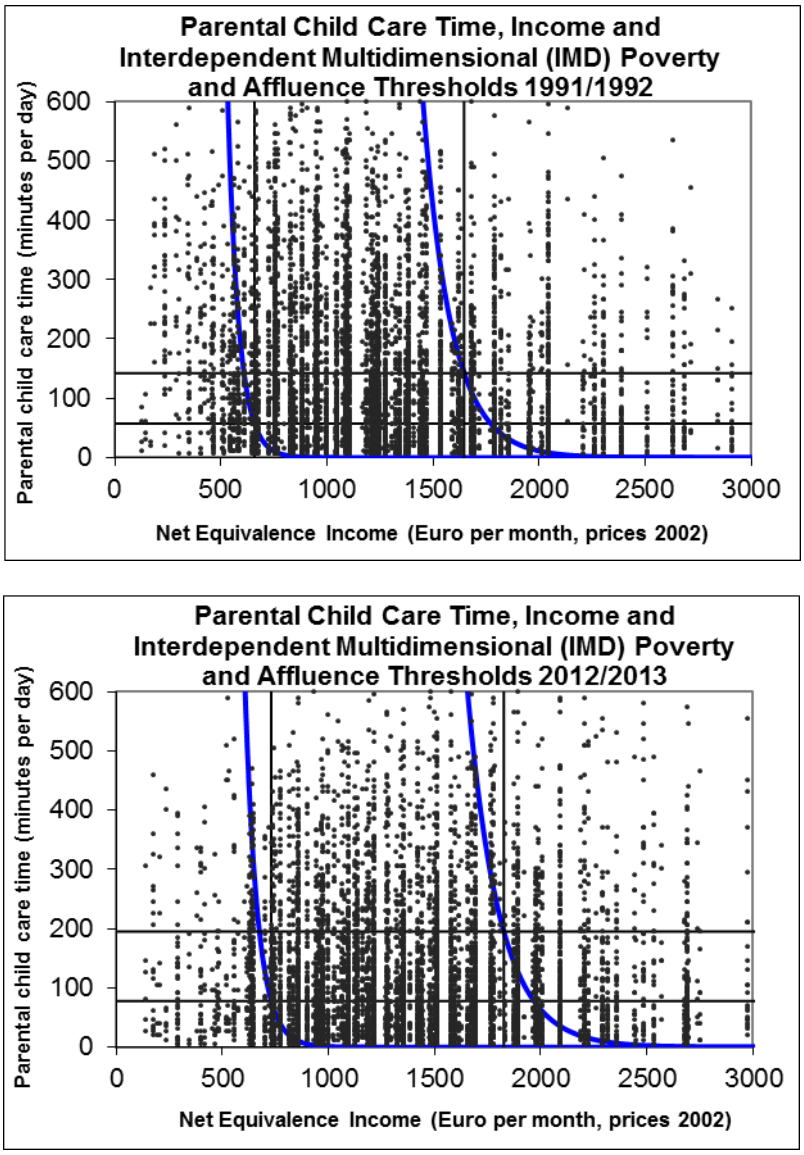
6.1 Overall Multidimensional Polarization Results: Headcount Ratios and Well-Being Indicators

Let us start with the incidence of interdependent multidimensional polarization of parental child care time and income measured by headcount ratios.

Headcount Ratios

The mapping of multidimensional subjective well-being on its time and income space provides meaningful and illustrative results of the multidimensional polarization incidence. Figure 4 shows all individual observations (personal days) for both data sets/years under investigation together with its framing poverty and affluence thresholds and the multidimensional poverty and affluence lines. The multidimensional poverty and affluence lines, as discussed, are the respective contours of the estimated subjective well-being function (Figure 3a). Figure 5 aggregates the information with its headcount ratios in dividing regions. Table 2 shows aggregated unidimensional child care time and income headcount ratios as well as the Interdependent Multidimensional (IMD) headcount ratio.

Figure 4: Parental Child Care Time and Income Observations, Germany 1991/92 and 2912/13



