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Measuring Intra-Generational Redistribution in PAYG Pension Schemes

Abstract

In this paper, we propose a novel index for measuring intra-generational redistribution in pay-as-you-go pension schemes. Our index solely requires information on contributions and pension benefits of retirees, enabling us to measure intra-generational redistribution isolated from possible inter-generational redistribution. We use contribution records of approx. 100,000 German individuals, who progressed into retirement in 2007-2015, to measure the level of intra-generational redistribution in the German statutory pension scheme (GRV). A recent reform of childcare benefit provision, which became effective in 2014, confirms the predictions of our index. The reform introduced additional benefits for a subgroup of substantial size of German mothers, due to which the index value for women, but not for men jumps up. Our findings suggests that GRV fulfils the ideal of a Bismarckian pension system without intra-generational redistribution for men, while women benefit from intra-generational redistribution.

JEL-Codes: H550, D310, C550.

Keywords: PAYG pension systems, intra-generational redistribution, Beveridge vs. Bismarck, index, microdata, Germany.

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1 Introduction

Demographic change and the ageing of societies have become major challenges to industrialized countries. Pension reforms, especially in the first, pay-as-you-go (PAYG) financed pillar of public pension schemes, will therefore be unavoidable, but need to be backed by public acceptance and, ultimately, democratic support. Arguably, this support is stronger when pension reforms appear acceptable along two dimensions. First, the reforms need to balance the interests of the involved living, and possibly also yet unborn, generations, i.e., after a reform the pension system must still be seen as broadly *inter*-generationally fair.[1]

Second, public pension systems are usually considered as a part of the broader public tax-transfer mechanism. Although controversial, the public and many politicians expect public pension systems to also redistribute *intra*-generationally, i.e., between different types of households of the same generation. Interestingly, the academic discourse focuses almost exclusively on the first dimension; despite its high political relevance, there is only a small literature that attempts to systematically investigate intra-generational redistribution.

Our paper aims at providing new insights into the relevance of intra-generational redistribution and the effects that even minor parametric reforms might have on it. We do so in a threefold manner. First, we develop a novel index measure for intra-generational redistribution in PAYG pension schemes.[2] Second, we resolve several theoretical and empirical shortcomings of existing measures of intra-generational redistribution. Third, we apply our index to micro-data from the German public pension system ('Gesetzliche Rentenversicherung', GRV) and a recent reform of childcare benefit provision in order to highlight the resulting, substantial effect sizes.

The rate of return on an individual's contribution to a PAYG pension system depends on two factors: (i) the size of the future workforce—the more contributors, the higher one's own pension benefit—and (ii) the link between one's own contributions and benefits. While in the first case the sizes of two consecutive generations are most relevant (giving rise to inter-generational redistribution), whether the link between contributions and benefits is more or less direct matters in the second case and may lead to different levels of intra-generational redistribution.

Let us consider two polar cases. In the first case of a *Bismarckian* pension

[1] While potential 'generational conflict' is a topic in public debate and academic discourse, the existing empirical evidence in its favor is not overly robust (for a summary of evidence cf., e.g., Krieger and Ruhose 2013).

[2] It should be noted that we focus only on redistributive elements within the pension system. We do not consider other parts of the tax-transfer system, through which the effects that we predict and measure could be strengthened or weakened.

system (cf. Cremer and Pestieau 2003; Casamatta, Cremer and Pestieau 2000a,b), benefits are earnings-related with full proportionality between earnings (and thus earnings-related contributions) during work-life and paid-out pension benefits after retirement. The other polar case assumes that there is no link at all between earnings and benefits, which is typically achieved by having flat benefits for every member of the pension scheme, regardless of one's personal level of contributions or, as a matter of fact, income taxes, given that pension schemes of this type—so called *Beveridgean* pension systems—are often tax-financed.[3]

Most real-world pension schemes are somewhere in-between these extremes, as Krieger and Traub (2011, 2013) show. This is because of the—above mentioned—observation that the majority of voters prefers some redistribution among members of the same generation even in traditional Bismarckian pension schemes. Table 1 gives an overview of non-earnings related benefits in the German public pension system,[4] which was introduced by Reich Chancellor Otto von Bismarck in 1889 as the prototype Bismarckian pension system with a fully proportional earnings-benefit link. This link has weakened over time through, among other things, benefits based on child-raising times, where mothers receive benefits *as if* they were working, although they do not. Benefits of this type play a significant role in today's German pension system.

Table 1: Non-earning related benefits in the German Pension System

Type of benefits
– Benefits due to Early Retirement
– Benefits without contributions due to education, unemployment, illness and other work-related circumstances
– Benefits due to Child Raising
– Benefits payable to Repatriates / Foreigners resident in Germany under Special Conditions
– Higher evaluation of Vocational Periods
– Health / Long-Term Care Insurance for Pensioners
– Minimum Pension
– Invalidity Pension
– Part-Time Work for Older Workers

[3]Due to the larger degree of redistribution, Beveridgean pension schemes are typically smaller (less generous) in absolute terms than Bismarckian pension schemes (cf. Conde-Ruiz and Profeta 2007).

[4]We present information on the German pension system here because the empirical analysis in our paper will refer to this very system.

One approach to measure intra-generational redistribution in a public pension scheme is to identify all benefit payments which are not backed by contribution payments (such as the ones in Table 1), add them up and relate them to total benefits (as in, e.g., Börsch-Supan and Reil-Held 2001). However, not all benefits can be clearly identified as not being backed by contributions. In order to overcome this problem, broader measures of intra-generational redistribution have been proposed. These measures include the 'index of non-contributiveness' by Lefèbvre and Pestieau (2006) and Lefèbvre (2007), the 'index of progressivity' by the OECD (2013), correlation analyses between individual contributions and individual pension entitlements as suggested by Stöwhase (2016), and the 'Bismarckian factor' proposed by Krieger and Traub (2008, 2011, 2013) and recently employed by Krieger et al. (2020) in an experimental study.

