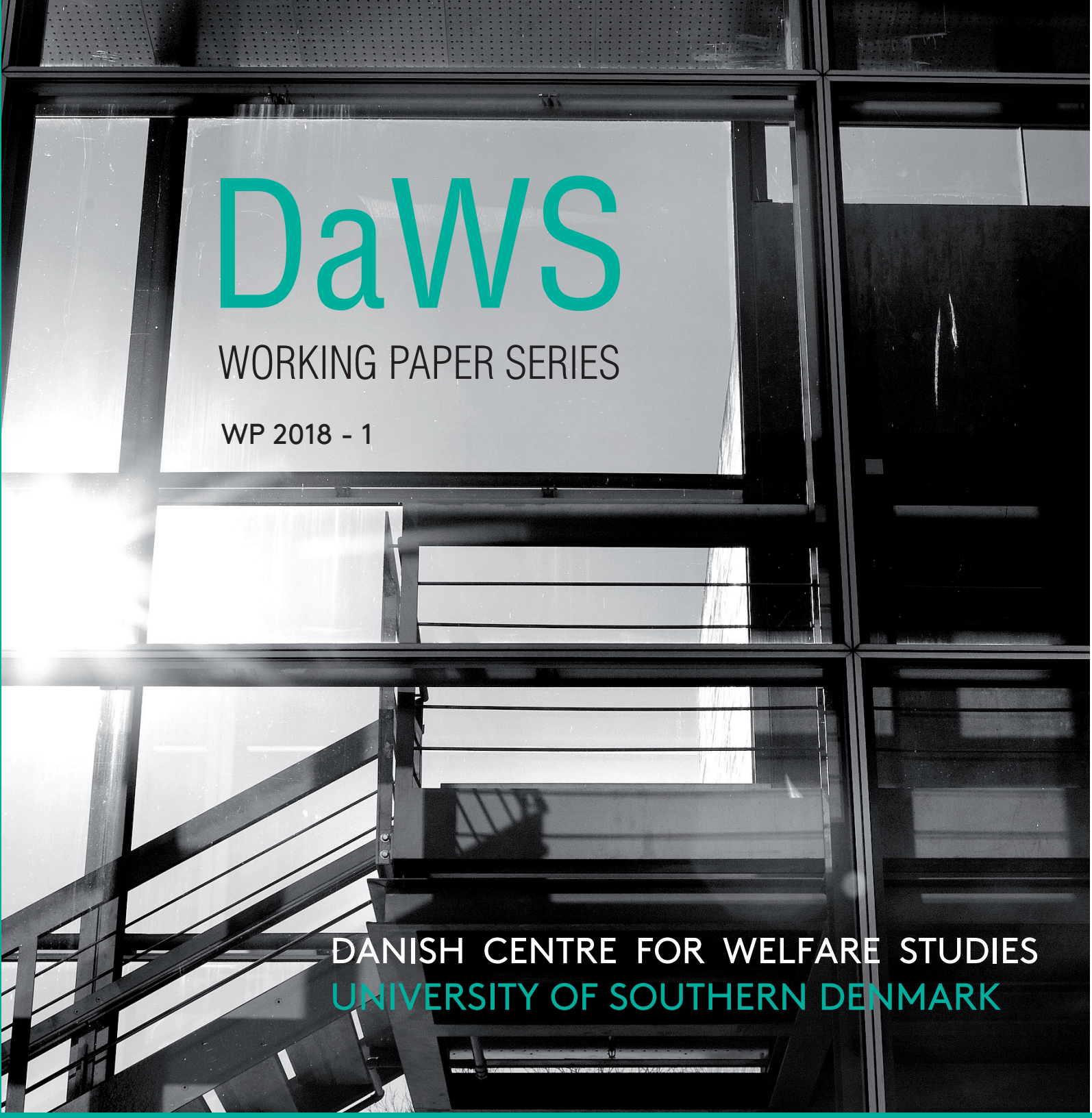

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Measuring Economic Sustainability and Intergenerational Fairness: A new Taxonomy of Indicators and Implications for Policy

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A New Taxonomy of Indicators and Implications for Policy