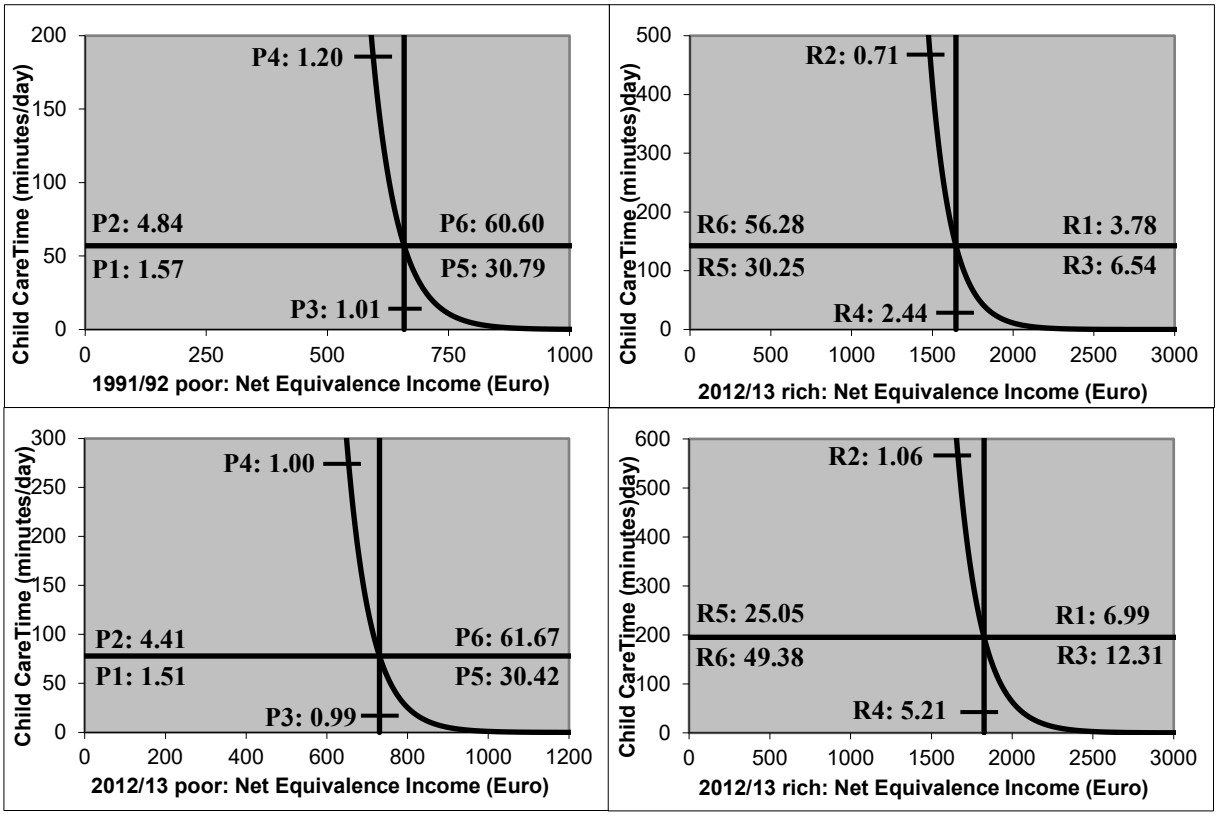
Source: GTUS 1991/92 and 2012/13, own calculation.

Poverty Pole Headcount Ratios

As to Figure 5 and Table 2 the poor interdependent multidimensional (IMD) child care time and income parents are expressed under the isopoverty line by the regions P1, P2 and P3 together: 6.91% of all parents are assigned to be IMD poor in 2012/13. Though decreasing from 1991/92 from 7.42% to 6.91% in 2012/13 the change is not significant (see also Table 3), the IMD headcount ratio remains around a remarkable 7%.

The single poverty regions show a broad spectrum of different importance. Let us focus on the actual 2012/13 situation: Beyond the non-poor in any dimension, region 5 is prominent with 30.42% where above poverty income is compensating the parents' child care time deficit. In contrast, above poverty income is assigned not to be compensated in region 3 by roughly 1%. Thus income (as the dominant factor in the estimated CES subjective well-being function) is the compensation driver. Nevertheless, for 1%, which is about 14% of all IMD poor parents, even above poverty income cannot compensate their time deficit, they remain multidimensional poor.

Figure 5: Parental Child Care Time and Income and Interdependent Multidimensional (IMD) – Poverty and and Affluence Headcount Ratios, Germany 1991/92 and 2912/13



IMD = Interdependent Multidimensional; Significance *** < 0.1% ; ** < 1%; * < 5%.
Source: GTUS 1991/92 and 2012/13, own calculation.

Table 2: Parental Child Care Time and Income and Interdependent Multidimensional (IMD) – Poverty and and Affluence Headcount Ratios, Germany 1991/92 and 2912/13

	Poverty			Affluence			Poverty and Affluence		
	1991 /92	2012 /13	Index 1991/92=100	1991/ 92	2012 /13	Index 1991/92=100	1991/ 92	2012/ 13	Index 1991/92=100
Unidimensional Income	7.61	6.92	*90.9*	12.76	24.51	*192.1****	20.37	31.43	*154.3****
Child Care Time	33.37	32.92	*98.7*	34.74	33.1	*95.3**	68.11	66.02	*96.9***
Multidimensional IMD	**7.42**	**6.91**	***93.1***	**11.03**	**20.36**	***184.6****	**18.45**	**27.27**	***147.8****

Source: GTUS 1991/92 and 2012/13, own calculation.

One further poverty situation is of particular interest, it is where parents are time poor as well as income poor (region P1): with 1.51% of all parents and 21.9% of all IMD poor it is the second large group of IMD poverty.

Concerning child care time deficit regardless any income, remarkably 32.92% (P1, P3, P5) show a time deficit (below the time poverty threshold) which is much more frequent than those with an income deficit below the income poverty threshold (6.92%, P1, P2, P4); a remarkable picture of particular child care time poverty which is still similar as twenty years ago.

Affluence Pole Headcount Ratios

Taking the IMD affluent regions together (R1, R2 and R3) then 20.36% parents could be assigned to be IMD rich in child care time and income. Remarkably, whereas the IMD poor remain around 7% over those twenty years, the IMD well-being incidence of the rich almost doubled from 11.03% to 20.36% over this period (Table 2).