While all of these measures work in theory, they are difficult to employ empirically because of their restrictive assumptions.[5] For instance, Krieger and Traub (2011) use the Luxembourg Income Study (LIS), which is a collection of independently sampled waves, for comparisons of the distributions of incomes and retirement benefits. LIS data does not come, however, as a panel which implies that one cannot derive individual earnings histories from this data set. Therefore, the authors have to assume that the income distribution does *not* change from generation to generation in order to be able to compare different generations (i.e., workers and retirees) within a wave. As we will show in the next section of our paper, all existing measures of intra-generational redistribution suffer from critical assumptions like this.

Our novel measure of intra-generational redistribution in pension systems does therefore take a different avenue. It relates work-life contributions to the pension scheme and the resulting benefit entitlements to a benchmark, which rests on the ratio of two hypothetical benefit distributions resulting from idealized Beveridgean and Bismarckian pension systems. The construction of our measure follows broadly the construction of Lorenz curves and the Gini coefficient, but shows resemblance to measures of inequality in tax systems, such as the Suits index (Suits, 1977). This leads to a more general representation of intra-generational redistribution than existing measures, which facilitates also empirical applications. This allows us to make use of a rich data-set on individual earnings histories of approx. 100,000 German individuals, who progressed into retirement in 2007–2015, to measure intra-generational redistribution in the GRV and to test the robustness of our measure.

To preview our main empirical finding, a recent reform of childcare benefit provision, which became effective in 2014 and introduced additional benefits for a sub-

[5] Note that the experimental design in Krieger et al. (2020) avoids the difficulties experienced in empirical work.

group of German mothers, led our index value to jump up for women, but not for men. Our findings suggests that the GRV fulfils the ideal of a Bismarckian pension system without intra-generational redistribution for men, while women benefit substantially from intra-generational redistribution.

Our paper is structured as follows. Section 2 discusses existing measures of intra-generational redistribution and their limitations. Furthermore, we derive our index in the section. The following section 3 presents the empirical application of our index to the German pension system using micro-data on German retirees. Section 4 concludes.

2 Measuring Intra-Generational Redistribution

2.1 Existing Measures of Intra-Generational Redistribution

There are very few approaches to measure intra-generational redistribution in the literature, which usually allow either for comparisons over time or between countries, sometimes also between specific subgroups of a population. In the following, we will introduce the most important indices and discuss their properties.

The 'index of non-contributiveness' (INC) introduced by Lefèbvre and Pestieau (2006) and Lefèbvre (2007), here denoted by β^{INC}, is defined as the ratio of the income share of public pensions in the bottom quintile, B, to the same share in the top quintile, T:

$$\beta^{INC} := \frac{P_B/Y_B}{P_T/Y_T} = \frac{P_B}{P_T} \cdot \frac{Y_T}{Y_B}, \tag{1}$$

where Y_i and P_i, $i \in \{B, 2, 3, 4, T\}$, are the mean income and the mean pension benefit, respectively, of the ith quintile of the income distribution. A pure Beveridgean pension system with equal benefits for all retirees implies $P_B/P_T = 1$ and hence, $\beta = Y_T/Y_B \geq 1$. A purely Bismarckian system which relates benefits solely to previous earnings would yield $P_B/Y_B = P_T/Y_T$ and therefore $\beta = 1$. Although it is possible to normalize this measure to fit into the $[0, 1]$ interval (cf. Krieger and Traub, 2011, 2013),[6] there are some obvious disadvantages for the measurement of intra-generational redistribution.

[6] Following Casamatta et al. (2000a), Krieger and Traub (2011, 2013) assume that retirees' incomes are a linear combination of a flat and an earnings-dependent component: $P_i = \tau \cdot (\alpha Y_i + (1-\alpha)\mu)$, where $\alpha \in [0, 1]$ is the 'Bismarckian factor', $\mu = \sum_i Y_i/5$ the average income of the entire income distribution, and τ a measure of the generosity of pension system (i.e., a measure of inter-generation redistribution). Here, the Bismarckian factor is the relevant measure of intra-generational redistribution: $\alpha = \frac{(P_T - P_B)\mu}{(P_T - P_B)\mu - P_T Y_B + P_B Y_T} \in [0, 1]$. A pure Beveridgean pension system ($P_B = P_T$) leads to $\alpha^{Bev} = 0$, a pure Bismarckian system ($P_B/Y_B = P_T/Y_T$) to $\alpha^{Bis} = 1$.

First, considering only the ratio between the top quintile and the bottom quintile of the income distribution, potentially one loses important information contained in the complete income distribution.[7] Second, the INC compares two entirely different generations with each other, the working population and the pensioners, thereby implicitly assuming that the income distribution does not change from generation to generation. The same needs to be assumed for any redistributive measures introduced by governments at different times. Clearly, neither can be taken for granted. A suitable measure should rather compare the benefits of current retirees with their previous contributions, which then includes intra-generationally redistributive measures during work-life.[8] As a consequence, it is preferable to consider individual contributions and benefits at the micro level.

The 'index of progressivity' (IOP) as applied by the OECD in its publications on pension politics (OECD 2013) resolves the first, but not the second disadvantage. IOP, here denoted by γ^{IOP}, relates inequality in pension benefits to inequality in earnings:

$$\gamma^{IOP} := 1 - \frac{G_P}{G_Y}, \tag{2}$$

where $G_P = \frac{1}{2}\overline{P}n^2 \sum_{i=1}^{n} \sum_{j=1}^{n} (P_i - P_j)$ and $G_Y = \frac{1}{2}\overline{Y}m^2 \sum_{k=1}^{m} \sum_{l=1}^{m} (Y_k - Y_l)$ are the Gini coefficients of pensions and earnings, respectively, $\overline{P}$ and $\overline{Y}$ are mean pensions and mean earnings, n the number of pensioners, and m the number of employees. In a pure Bismarckian pension scheme, $\gamma^{IOP} = 0$ since $G_P = G_Y$. In contrast, in a Beveridgean scheme, $\gamma^{IOP} = 1$ because $G_P = 0$. Compared to INC, the IOP makes use of the complete distribution of both pension benefits and earnings. However, this measure still relates current pensions to current earnings without linking individuals' contributions and pension entitlements.