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Abstract

Questions of intergenerational fairness and economic sustainability, including the long-term affordability of social welfare programmes such as health care and pensions, have come to the fore as a result of the changing age composition of society during the second demographic transition, which combines low fertility and increasing life expectancy. This working paper aims to facilitate the informed choice among indicators of economic sustainability and intergenerational fairness and the decisions by policymakers about their uses. We show that the same type of indicator measured at different levels, such as the general government, the (market) economy or the total economy (which includes both the market economy and the household economy), often leads to substantively very different conclusions. For instance, an indicator limited to parts of the public system, such as pensions, may signal serious stress or unfairness while a family of indicators measured at different levels would signal institutional reform and show where its resources can be. Discussing families of related indicators is therefore often the more cautious approach. Next we argue that sustainability analysis is frequently built on exogenously set age limits, even though it is obvious that old age does not everywhere start at age 65 and most likely it will not start at age 65 in the future. We discuss solutions suggested by the research community to overcome problems of this way of partitioning the lifecycle. Third, we use our taxonomy of more than 80 indicators to spot holes, shortcomings and absences. Lastly, we show some structural differences between indicators of sustainability and fairness.

Introduction

Economic sustainability and intergenerational fairness are closely related issues.[1] The problem of sustainability, which includes long-term affordability of public programmes such as health care and pensions but in more general terms the subsistence of current consumption patterns,[2] came to the fore as a result of the changing age composition of society during the second demographic transition, which is characterised by the combination of low fertility and increasing life expectancy. Ageing societies face problems of financing their large intergenerational transfer programmes. Alternatively, they have to come to terms with the fact that currently young and future cohorts must accept significantly worse conditions, which translates the problem of sustainability into the terms of intergenerational fairness. The connection between the two concepts is intuitive even though both sustainability and intergenerational fairness have various definitions and reference points. Many of the indicators measuring the two interlinked issues reflect one or the other such reference points.

As population ageing is becoming a growing concern, a number of new indicators have been suggested by the research community. Currently the problem is not that we do not have indicators describing the ageing process and its consequences, the problem is we have too many and that they are frequently misinterpreted; besides, we possibly do not have the most meaningful of them yet.

Surveying the related literature, we have collected over 80 indicators of which we will refer only to a few in this paper; further details can be found in our report.[3] This is not the first such collection. The growing number of measurement tools also led to efforts of surveying them. Robert Fenge and Martin Werding bring together indicators measuring the consequences of population ageing for the public pension system and the general government.[4] They organise their findings in two dimensions: by scope (indicators applying to specific public programmes, such as the pension system, or the entire

general government) and by level (whether the concept applies at the micro-level, and as such affects individual decisions, or at the macro-level). We explicitly use and extend the "scope" dimension of their taxonomy. Jeroen Spijker goes beyond the strict focus on the public sector and differentiates among indicators by the domains covered, such as purely demographic, purely economic, demographic and economic related, health and disability related and based on human capital.[5] Our subcategories in the cross-sectional partitioning owe much to his suggestions.[6]

We created a notation system and translated each indicator in order to make them comparable. We established a taxonomy to find overlaps, connections and families of indicators as well as to discover holes in the indicator system and facilitate the invention of new indicators. The structure of the taxonomy is presented in Table 1. We include only those indicators that we describe in the paper. The comprehensive classification table completed with formal definitions, occasional comments and references can be found in an Appendix (available at request).

The working paper is structured so as to focus on some of our conclusions. First, we show that the scope of an indicator matters. Conclusions of a social process on sustainability and intergenerational fairness can be quite different if we limit the analysis to the pension system or extend it to the entire economy or beyond. Secondly, we show that the indicators in question are based all too often on ad hoc partitioning of the lifecycle, such as old age defined as a stage of life starting at age 65. Instead, we will show indicators that mitigate the ad hoc nature of partitioning by endogenising it or eliminating it altogether by parametrising the entire age distribution. Thirdly, we found that the classification table helps inventing new indicators that can be relevant. Fourthly, we will differentiate between indicators of sustainability and fairness.