With focus again to 2012/13 the prominent group of IMD affluent parents is in region R3: 12.31% are IMD affluent, income rich but child care time not rich. They are assigned not to compensate their child care time deficit (being below the affluent time threshold) by high income; they "remain" IMD affluent. At a first glance this interpretation might be confusing, however, the hint that compensation is an assignment of being outside a pole (not being in a shaded pole area, poor or rich, Figure 1) should help.

In contrast, 5.21% are assigned not to be IMD affluent though the parents are income rich but child care time not rich (region R4). Their child care time deficit is assigned to be compensated by high income. Remarkably, almost every sixth income rich parent (17.52%) faces a child care time deficit (R3, R4) (being above the affluence income threshold and below the affluent time threshold).

One further affluence situation is of particular interest, it is where parents are time rich as well as income rich (region R1): with 6.99% of all parents this group is distinct larger than the poverty counterpart with 1.51%.

Interdependent Multidimensional Poverty and Affluence: Headcount Ratio Polarization

Altogether interdependent multidimensional polarization of parental child care and income increased significantly over the twenty years period by 48%. Increased polarization, by the same time characterizing a diminished "middle class", means relatively more parents moved (or were pushed) to the lower and upper end of the distribution. However, the disaggregated polarization results revealed an asymmetric headcount picture and development: with around 7% IMD poor in contrast to around 20% IMD rich the affluence pole is almost three times higher occupied than the poverty pole (2012/13). And, it is only the affluence pole which increased significantly over those twenty years even by 85%.

Though this sounds like a nice picture of an increasing well-being of multidimensional child care time and income, however, after twenty years and the proven income well-being dominance and its compensation power, there are still one third (32.92%) of all parents with a remarkable child care time deficit (P1, P3, P5) under the poverty perspective.

Compensation and no compensation areas

Compensation between parental child care time and household income proved to be significant in explaining German society's subjective well-being (panel estimation results) with a larger household income than parental child care time impact.

However, as the above results have shown, there are different areas of assigned compensation and no compensation defining multidimensional poor respectively rich: with focus on 2012/13 and with regard to the time poor (being below the time poverty threshold) there is a relatively large group where *income is compensating* parental child care time (30.4%; P5). At the affluence pole *income is compensating* the time deficit of the not time rich (being below the time affluence threshold) for about 54.6% of all parents (R4, R6) which again demonstrates the allover income dominance in the society's evaluation.

There is compensation power of parental child care time, too: With regard to the income poor (being below the income poverty threshold) *time is compensating* income below the income poverty threshold by 1.06% (P4). At the affluence pole *time is compensating* the income deficit of the not income rich (being left of the income affluence threshold) for 74.4% of all parents (R5, R6).

So, is time money? Yes, but only to a certain extent. Against it and again, parental child care *time deficit is not compensated* even being above the income poverty threshold for 1% which nevertheless are 14% of multidimensional poor parents (Figure 2: P3). And in addition, there are 4.4% of all parents, which is about 63.9% of multidimensional poor parents, who are not child care time poor but are assigned *not to compensate income poverty* (P2). No compensation of the not time rich also is assigned for about 12.3% parents even above the high income threshold (60.5% of IMD affluent parents). Hence, beyond compensation, no compensation areas are important parts of being assigned multidimensional poor respectively multidimensional rich.

Interdependent Multidimensional Subjective Well-Being

Whereas the above headcount ratio tells us how many parents will be assigned to different regions, one-value well-being intensity measures now describe intensity in the combined multidimensional subjective well-being space. Table 3 provides the two discussed subjective well-being gap measures: P_{median} which divides the poles by the overall median, and P_{poles} which relies on the poverty and affluence thresholds as pole markers.

The result: both IMD polarization well-being measures show a significant increase in IMD polarization over those twenty years. This increase is less distinct when the pole limits are closer to the pole ends (P_{poles} Index = 107 vs. P_{median} Index = 117). The move to the pole ends is impressed by the poverty pole development: The hard up of the multidimensional poor in particular drives the increased polarization well-being intensity over the twenty years period.

In addition, allover inequality of IMD well-being increased over this period (Gini: + 6.3%).

Altogether: Both, the headcount ratio as well as the well-being indicators, prove a significant polarization increase of interdependent multidimensional parental child care time and income over twenty years in Germany. And, rather than a symmetric situation and move to the pole ends, the poverty and the affluent poles are different in magnitude and development: There are relatively more IMD rich than IMD poor parents, however IMD poor parents are affected by a greater IMD well-being intensity.

6.1 Multidimensional Polarization by the Minimum Multidimensional Polarization Gap (2DGAP)

At a first glance the picture from the results above seems to be complete and conclusive: incidence and well-being intensity of parental child care time and income is rising over the twenty years under investigation. However, and shortly discussed above, when an overall well-being indicator is considered, very different time and income pairs only show the same level of well-being on a certain well-being indifference curve. Thus, the different individual time and income situations are no longer visible, a strong restriction for any targeting policy approach.

But, there is the discussed solution for a more distinct and transparent picture: each individual situation is individually captured by a different 2DGAP value, which for each individual is a unique gap (shortest path to circumvent the respective pole). This 2DGAP shows how severe is multidimensional poverty respectively how intense is multidimensional affluence.