If information on both contributions c_i and pension entitlements p_i is available for all individuals i, $i = 1, ..., N$, a simple alternative to the above measures is a correlation analysis. Stöwhase (2016) calculates the coefficient of correlation of a contribution vector $C = \{c_1, c_2, ..., c_n\}$ and a benefit vector $P = \{p_1, p_2, ..., p_n\}$ for

[7] For instance, if pension benefits are calculated differently at different income levels, INC will be biased. Consider a Bismarckian pension scheme that covers the middle class only, i.e., there is a tight link between earnings and benefits in the second, third and fourth quintile, while at the bottom and the top of the distribution only a flat minimum benefit is received. Then, $\beta^{INC} > 1$ since $P_B/P_T = 1$. For the middle-class members of the scheme (ignoring the third quintil for simplicity), we have $\beta_{2,4}^{INC} = 1$ since $P_2/P_4 = Y_2/Y_4$. Hence, since $\beta^{INC} > \beta_{2,4}^{INC} = 1$, the INC based on B and T only obviously lacks complete information.

[8] Note that this does not take into consideration any kinds of redistribution between different groups of retirees, such as redistribution via the tax system between rich and poor retirees, or more complex forms of redistribution following from differences in life expectancy (cf., e.g., the discussion in Krieger and Lange, 2012).

all N pensioners. While it is straightforward that a pure Bismarckian system implies $\text{Corr}(C, P) = 1$, a measure that is exclusively based on this correlation suffers from the problem that it cannot be normalized. This is because in a Beveridgean pension scheme its value would depend on the distribution of pension benefits P, which is not accounted for. Hence, any $Corr(C, P) \neq 1$ is hard to interpret. However, the measure of correlation could be a good starting point for developing a new measure of intra-generational redistribution if normalization is possible.

2.2 Introducing a Novel Measure of Intra-Generational Redistribution

In order to overcome the previously shown problems of existing measures of intra-generational redistribution in PAYG pension systems, we propose now our novel index that relates paid contributions to resulting benefits. Similar approaches can be found in the literature on inequality and the progressiveness of tax systems. Lambert and Ramos (1997) present a general index of horizontal inequity in income taxes that measures the inequality of post-tax incomes for pre-tax equals. In a similar vein, Suits (1977) proposes an index, the so called 'Suits index', to measure tax progressivity by relating accumulated incomes to accumulated tax burdens. This is reminiscent of the Gini ratio. Our index follows similar lines: it provides a standardized measure of intra-generational redistribution by relating contributions and the resulting entitlements to a benchmark, which rests on the ratio of the (hypothetical) distributions of 'ideal' Bismarckian and Beveridgean pension schemes.

Let us start by assuming a population consisting of two groups at time t: N retirees, indexed and ordered by $i \in \{1, 2, ..., N\}$, and K working-age contributors, indexed and ordered according to paid contributions by $j \in \{1, 2, ..., K\}$. Until her retirement, each individual i has paid amount e_i into the pension scheme. This contribution payment in any period t is given by:[9]

$$e_i = \sum_{l=1}^{m} h\left(Y_l^i \lambda_l\right), m \leq t, \tag{3}$$

with m representing the time of retirement, Y representing personal income respectively the contribution assessment basis, and λ being the contribution rate that had to be paid in each period of worklife.[10] Function $h(\cdot)$ adjusts each period's paid contributions according to the rules of the present pension system. For instance,

[9]For easier notation, we will skip the time index in the following. Any equation refers always to the current period t.

[10]Note that $m \leq t$ ensures that the individual has retired in the past or in the most recent period t. That is, we consider current pensioners only at this stage.

in the German GRV, which we will refer to in our empirical analysis in section 3, paid contributions are transformed into so called 'earnings points' following the specific rules of GRV.[11] Other functional forms may, e.g., include a binary component counting only 'best' (rather than 'all') contribution years.[12]

The sum of contributions e_i of each individual i represents the basis for calculating the personal pension entitlement PE_i. This entitlement defines the actual amount of pensions paid out to i. Using (3), we can define entitlements for members of both the Beveridgean or the Bismarckian pension system at time t:

$$Beveridge: \qquad PE_i^{Bev} = \frac{\sum_{i=1}^{n} e_i}{N}\delta, \tag{4}$$

$$Bismarck: \qquad PE_i^{Bis} = e_i\delta, \tag{5}$$

where PE_i represents the pension entitlement of individual i and δ is a measure of generosity, which indicates how contributions e_i are valued. More generally speaking, the generosity measure indicates the level of redistribution between generations (Krieger and Traub, 2011, 2013). It depends on the development of societal key indicators like income or demography in the long run, while it is often decided upon by legislators in the short run (thereby ignoring—in a non-sustainable manner—their decision's long-run implications; cf., e.g., Browning, 1975; Sjoblom, 1985). For the sake of convenience, we assume that δ is not varying over time.

Equation (4) represents an idealized Beveridgean pension scheme, in which the total sum of contributions made by all N contributors is evenly split, awarding each individual the same entitlement regardless of her individual contribution e_i. Equation (5) is designed as an idealized Bismarckian system, where each individual's pension entitlement depends solely on her own past contributions.

Next, let us define the actual pension system:

$$PE_i^{PS} = G(e_i, x_i)\delta, \tag{6}$$

$$\sum_{i=1}^{N} G_t(e_i, x_i)\delta = \sum_{j=1}^{K} Y_t^j \lambda_t + SG_t. \tag{7}$$

Equation (6) represents how personal entitlements are calculated in the actual pension scheme. The individual pension entitlement depends on own contributions e_i as well as other individual factors x_i. How these factors are valued depends on the actual (redistributive) design of the pension scheme represented by function $G(\cdot)$. Equation (7) is the budget constraint of the pension scheme. The sum of pension

[11] Points systems exist also in Estonia, France (occupational plans), Lithuania and the Slovak Republic (OECD, 2019).

[12] Only comparatively small fractions of career earnings are considered in, e.g., France (main scheme, best 25 years), Slovenia (24) and Spain (25) (OECD, 2019).

entitlements is funded by the sum of contribution payments of all contributors and (possibly) a state grant SG that subsidizes the pension scheme.