Table 1: A taxonomy of indicators of economic sustainability and intergenerational fairness

	Cross-sectional				**Long time-horizon**		
	Partitioning of the population by			**Parametric characterisation**	**Cohort**		**Population**
	Chronological age	**+ Other non-economic characteristics**	**+ Other incl. economic characteristics**		**Remaining lifetime**	**Entire lifetime**	
Specific public programmes	old-age dependency ratio			pension support ratio; turnover duration	contribution wealth; pension wealth	net transfer rate	contribution wealth; implicit pension debt; pension wealth; *implicit education capital*
General government				fiscal support ratio	human capital investment gap	generational imbalance	sustainability gap
Market economy				economic support ratio; arrow diagram; Silver Club			*consumption deficit*
Total economy				total support ratio			

Note: The table includes indicators that are specifically referred to in this paper. Definitions and further description are given in the text. Many cells appearing empty here are populated in the complete taxonomy table that includes more than 80 entries. It can be can be found in the Appendix (available at request).

Scope

The first dimension of our taxonomy is the scope or measurement level of the indicator.

We distinguish four such levels, those of

- specific public programmes, such as education, health care or pensions
- the general government[7]
- the market economy and
- the total economy, which combines the market economy and the household economy.[8]

Below we present two examples for the use of the 'scope' dimension but we will also refer to its potential later. Both examples demonstrate that a population process can spell different consequences on sustainability in various sectors of the economy or society. Also, it can shed new light on widely held views on intergenerational fairness.

The 'scope' dimension can be applied to establish families of related indicators such as the group of support ratios. All members of this indicator family include the age distribution of the population but in addition to that they also take into account economic characteristics. The *fiscal support ratio*[9] weights the demographic age distribution by the age profiles of benefits received from and taxes paid to the general government, respectively, and calculates the ratio between the resulting numbers of effective taxpayers and effective beneficiaries. The *pension support ratio* does the same but it is limited to benefits and contributions of the public pay-as-you-go pension system. In contrast, the *economic support ratio*[10] extends the scope to the entire market economy and applies per capita age-profiles of labour income and consumption as weights. Finally, the *total support ratio* extends the economic support ratio to include age profiles of unpaid household labour produced and consumed.

The rationale of connecting related indicators or to extend the scope of analysis from the pension system to the general government to the market economy and finally to the total economy is that sustainability conclusions can turn out to be quite different at the various levels. In Figure 1, we demonstrate for a sample of selected countries that the dramatic unsustainability in the pension system can go hand in hand with modest or even mild sustainability problems in the general government and the economy in particular if the household economy is also taken into account. The columns in the figure represent percentage changes in the respective support ratios if the 2010 per capita age profiles of inflows and outflows mentioned above are combined with the age distribution of the population in 2060.

The countries in Figure 1 were selected so as to include the five largest nations in the EU and at least one representative of all European welfare regimes.[11] In each case, the pension support ratio, that is the rate of the number of effective contributors to the number of effective pensioners, would take a major negative drop between 23% in Sweden and 39% in Spain, should current per capita age profiles of contributions and benefits still prevail in 2060. This implies serious sustainability problems. However, the population pressure on the general government is less severe (the fiscal support ratio would decrease between 11% in Sweden and 22% in Spain), because the beneficiaries of the general government are less old and its contributors are older than those of the pension system. Consequences on the economic support ratio would be broadly comparable. More strikingly, if the total economy is considered, which includes the market economy recorded in the National Accounts as well as the household economy that is the output of unpaid household labour, population ageing would not create any negative effect at all on the support ratio. The age profile of consumption is so much younger, and that of labour is so much older in the household economy[12] that the resulting decrease in consumption and growth in labour would compensate for the imbalances of the market economy.[13]