In addition and discussed, the gap components, income (a) and child care time (b), will be transparent for each individual multidimensional 2DGAP distance (c) (see equations 6 and 7). This allows in particular targeted economic and social policies which respect at the same time the interdependence here of parental child care time and income.

The overall impressive 2DGAP result (Table 3): the aggregated 2DGAP C measure (average of all individual gaps) as well as its income (A) and child care time component (B) show a highly significant increase in multidimensional well-being polarization of parental child care time and

income. Thus, the pole centers (C measures) moved to the ends of the multidimensional distribution and reflect a strengthened pole deepness.

Table 3: Parental Child Care Time and Income – Multidimensional Polarization Measures, Germany 1991/92 and 2012/13

	1991/92	2012/13	*Index 1992=100*	Sig.[1]
IMD Headcount Ratio				
HCR $_{poor}$ (%)	7.42	6.91	*93*	
HCR $_{rich}$ (%)	11.03	20.36	*185*	***
HCR $_{poles}$ (%)	18.45	27.27	*148*	***
IMD Inequality Well-Being				
Gini	0.016	0.017	*106.3*	***
90/10 Relation	1.104	1.110	*100.5*	[2]
95/5 Relation	1.120	1.132	*101.1*	[2]
IMD Polarization Well Being				
P_{median} (%)	2.15	2.52	*117*	***
$P_{poles,\ poor}$ (%)	1.82	2.30	*126*	***
$P_{poles,\ rich}$ (%)	1.69	1.44	*85*	***
P_{poles} (%)	3.51	3.74	*107*	***
2DGAP Income Component				
$A_{poor,income}$ (€)	102.51	144.39	*140.9*	***
$A_{rich,income}$ (€)	21.91	32.61	*148.8*	***
A (€)	**124.42**	**177.00**	***142.3***	***
2DGAP Child Care Time Component				
$B_{poor,time}$ (minutes)	30.91	40.70	*131.7*	***
$B_{rich,time}$ (minutes)	96.29	111.46	*115.8*	***
B (minutes)	**127.21**	**152.16**	***119.6***	***
IMD 2DGAP				
C_{poor}	109.07	152.50	*142.3*	***
C_{rich}	105.67	125.64	*119.6*	***
C	**214.74**	**278.14**	***129.5***	***

[1] Two sample difference in means test with variance inhomogeneity and unequal variances; [2] Two ample difference in shares test; Significance *** < 0.1% ; ** < 1%; * < 5%.

Source: GTUS 1991/92 and 2012/13, own calculation.

This result is in line with the one-value well-being gap result above which stresses the importance and validity of our results; the more, since both approaches, the well-being gap and the 2DGAP, do not necessarily show similar pictures in general. They might yield different results like in our multidimensional polarization analysis of genuine personal leisure time and income (Merz and Scherg 2014).

2DGAP Overall (C): the *mean multidimensional polarization 2DGAP* (C, Equations 6 and 7) increased significantly by C = +29.5% (Table 3). Thus and again, we face a remarkable growth of the interdependent multidimensional polarization of parental child care time and income over those twenty years. This increase is driven rather by the poor C_{poor} = +42.3% than the rich C_{rich} = +19.6% 2DGAP intensity.

Thus, increased multidimensional polarization of child care time and income is characterized by an expanded poverty gap, though the headcount ratio of the poor remained at about 7%.

The virtue of the 2DGAP approach is making transparent the single components ensuring interdependence of its components. So the question now arises which of the 2DGAP components, income (A) or child care time (B) is most contributing to this result of an increasing interdependent polarization.

2DGAP Income component (A): The summarized mean minimum *income 2DGA*P component increased from €124.42 to €177.00 by +42.3%, a remarkable and highly significant development. The poverty income component in both years is by far greater than the affluence income component (e.g. 2012/13: $A_{poor,income}$ = €144.39 vs. $A_{rich,income}$ = €32.61); i.e. the multidimensional poor parents face a deeper income gap (they are farer away from the IMD poverty threshold) than the multidimensional affluent parents respectively. This might be an indication to focus rather on an income oriented anti-polarization policy for the poor than for the affluent in the multidimensional context.

2DGAP Child Care Time component (B): The summarized mean minimum child care *time 2DGAP* component increased highly significant from 127.21 minutes to 152.16 minutes per day (+19.6%). In contrast to the income component contribution, the parental child care time contribution to multidimensional polarization is now higher for the affluent (2012/13: $B_{rich,time}$ = 111.46 minutes) than for the poor ($B_{poor,time}$ = 40.70 minutes). In other words: the affluent need relatively more time than the poor to leave their pole. A resulting anti-polarization policy with regard to parental child care time of the rich is debatable. However, policy support for IMD child care time poor is needed since there are about 40 minutes, i.e. 95.34% of the maximum gap component of 43 minutes (Table 4b), to get rid of IMD child care time poverty.

Polarization Centers

Mean minimum multidimensional polarization gaps (2DGAP C), which characterizes the shortest way to leave the poles, describe centers of polarization intensity. The starting scores of 2DGAP C ((xc,yc), Table 4a and Figure 3) identify the position of the mean minimum multidimensional polarization pole gaps. [16] Table 4b in addition provides the relative share of 2DGAP C to its maximum length, which, however, can be identified only for the poverty poles.