Equations (6) and (7) indicate legislators' various options for modifications, or reforms, of the pension scheme: the state grant and the contribution rate could be adjusted; the contribution assessment basis could be changed; the group of contributors could be adjusted; or the generosity δ could be changed.[13] However, these options only affect inter-generational redistribution. Regarding intra-generational redistribution, legislators only have the option to modify function $G(\cdot)$. For instance, the importance of own contributions e in determining pension entitlements could be shifted relative to the influence of individual factors x. This will change the degree of intra-generational redistribution for the current group of retirees.

The fact that intra-generational redistribution is affected only through the parameters of $G(\cdot)$ allows us to simplify our setting substantially. We can drop equation (7), in which all variables related to the degree of inter-generational redistribution are collected and which affect $G(\cdot)$ only in terms of level-shifts. Hence, we can measure intra-generational redistribution based exclusively on information regarding contributions and individual factors as well as the functional form of $G(\cdot)$. Closer inspection of equations (4)–(6), which are the only ones needed for our analysis, shows that this is indeed the case. Legislators using the presented framework to plan an adjustment of the rate of intra-generational redistribution via $G(\cdot)$ will of course have to take the budget constraint of equation (7) into account. However, for the purpose of our index, this constraint can be neglected.

Analogously to the methodology of the Suits index, let us now order and normalize the distribution of e on the interval $[0, 1]$, such that it measures the accumulated share of paid contributions. Furthermore, we define $F_E(e)$ as the cumulative distribution function of PE depending on e and the corresponding density function as $f_E(e)$. At any point e, $F_E(e)$ measures the accumulated sum of pension benefits in the sample population. Since we are only interested in the distribution of e in equations (4)–(6), we can also drop the constant generosity measure δ.

This yields the following equations for the distributions of pension benefits in the actual and the two idealized pension systems:

$$\text{Beveridge:} \qquad F_E^{Bev}(e) = \int_0^1 f_E^{Bev}(e)de := Bev(e), \tag{8}$$

$$\text{Bismarck:} \qquad F_E^{Bis}(e) = \int_0^1 f_E^{Bis}(e)de := Bis(e), \tag{9}$$

$$\text{Actual pension system:} \qquad F_E^{PS}(e) = \int_0^1 f_E^{PS}(e)de := PS(e) \tag{10}$$

[13] See e.g. Krieger and Stöwhase (2009) for the effects of discrete policy interventions on the generosity of the German pension scheme.

Using Equations (8)–(10), we can define our index of intra-generational redistribution as follows:

$$R = \frac{PS(e) - Bis(e)}{Bev(e) - Bis(e)}. \tag{11}$$

Equation (11) measures intra-generational redistribution by calculating how strongly the underlying pension system is trending towards one of the two benchmark distributions. Since these benchmarks are constructed by using the contributions of the underlying sample population, this trending is measured relative to the difference between the two benchmarks, as expressed by the denominator of R, which provides a standardization.

As stated above, this index is closely related to measures of inequality and progressiveness in tax systems that themselves are related to more general measures of inequality, in particular Lorenz curves and the Gini coefficient. Those measures should generally satisfy four main criteria, namely scale or mean independence, symmetry, transfer sensitivity, and decomposability. In the following, we will discuss briefly whether these criteria also apply to our index.

R satisfies the condition of scale or mean independence. If all individual contributions and pension entitlements were doubled, R remains unchanged. The applied normalization ensures that R does not depend on the size of the retiree population, meaning that N has no direct effect on R. The order of individuals depends solely on contributions, which satisfies the criterion of symmetry. The transfer of pension entitlements from retirees with high contributions to those with lower contributions increases the index, meaning that R moves towards the Beveridgean benchmark of fully equalized benefits. Therefore, the index also satisfies the Pigou-Dalton criterion of transfer sensitivity.

Another desirable feature of an inequality measure is decomposability, meaning that the index can be calculated for different subgroups. This is the case. Pension entitlements can always be measured based on the contributions made by any arbitrarily chosen subgroup of new retirees. Note, however, that although the index allows for decompositions, the sum of index values for different subgroups does not yield the index value of the entire population.

Importantly, while our index yields 0 for the Bismarckian or 1 for the Beveridgean benchmark, it is not confined to this range. For example, pension systems that are more restrictive than an idealized Bismarck system (e.g., if they redistribute regressively) would yield a negative index value. It is also possible, that $PS(e)$ intersects $Bis(e)$ (this could happen even more than once). In this case, the calculation results in $PS(e) = Bis(e)$ and an index value of 0 despite redistribution occuring. As in the case of intersecting Lorenz curves, a possible solution would be to subdivide the