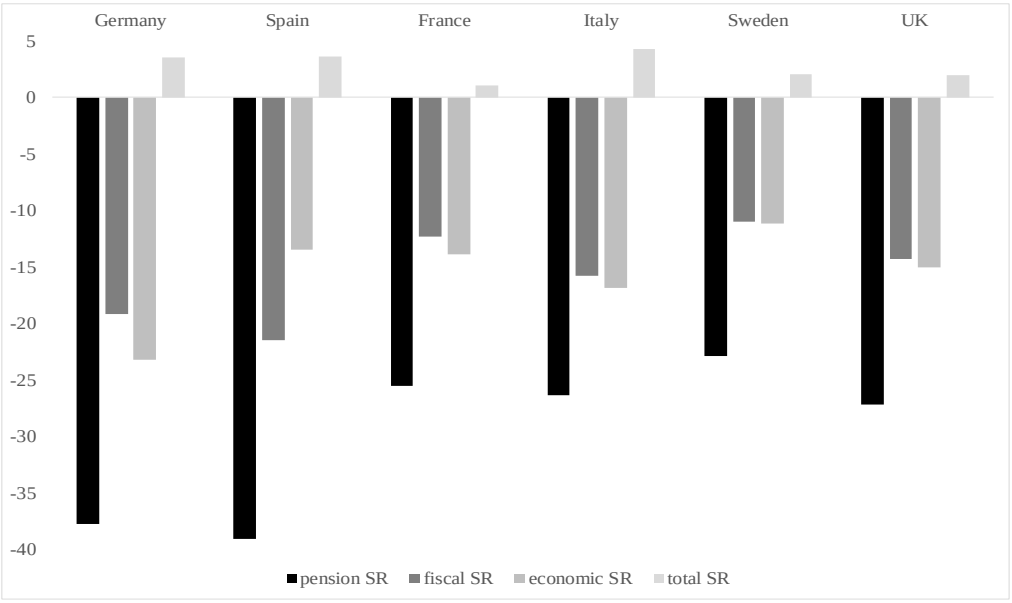

Figure 1: Changes in various support ratios if per capita age profiles of the public sector and the economy in 2010 are applied to the expected 2060 age distribution in selected European populations (%)

Source: Authors' calculation based on data of Eurostat (population projection), Istenič et al (2017) (public and private transfers), Vargha et al (2016) (household time transfers).
Note: SR: support ratio; see descriptions in the text.

In short, population ageing affects the pension (and health care) systems seriously and these institutions require major reforms but societies on the whole are exposed to smaller pressure and consequently they have the necessary resources to mobilise when confronted with the later phases of the demographic transition. Such findings based on data-intensive but simple indicators are in line with results produced by more complex models. Ronald Lee, Andrew Mason and their co-authors[14] show that intergenerational reallocations of different scope, such as the general government or the market economy, imply different levels of optimal fertility, and although current fertility levels are insufficient to maintain government in industrialised countries, they are not far from what is required for maintaining current consumption levels.

Our other example for the merits of using families of indicators based on the variation of scope rather than single indicators is the pro-elderly bias in public spending. As it has been demonstrated (1) currently older persons receive more public transfers than in past decades; (2) the elderly population receive more than children; and (3) the elderly/children public transfer ratio has been increasing.[15] However, these observations, while true, ignore other transfers and are limited to the public sector. If the scope of measurement is expanded to the level of the market economy and further to the total economy the conclusion reverses. In Figure 2 we show per capita values of three transfer packages. The curves represent 17 European countries covering 85 percent of the EU population. For the sake of cross-country comparability values are re-scaled by the per capita labour income of the 30-49-year-old population. The first package is net public transfers (taxes paid less transfers and public services received) that is the level of the general government. The shape of the continuous curve confirms pro-elderly bias: the elderly population gets significantly higher per capita net transfers through public channels than children do. However, if net private, mostly intra-familial transfers of market goods and services are taken into account, that is the scope is extended to the market economy, the pro-elderly bias disappears (see the dotted line in Figure 2). Finally, when net transfers

of the value of unpaid household labour are also included, that is the analysis is extended to the level of the total economy, children receive more transfers per capita than the elderly (dashed line in Figure 2). The pattern is repeated in each of the 17 sampled countries.