[16] The starting scores are calculated by an iterative process using the mean 2DGAP components and the orthogonal property of 2DGAP C; the Stata program is available from the authors.

Table 4a: Parental Child Care Time and Income – Multidimensional Polarization Centers, Means and Compensation, Germany 1991/92 and 2012/13

	1991/92		2012/13	
IMD	poor	rich	poor	rich
Income (€) (x_c)	**504.31**	**1,885.02**	**536.09**	**2,095.69**
Mean IMD Income (€)	514.60	2221.23	547.36	2351.39
Income Threshold (€)	658.47	1,646.18	730.45	1,826.13
Time (minutes) (y_c)	**110.34**	**132.84**	**128.71**	**163.36**
Mean IMD Time (Minutes)	138.70	148.22	153.45	190.87
Time Threshold (Minutes)	57	142.50	78	195
Well-Being IMD Mean	**6.326**	**7.034**	**6.353**	**7.082**
Well-Being (x_c,y_c)	6.348	6.978	6.381	7.040
Well-Being Threshold	6.443	6.914	6.503	6.978
Compensation (x_c,y_c)				
A Mean 2DGAP Income	102.51	21.91	144.39	32.61
B Mean 2DGAP Time	*30.91*	*96.29*	*40.70*	*111.46*
A/B	***3.32***	***0.23***	***3.55***	***0.29***

[1] IMD=Interdependent Multidimensional Polarization; [2] x_c,y_c starting scores of mean multidimensional income and time 2DGAP intensity C

Source: GTUS 1991/92 and 2012/13, own calculation.

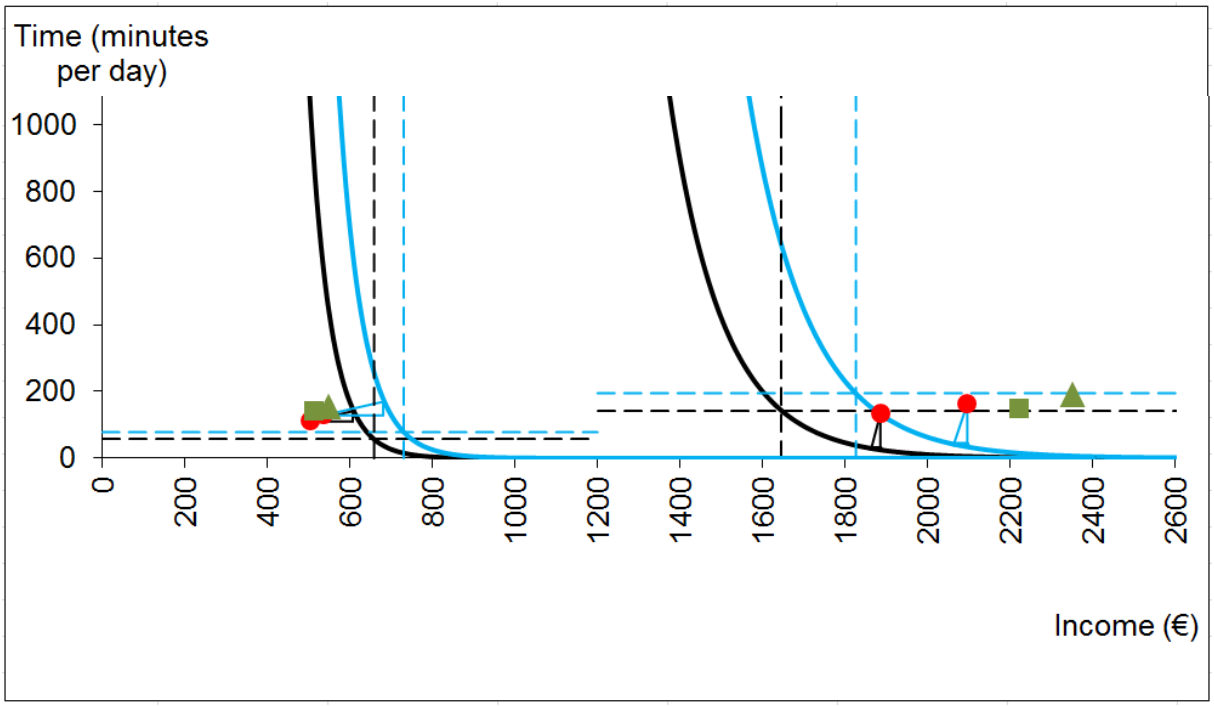
Table 4b: Parental Child Care Time and Income – 2DGAP Measures, Germany 1991/92 and 2012/13

2DGAP	1991/92			2012/13		
	mean	max	%	mean	max	%
A Income [€]	102.51	595.54	17.21	144.39	671.86	21.49
B Time {minutes]	30.91	177.86	17.38	40.70	42.69	95.34
C	109.07	621.53	17.55	152.5	673.22	22.65

Source: GTUS 1991/92 and 2012/13, weighted data, own calculation.

Figure 6 sums up and illustrates the numerical results: means, the positions of mean polarization gaps (2DGAP C), their polarization centers and the development over that twenty years period in Germany.