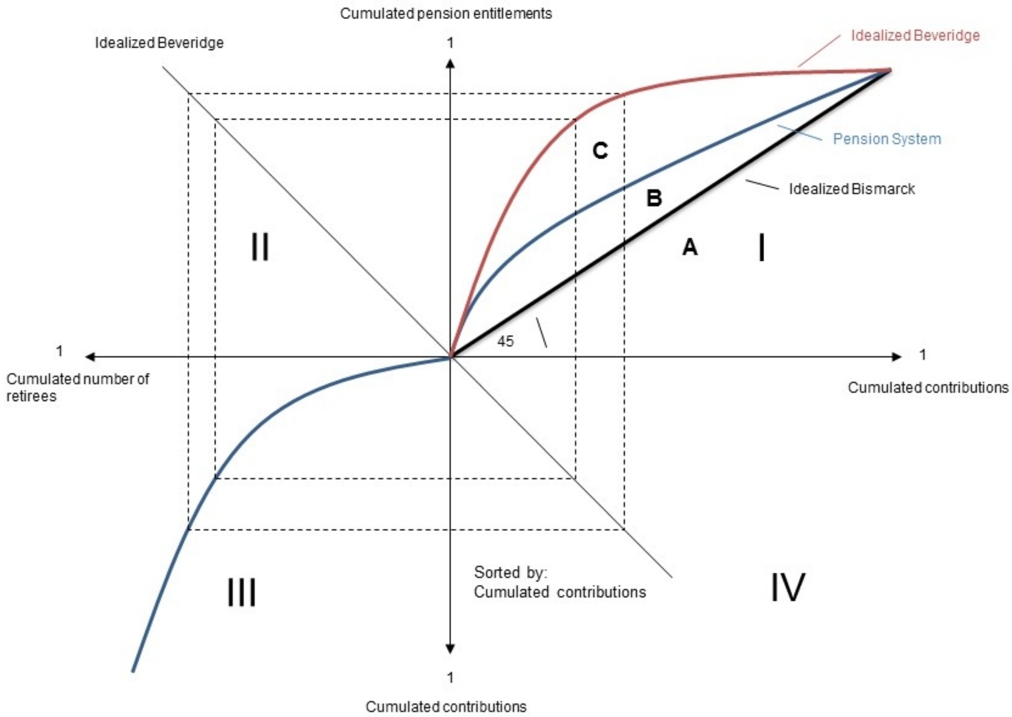

Figure 1: Graphical derivation of index R

sample population at the intersections and calculate index values for the resulting sub-samples.

Values greater than 1 are feasible, if the underlying pension system is extremely generous, such that $PS(e)$ intersects or lies above $Bev(e)$. This is also possible, if all retirees have contributed only very small amounts such that $Bev(e)$ is not sufficient to provide basic welfare. Another special case would be a perfectly equal distribution of paid contributions. This could occur if the underlying pension scheme would not utilize a proportional contribution rate but a flat and equal contribution. In this case we would receive $Bev(e) = Bis(e)$ and the index would not be defined, since the denominator would be 0. Nevertheless, those special cases are relatively unlikely, since those cases would systematically violate the principle of equivalence, which is not likely if we apply the index to real world pension systems.

Figure 1 shows how to graphically derive index R. Using normalized values for a given sample population of retirees, quadrant I relates individual contributions to pension entitlements. The bisector of quadrant I represents the idealized Bismarckian pension system as defined in equation (9). In this benchmark system, pension entitlements depend only on individual contributions and strictly adhere to the principle of equivalence.

Equation (8), the Beveridgean benchmark, is derived via quadrants II-IV. Quadrant III represents the distribution of individual contributions with the horizontal axis depicting the number of retirees, ordered and normalized by contributions. The resulting curve represents the composition of the underlying sample population, i.e., the income distribution and the contribution scheme prior to retirement. If contributions are determined by proportional contribution rates, a curve with a very sharp increase in the upper parts of the retiree distribution would therefore be a representation of unevenly distributed incomes. The distribution of quadrant III, which is the sole determinant for the Beveridgean benchmark, has now to be transferred to quadrant I to receive the second benchmark distribution. This is achieved via quadrants II and IV. Contributions are mirrored to quadrant I via quadrant IV, while the required pension entitlements are determined and transferred via quadrant II. The second quadrant relates the accumulated number of retirees to accumulated pension entitlements. Therefore, the bisection of this quadrant represents the idealized Beveridge system of equation (8). Here, every sample member receives exactly the same pension entitlements.

After constructing the two benchmark distributions, the actual pension entitlements of the retirees can be calculated to construct the curve that represents the pension system in quadrant I. The purpose of index R is to measure how strongly the curve of the pension system is trending towards one of the two benchmarks. Using Figure 1, equations (8)–(10) can be represented as the areas of quadrant I:

$$\begin{array}{cl} \text{Beveridge:} & A+B+C \\ \text{Bismarck:} & A \\ \text{Pension System:} & A+B \end{array}$$

Therefore, equation (11) can be interpreted as:

$$R := \frac{A+B-A}{A+B+C-A} = \frac{B}{B+C}.$$

This representation is reminiscent of the graphical derivation of the Gini coefficient. It is important to note, however, that the size of C differs depending on the underlying pension system. Direct comparisons of pension systems of different countries cannot easily be conducted.

3 Empirical Application Using German Contribution Records

3.1 The German Old-age Pension System

The German statutory pension plan (Federal Pension Insurance GRV) is designed as an earnings-related PAYG scheme based on the principle of equivalence. Regular old-age pensions can be claimed at the statutory retirement age which is, as of now, gradually increasing from age 65 to 67 for individuals born after 1964. Furthermore, a minimum of five years of paid contributions is required to be entitled for an old-age pension.

Equivalence is achieved by income-related 'earnings points'. Paying exactly the contribution of an average earner (relative to all contributors in a certain year) yields one full earnings point. Contributions by earners above and below the average yield the corresponding fraction or multiple of an earnings point; e.g., earning, and contributing, half the average will result in 0.5 earnings points. The sum of earnings points forms the basis for calculating pension claims at the time of retirement. This design could be characterized as a pure Bismarckian pension system when claims would indeed depend exclusively on one's own contributions. However, additional non-earnings related pension points can be awarded. These are primarily the ones listed in Table 1.

Earnings points can also be deducted in case of a settlement of pension entitlements following a divorce or because pension claims exists against other countries' pension systems ('Vertragsrenten'). The extent of those additional benefits (and deductions) determines the level of intra-generational redistribution of the German statutory pension plan. At retirement, earnings points are multiplied with the so-called pension value resulting in the final pension entitlement (in Euro).[14] The pension value is the same for all pensioners and is adjusted on a yearly basis according to the growth rate of gross wages and some demographics-related parameters.[15]

3.2 Data

We use data on new entries into the pension system ('Versichertenrentenzugang') from 2007 to 2015 provided by the Research Data Centre of the German Pension Insurance. The Research Data Centre offers cross-sectional and longitudinal datasets on individuals who are insured in the Federal Pension Insurance on an annual basis. Our data on new retirees is a 10 percent sample of individuals that enter retirement in a certain year and provides socio-demographic and pension-specific information. In 2015, this data compromises about 130 variables for approx. 105,000 individuals.[16]

[14] The so called 'pension formula' adjusts earning points also with an access factor, that measures early/late retirement and with a pension type factor, that applies to, e.g., widows' pensions. In case of a regular old-age pension ('Regelaltersrente') this factor is 1.