Figure 6: Parental Child Care Time and Income – Means, Mean minimum polarization intensities (2DGAP C) and polarization centers, Germany 1991/92 and 2012/13



1991/92: Black lines, continuous and dashed; 2012/13: Blue lines, continuous and dashed; Round scores: Starting scores of mean multidimensional time and income 2DGAP intensity C; Quadrats: Mean IMD income and mean IMD time 1991/92; Triangles: Mean IMD income and mean IMD time 2012/13.
Source: GTUS 1991/92 and 2012/13, own calculation.

Four results illustrate the numerical findings (Figure 6, Tables 4a, b):

1. The mean polarization gaps (2DGAP C) are relative short, the poverty and affluence pole centers are relative near the respective interdependent multidimensional polarization (IMD) line. Pole deepness is more distinct in the poverty pole.
2. There is a particular move of the IMD time and income means and mean affluent gap/polarization center move to higher income in particular for the affluent.
3. Affluence: relative steep ascending mean gaps pinpoint the importance of the parental child care time component (2DGAP B).
4. Poverty: high and important relative shares of the 2DGAP time components (2DGAP B) compared to the maximum 2DGAP time components again pinpoints the importance of parental child care time of the poor in both respective years.

Compensation: The price of parental child care time

There is another interesting feature of the multidimensional polarization gaps: The 2DGAP components a and b (respectively their mean values A and B) allow a practical substitution qualification of parental child care time compared to income. The slope -a/b at the IMD isopolarization curve characterizes the replacement relation between both dimensions, income and child care time. The replacement ratio (input ratio) at the mean polarization 2DGAP C describes the substitution at the pole centers. A replacement ration for instance of a/b= 0.5 respectively b/a=2 then requires the double of time compared to income units to leave a pole.

The result for the poor in 2012/13 is A_{poor} / B_{poor} = €144.39/40.70 minutes = €3.55 per minute. Thus, €3.55 per minute is required to leave multidimensional poverty. The replacement ratio of the affluent is A_{rich} / B_{rich} = €32.61/111.46 minutes = €0.29 per minute; already with 29 cents one minute can be "compensated".[17] Thus, time could be characterized as to be more valuable for the affluent than for the poor. Or in other words: time (to leave IMD poverty) is more expensive for the poor than for the rich (to leave IMD affluence), the poor have to spend €3.55 whereas the affluent have to spend only 29 cents for one minute of parental child care time.

Thus the evaluated compensation between parental child care time and income by the German population yields distinct different compensation prices in leaving the multidimensional polarization poles. A greater amount of income for one minute child care time is needed for the poor compared to the rich to leave the respective IMD pole.

This result, too, stresses the particular importance of the time component for the interdependent multidimensional polarization of parental child care time and income.

7 Multidimensional Parental Child Care Time and Income Polarization in Germany – 2DGAP Intensity Results for Socio-Economic Groups

Is multidimensional polarization different for different people? What socio-economic characteristics influence the situation? Do personal, job and household and even regional characteristics have different impacts on the poor and the affluent poles of multidimensional polarization of parental child care and income? Are there differences in the probabilities/risk to be in the poor or rich pole?

These are the questions we now want to answer for the 2DGAP intensities by a two stage Heckman 1976 approach. The first selection stage estimates the risk (probability) to be multidimensional poor respectively rich by a probit approach with all parents having positive parental child care time as well income values. The second stage explains the amount (length) of the 2DGAPs (C) by a selectivity corrected linear OLS regression model for the poor respectively the affluent intensity gaps of those affected by.

Remember: the longer the 2DGAP distance C the closer somebody is at the pole ends. Thus, a positive estimated coefficient of the 2DGAP gap amount is deepening poverty and affluence and strengths polarization. Note, the assignment to be multidimensional poor respectively affluent is based on the subjective well-being evaluation of German society (all parents based on twenty years panel econometric estimates with the German Socio-Economic Panel).

Table 5 presents the 2012/13 results with regard to the risk and the 2DGAP amount being multidimensional poor or affluent. The selection of socio-economic variables follows proven market and non-market variables in the literature but are restricted by the variables at hand over twenty years of SOEP panel data, of course.

Overall result

The overall result: there are remarkable differences with respect to the significance and sign of the variables and their socio-economic background. And, this holds for the pole probabilities as well as for the pole intensities.

[17] The different situated pole centers result in different slopes of the respective different indifference curves.

Table 5: Multidimensional Polarization of Interdependent Parental Child Care Time and Income – 2DGAP Polarization Risk and Intensity: Two Stage Heckman Estimation Results – Germany 2012/13

	IMD[1] poor		IMD affluent	
	coeff.	p-value	coeff.	p-value
IMD Polarization Risk				
Personal				
Female	-0.0922	0.145	0.161***	0.000
Age	-0.088***	0.000	0.134***	0.000
$Age^2/100$	0.0981***	0.000	-0.130***	0.000
German	-0.575***	0.000	-0.146	0.274
Education				
Second. School	-0.464***	0.000	0.397***	0.000
Abitur- Fachabitur	-0.667***	0.000	0.971***	0.000
Occupation				
Self-employed	-0.600***	0.000	0.539***	0.000
Blue Collar	-0.998***	0.000	-0.0104	0.924
White Collar	-1.128***	0.000	0.627***	0.000
Civil Servant	-1.517***	0.000	1.117***	0.000
Job				
Working minutes. day	0.000128	0.318	-0.000340***	0.000
Shift Work	-0.00089	0.992	-0.139*	0.027
Work at Home	-0.180	0.070	0.155**	0.002
Family and Household				
Household Size	-0.567***	0.000	0.462***	0.000
No. Children age 1-3	0.536***	0.000	-0.520***	0.000
No. Children age 4-5	0.469***	0.000	-0.554***	0.000
No. Children age 6-9	0.331***	0.000	-0.521***	0.000
No. Children age 10-18	0.431***	0.000	-0.632***	0.000
Paid C. Care Support	0.0094**	0.005	-0.0048	0.065
Unpaid C. Care Supp.	-0.00168	0.772	0.000784	0.853
Region				
Community type	0.125***	0.000	-0.0479*	0.021
East Germany	0.286***	0.000	-0.193***	0.000
Constant	3.204***	0.000	-5.847***	0.000
IMD Polarization Intensity (2DGAP C)				
Personal				
Female	-7.198	0.662	28.21*	0.022
Age	3.434	0.553	1.168	0.908
Age^2	-0.0497	0.434	-0.0260	0.799
Not enough time	28.22***	0.000	-1.223	0.665
Education				
Second. School	-59.02*	0.019	28.02	0.417
Abitur- Fachabitur	-61.99	0.072	64.90	0.358
Occupation				
Self-employed	-6.293	0.873	49.15	0.229
Blue Collar	-118.8*	0.019	36.11	0.122
White Collar	-115.1*	0.037	34.70	0.446

Civil Servant	-71.92	0.459	51.90	0.488
Job				
Working minutes. day	-0.110**	0.003	-0.120***	0.000
Shift Work	-23.23	0.351	-39.70**	0.003
Work at Home	16.54	0.607	-3.169	0.791
Family and Household				
Household Size	-53.86	0.058	18.02	0.547
No. Children 1-3	82.95**	0.009	-1.132	0.974
No. Children 4-5	136.7***	0.000	-6.154	0.864
No. Cchildren 6-9	18.44	0.416	5.057	0.883
No. Children 10-18	62.62*	0.013	-27.21	0.507
Paid C. Care Support	1.127	0.207	-0.529	0.328
Unpaid C. Care Supp.	-0.301	0.840	-0.307	0.677
Region				
Community type	9.309	0.248	-5.754	0.207
East Germany	-10.39	0.584	-20.68	0.181
Constant	105.9	0.393	-48.52	0.920
Mills Lambda	48.55	0.396	49.18	0.587
n	6853		6850	
n censored	6309		5517	
N uncensored	544		1333	
Wald Chi²	125.27***		247.34***	

[1] *Interdependent Multidimensional;* * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Source: GTUS 2012/13. own calculation.

2DGAP polarization risk

Personal characteristics: Women have a significant probability being in the affluence pole (not poverty pole). The affluence pole combines higher parental child care time as well higher household income. Thus, we face higher female time for children in better income situated households. This is in some accordance with the above mentioned Guryan, Hurst and Kearney 2008 result of a positive correlation of child care time and income, which is in contrast to the opportunity costs approach of economic modelling discussed.

The elderly have a diminishing risk being multidimensional poor and an increasing probability being in the multidimensional affluent pole. Foreigners have a significant higher risk being multidimensional poor; no significance for the affluence pole.

Education: Higher education diminishes significantly the risk of IMD poverty and increases the probability to be in the rich pole of child care time and income, a result in some accordance to Craig 2006. Remember, this is again in contrast to the economic perspective where the positive influence of higher education in child care is not expected given that the opportunity cost of time is higher for higher-educated with higher wages.

Occupation: Occupation, different for different jobs, reduces significantly the risk for the poor pole position and rises the probability for the affluent pole. A positive correlation of being active and earning (more) money than being non-active in the labor force should be behind. Working hours at the day of measured individual child care time increase the risk of less time for the children; however and surprisingly not significantly. Work at home has a positive significant influence for the high time and income pole but plays no role at the lower end of the distribution as it might be expected because of probably less work at home of the poor.

Family and household situation: a larger household diminishes multidimensional poverty risk and increase significantly multidimensional to be in the affluence pole; probably because of further

personal and financial support of other household members. The time slot GTUS diary data about time use for child care does not show information about how many children are present that time. Nevertheless, the number of children in the household by age classes can be constructed and show a significant influence in rising multidimensional poverty (Table 5). Hence the pure household size variable hides the children's situation which indeed – different in children's age classes – is highly influencing the situation in both IMD poles. As expected, the risk to be multidimensional poor is in particular given for families with younger children.

Support for child caring by others (friends, neighbors or relatives) has no influence for both pole probabilities. A contribution of paid nursing/child care is visible for the IMD poor which reveals a relaxed parental child care time if allowed by the financial situation.

Region: Even after more than twenty years after the German re-unification there are still West- and East German differences. Living in East German (Neue Länder) rises the risk to be multidimensional child care time and income poor and diminishes that of being multidimensional affluent. The less regional dense the population, say the more living in the country side, the greater is the risk to be multidimensional poor respectively the lower is the probability being in the affluent pole. Since commuting is considered in the child care time definition, increased travelling activities to bring the children to their various activities out of the living place might result here in a positive influence of the community type variable.