[15] For a more detailed information about the German pension system see, e.g., Börsch-Supan and Wilke (2004).

[16] For more detailed information on the scope of the data, see Himmelreicher (2005).

3.3 Measuring Intra-generational Redistribution for New German Pensioners

In the following section, we will apply our index R to data of pensioners that entered retirement in a certain year. We focus on new retirees, because changes of pension system parameters are usually phased in and therefore the effect is most pronounced for new retirees. This is especially true for changes in intra-generational redistribution, as they are usually not introduced in a backdated way and thus start to affect only the newest cohort. Technically, by looking only at new entries into retirement we reduce the risk that our measure accidentally includes inter-generational redistribution. Furthermore, we focus on those new retirees that claim a regular old-age pension, which is the standard pension claim in the German Federal Pension Insurance. We do so to avoid distortions which may result from mixing regular, early retirement and invalidity pensions.[17]

Following the rules of the GRV, we will use two primary reference values of the earnings points system. Our measure of paid contributions is the sum of 'own earnings points' (OEP) that an individual accumulates during her contribution period. Own earnings points can only be obtained by being employed and paying contributions; therefore, they are a direct and proportional proxy of contributions paid e_i. As described above, one year of employment yields a certain number of earnings points, which result from a comparison of one's own wage and the average gross income. Therefore, the resulting number of OEPs when entering retirement in t is given by

$$OEP = \sum_{l=1}^{t} \frac{Y_l}{\overline{Y}_l},$$

with Y_l being personal income in year l and $\overline{Y}$ being the mean income of all contributors.[18] Note, that this way of calculating earning points reflects the idea of function $h(\cdot)$ in equation (3). In a pure Bismarckian pension system, these points would be the relevant basis for pension benefits.

Regarding pension entitlements, we use the sum of personal earning points PEP which is the final sum of earning points after adjustments. Personal earning points are defined as:

$$PEP = \underbrace{OEP}_{\text{own contributions}} + \underbrace{\text{additional } EP - \text{deducted } EP}_{\text{not depending on own contributions}} \quad (12)$$

[17]Early retirement generally results in a reduced pension entitlement depending on the years left until statutory retirement age. Invalidity pensions are paid depending on the level of reduced earnings capacity in the years before statutory retirement age.

[18]Additionally, contributable income Y and therefore OEP per year are capped by a contribution ceiling.

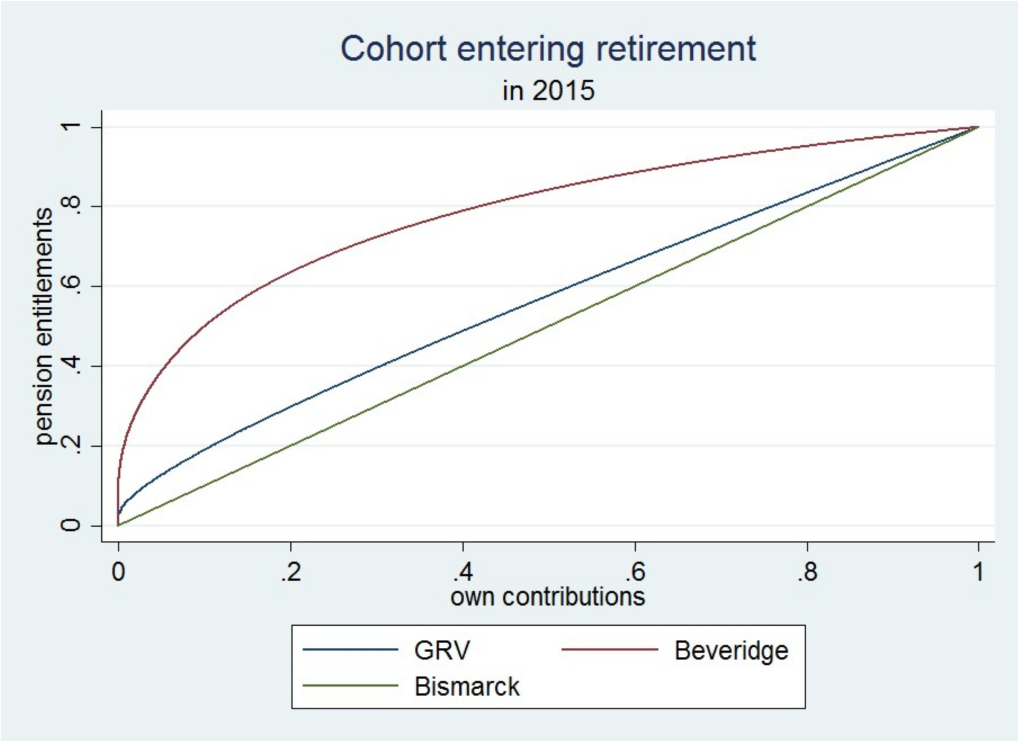

Figure 2: New retirees in 2015

Since we are looking at regular old-age pensions, personal earning points are the main determining factor of an individual's pension entitlement. There are regional differences due to German reunification, but these differences do only affect how the sum of personal earning points is valued or they have already been corrected during the contribution period.

Figure 2 presents the results for new pensioners who entered retirement in 2015 and received benefits for the first time. The actual pension system (PS) as defined in equation (10) is represented by the GRV curve. According to the Beveridge curve, the majority of contributions were located in the lower 40 percent of the distribution of own earnings points. In terms of personal entitlements, the GRV curve indicates redistribution that is especially pronounced in the lower half of the distribution of own contributions. The corresponding values for equations (8)–(10) are: $Bev(e) = 0.7857$, $Bis(e) = 0.5000$ and $PS(e) = 0.5647$. Inserting these values into equation (11) yields

$$R = \frac{0.5647 - 0.5000}{0.7857 - 0.5000} = 0.23$$

Figure 3 shows the underlying curves for male and female new entries into retirement. It is striking to see that the GRV curve is much closer to a Bismarckian system for men than for women. Furthermore, we find differences in the underlying distribution of individual contributions. The Beveridge curve for women concentrates

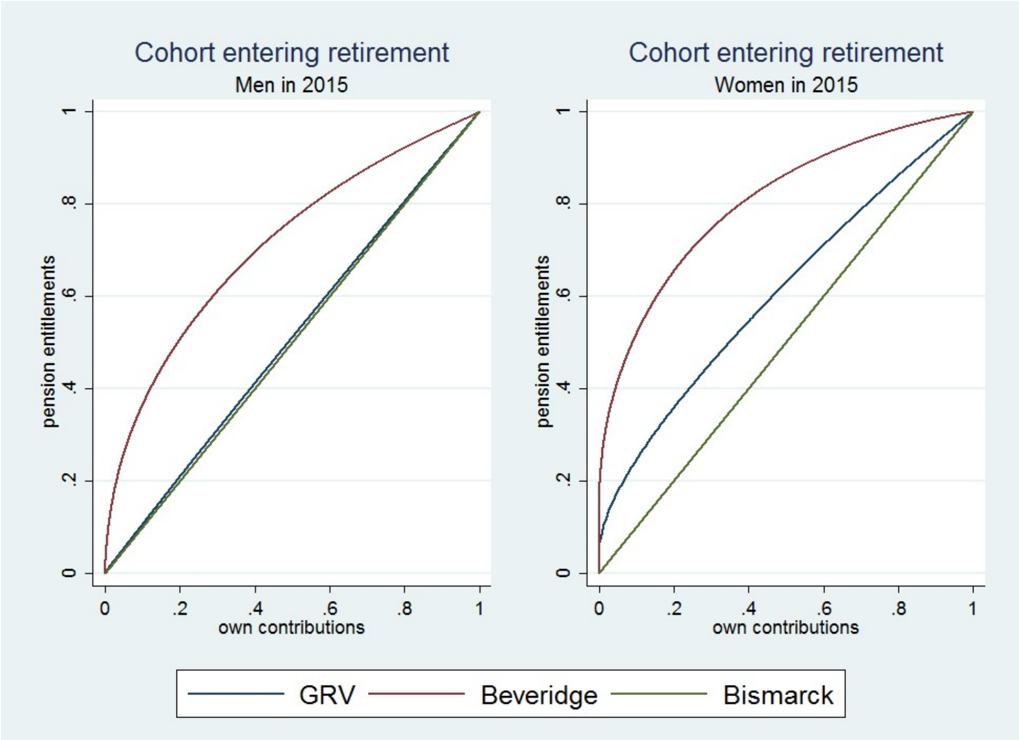

Figure 3: New retirees in 2015 by sex

more mass in the lower quantiles of the distribution of individual contributions, while male contributions are more evenly distributed.

The respective values of index R are 0.23 for all retirees,[19] 0.04 for men only and 0.36 for women only. That is, our index R is much smaller for men than for women, which indicates that—measured in terms of individual contributions—men receive significantly fewer additional entitlements (beyond the Bismarckian line of own contributions in figure 3) than women. This is not surprising because women are more likely to gain additional earnings points that are detached from individual contributions (e.g., for raising children). In addition, they are—on average—more likely to receive bonus points in case of divorces.

Note that the total value for R measures the effect of the whole population with both males and females being part of the distribution of own earnings points and pension entitlements. Therefore the total value of R should not be interpreted as a function of the values for men and women.

Since data of new retirees is available from 2007 to 2015, we can also calculate R for several cohorts to explore time trends. Figure 4 depicts the development

[19]Note that the total value for R measures the effect of the whole population with both males and females being part of the distribution of own earnings points and pension entitlements. Therefore the total value of R should not be interpreted as a function of the values for men and women.

Figure 4: Index values over time

over time for the overall population as well as gender-specific developments. For the total populations, index R exhibits a slightly increasing trend between 2010 and 2013 with a significant increase in 2014. For men, the index remains nearly constant over time. In contrast, the index decreased slightly for women prior to 2014, which was primarily driven by a significant reduction of redistributional entitlements. From 2007 to 2013, received entitlements, which represent the numerator of R, dropped from 0.092 to 0.0693, a decrease of approx. 25 percent. At the same time, individual female contributions, measured by $Bev(e)$, increased from 0.7662 to 0.7746, i.e., by approx. 1 percent. Taken together, women showed a tendency for reduced dependency on redistributional pension claims and an increased dependency on own contributions prior to 2014. This tendency might still be valid after 2014. Data on future retirees will show if this general downward trend will persist.

Independent of this general trend, we observe a significant upward shift in the value of R in 2014, indicating a massive change of the degree of intra-generational redistribution toward women in the GRV. This shift can be explained by a recent legislative reform—“Gesetz über Leistungsverbesserungen in der gesetzlichen Rentenversicherung” (enacted in June 2014)—that doubled the number of obtainable earnings points resulting from childcare. More specifically, the GRV awards non-earnings related pension points for raising children. Before the reform, mothers