2DGAP polarization intensity

Compared to the above probabilities to be in the poor or rich pole the explanation of the respective 2DGAP intensity by roughly the same variables is less successful, there are by far less significant single coefficients.

Personal characteristics: With no specific gender and age influence the individual assessment of "having not enough time for the children" is positive and significant for the poverty pole. Greater desire to have more time for the children is correlated with the severity of multidimensional poverty.

Education: Whereas education has a significant influence on the polarization risk for both poles, education is only influencing 2DGAP polarization intensity for the poor.

Occupation: Being a blue or white collar worker diminish the poverty IMD deepness. Higher working hours the interview day is diminishing the 2DGAP intensity both for the poor and affluent pole.

Family and household situation: In particular young children till 3 years and in the Kita ("Kindertagesstätte", professional outdoor child care) age till 6 years deepen the multidimensional poverty intensity.

The regional situation, though important for the risk explanation, play no significant role any further in the determination of the IMD intensity. Thus there are no further East-West differences in the pole intensity, in the respective pole deepness, once being at the pole ends of the well-being distribution.

8 Concluding Remarks

This study is about parental child care time, income and subjective well-being in an interdependent multidimensional (IMD) polarization perspective. Our novel approach combines these three components with the explicit evaluation of the compensation between interdependent parental child care time and income evaluated by German society over twenty years (1991/92 to 2012/13) with robust fixed effects subjective well-being estimates. Besides multidimensional polarization well-being measures and results, the minimum multidimensional polarization 2DGAP approach disentangled the singular parental time and income components ensuring their interdependence. With panel data from the German Socio-Economic Panel (SOEP) and German time use diary data from the German Federal Statistical Office from 1991/92 and 2012/13 we provided new insights and quantified socio-

economic relations concerning the risk and the 2DGAP polarization gap intensity amount over twenty years in Germany.

Our approach extends a plain question of the kind of positive or negative correlation between parental child care time and income mainly discussed in the literature so far (see chapter 2). We use individual subjective well-being to evaluate the compensation of child care time and income, and, we step further by asking, if the interdependent multidimensional situation is drifting apart, if the poor getting poorer and the rich getting richer with its interdependence of parental child care time and income.

Prominent result: Interdependent multidimensional (IMD) polarization headcount ratios, multidimensional well-being as well as the pole intensities increased significantly over the twenty years under investigation. Within that period a significant number of parents moved from the middle of society to the borders of the multidimensional distribution of child care time and income. After twenty years we found not only relatively more parents in the poverty and affluence pole but the intensity to be respectively rich or poor increased significantly, too.

Compensation between parental child care time and household income proved to be significant, but there are multidimensional regions of no compensation with parental child care time deficit not compensated by income. Neglecting regions of no compensation would miss an important contribution of being multidimensional poor or rich. In explaining German society's subjective well-being (panel estimation results over about twenty years) with its compensation/substitution household income showed a larger impact than parental child care time.

IMD polarization intensity measured by minimum 2DGAP in addition accentuates the polarization growth of parental child care time and income over that time period. Poverty and affluence intensity, measured by the respective gaps (2DGAP) from the pole centers (means) to the IMD poverty and IMD affluence line, were drifting to the ends of the distribution. The "deepness" of the poles increased significantly.

There are remarkable differences between the polarization poles: the income 2DGAP gap components grew faster than the respective time components in both poles. However, the stronger increase of the poor child care time component – as well its relatively larger distance to the IMD line – compared to the rich again stresses an increasing importance of parental child care time deficit in particular of the multidimensional poor.

The importance of the individual socio-economic background was estimated by a microeconometric two-stage Heckman approach of the risk to be in the respective multidimensional pole and subsequently of the amount of the 2DGAP intensity gap: Polarization risk (probability to be multidimensional poor respectively rich) compared to polarization intensity can be better explained by the analyzed set of personal, education, occupation, job, family and household, and region variables. The influence of the family and in particular younger children proved to be important for both, risk and intensity, an important hint for economic and social policy. Personal, education, occupation, job and region characteristics are rather important for the polarization risk than for the deepness of the poles.

With regard to literature results (though the compensation topic is not explicitly regarded there so far): the increased multidimensional polarization with increased lower time and income as well as higher time and income highlights the positive connectivity of both, parental child care time and income. A result which supports the findings of positive correlation between labor market involvement/income and parental child engagement (see our background) which is in contrast to the opportunity cost assumption of economic modelling, where higher opportunity costs pull to the market to the burden of non-market child care time.

Concerning economic and social policies, the proven multidimensional results discard a unidimensional policy and urgently ask for a more successful interdependent policy approach of parental child care time and income. One lesson of our results: to reduce multidimensional

polarization, economic and social policy should reduce the income gap and support in particular parental child care time for the poor. Remember: after twenty years and the proven income well-being dominance with its compensation power, there are still one third (32.92%) of all parents with a remarkable child care time deficit (P1, P3, P5) under the poverty perspective. For the rich rather income than time oriented policies seems to be more approbriate.

All our quantified results ask and support targeted polarization reducing policies in many ways: with respect to the poor and the affluent, with respect to the disentangled time and income components of the interdependent multidimensional approach, and with respect to the different socio-economic influences.

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