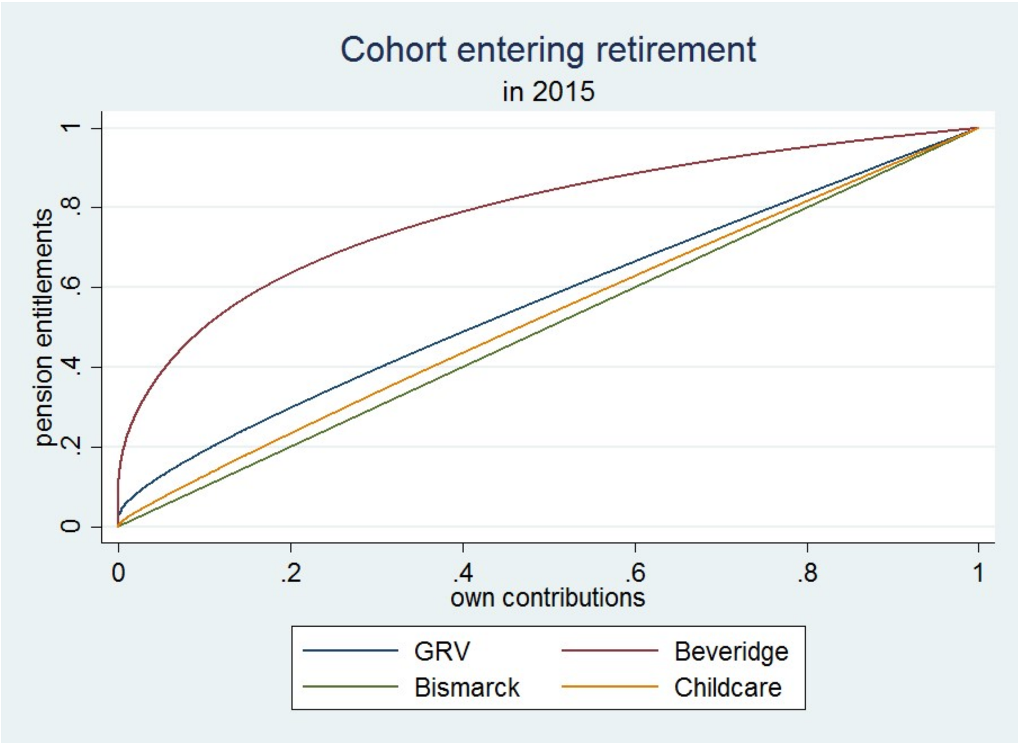

Figure 5: Results with and without childcare

received one earnings point per child born before 1992 and three earnings points for children born after 1992. One pension point means that a mother is awarded the equivalent of having been employed for one year, thereby earning the average income.

The ruling grand coalition in Germany considered this unfair for mothers with older children and therefore increased earnings points from one to two for any child born before 1992. The reform was designed in a way that even mothers close to retirement could benefit from the more generous benefits, which means that our analysis ought to capture the reform by driving up R for women, but not for men.[20] In fact, most women entering retirement in recent years received earnings points for childcare periods before 1992, since it is extremely unlikely that they had a child born after 1992. In order to measure the importance of the reform, we take the difference between R including all pension entitlements and R without the additional benefits for childcare periods in question. Figure 5 shows that childcare contributes substantially to the level of intra-generational redistribution in the GRV. If we remove childcare-related pension entitlements, retirees in 2015 are significantly closer to the Bismarckian benchmark line. Not surprisingly, this type of additional benefit

[20]It has to be noted that child care periods are awarded to the mother by default. Fathers can apply to receive these periods instead, but in practice this rarely happens.

Figure 6: Differences in the redistributional effects of childcare over time

is of much greater importance for women. The difference for male pension claims is nearly nonexistent (in 2015, the difference for men is 0.002).

Looking at the development over time, the reform of claimable childcare periods is clearly visible in Figure 6. It depicts the differences in R due to childcare periods. The difference for women increases significantly in 2014, while changes for men are marginal. The difference in the female R increases by 13 percentage points (from around 0.12 in 2013 to 0.25 in 2014). If we take into account that the overall female index value in these years increased by only 11 percentage points (from 0.25 to 0.36), we can conclude that without the reform female intra-generational redistribution would have followed the decreasing trend of previous years. These findings demonstrate that R is not only able to quantify changes in intra-generational due to reformed legislation, but also how different subgroups contribute to these shifts in redistribution.

4 Concluding remarks

Recent and future demographic change, caused by low fertility and rising longevity, let societies with PAYG pension schemes face an increasing need for reform, especially in their public pension systems. Reforming a pension scheme might require to deviate from the current level of intra-generational redistribution, which has—up to that point in time—also represented an accepted social consensus. This deviation will be of crucial importance for the feasibility of reforms of established pension schemes, as the new level of redistribution must also be accepted widely in society.

The purpose of this paper was to introduce a novel index that enables us to measure intra-generational redistribution in a PAYG pension system. Existing measures, like the index of non-contributiveness or the index of progressivity, are limited by setting different generations into relation, while information on individual contributions and resulting pension claims are not taken into account. Extending existing concepts for measuring inequality and the progressiveness of tax systems, we derive an index that relates paid contributions and resulting pension entitlements to a benchmark, which rests on a ratio of two hypothetical distributions, an idealized Beveridge system and an idealized Bismarck system. Therefore, this index does not depend on information on younger contributors. It utilizes the complete distribution of pension claims and own contributions rather than relying only on certain quintiles or moments. Our specification also allows to compare intra-generational redistribution across different cohorts, as well as for different subgroups within a generation.

Applying our index on contribution records of new German retirees, we are able to measure the development of intra-generational redistribution across different cohorts. We can also show that the index is able to measure the effects of legislative changes of intra-generational redistribution. We find that the index stays nearly constant before the year of 2014 except for a slight reduction over time for women. In 2015, the index scores a value of intra-generational redistribution of 0.23. In 2014, the index increases significantly, which can mainly be attributed to a singular regulatory change in the German public pension system: the extension of claimable childcare periods for children born prior to 1992. This is of specific interest, since the main arguments for this legislative reform put forward by its proponents related to of inter- rather than intra-generational justice. However, our analysis indicates a strong intra-generationally redistributive effect of this reform. In fact, our decomposition analysis reveals significant differences between men and women before and, even more so, after the reform. The level of intra-generational redistribution for male retirees resembles closely the Bismarckian principle of equivalence, while women's benefits are considerably less Bismarckian in nature.

Our approach allows to utilize high-quality micro data in order to derive very precisely the redistributive properties of pension systems. This precision comes at the price that our approach does not allow us to directly compare pension schemes of different countries as it would be possible by using, e.g., LIS data (which has other downsides, though). It would nevertheless be instructive to conduct analyses similar to ours for other countries, in which similar data may be available. For instance, there is register-based pension data in Sweden (cf. Edin and Fredirikson, 2000) and Denmark (cf. Hjollund et al., 2007). Moreover, even in cases where such real-world data is unavailable, our index could be applied on simulated data (cf., e.g., Fredriksen and Stølen, 2017, for a related approach). Future research should also include an analysis of recent trends in intra-generational redistribution in these countries and an investigation to which degree these trends have been the result of policy changes. Similar to the German reform of claimable childcare periods, the legislative importance of intra-generational redistribution in other countries' policy reforms could be investigated also from a political-economy perspective.

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