In short, as first noted by Gal, Vanhuysse and Vargha,[16] children receive more, not less, transfers per capita than the elderly population. The 'age-bias' of public transfers, a child/elderly ratio of 0.4 measured in terms of per capita transfers, balances out at the level of the national economy (taking a value of 1.1), and reverses (with the ratio of 2.4) if transfers of the household economy are also taken into account.[17] However, children receive most of their transfers from their family in forms unrecorded by current statistical standards and consequently invisible for much of the analysis of intergenerational relations, whereas the old population is supported through well documented, mostly public, channels.[18]

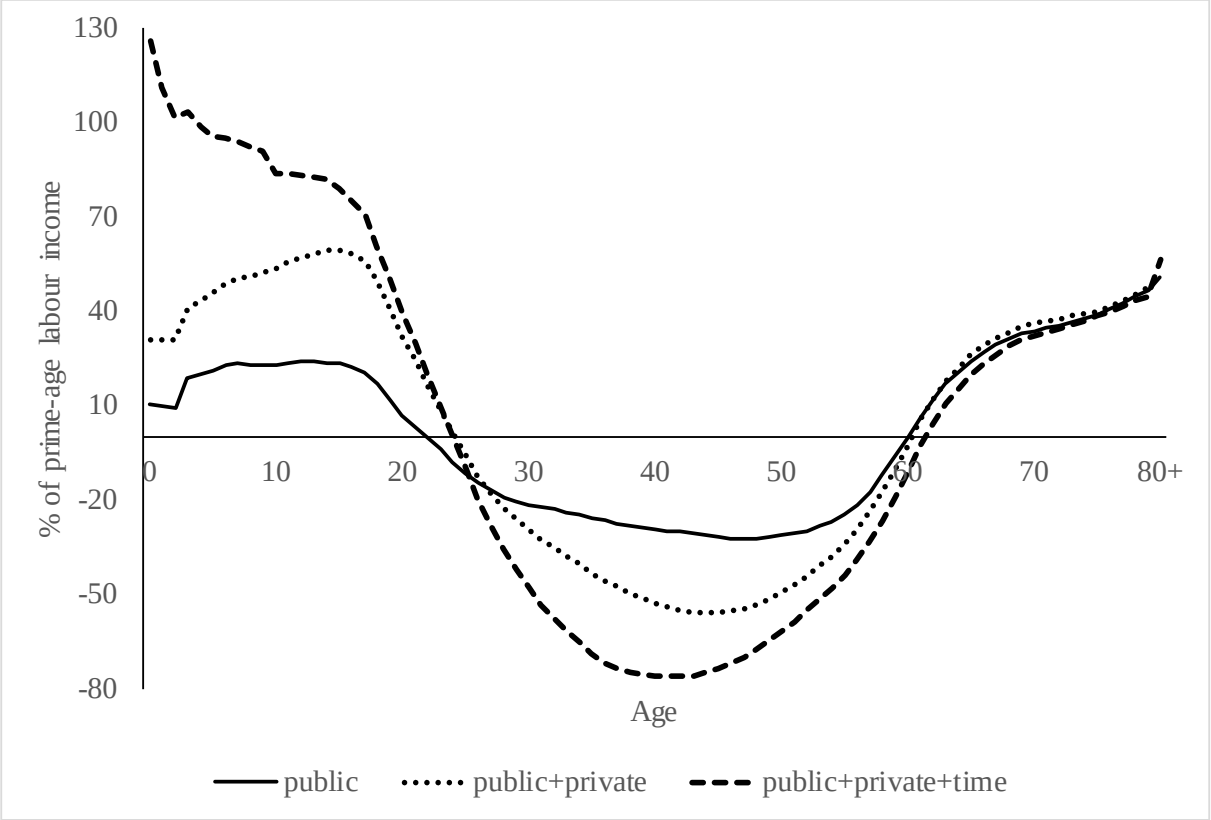

Figure 2: Per capita values of various transfer packages in the European Union

Source: Authors' calculation based on Istenič et al (2017) (public and private transfers) and Vargha et al (2016) (household time transfers).
Note: European Union: 17 member states representing 85 percent of the EU population. Prime-age: the age bracket of 30-49-year-olds.

This result significantly modifies the one-sided narrative of intergenerational transfers as a sneaky grab for resources by the old. The frequent references on "gerontocracy" and the growing "grey power" are limited to the statistically visible world of public transfers and largely ignore intra-familial transfers of cash and time. The more complete picture based on a family of related indicators is consistent with an alternative narrative of intergenerational developments. The growing public share of resources flowing to older persons may well have gone in parallel with increasing societal resources for the young. Higher public transfers to elderly recipients may turn out to be a form of compensation for lost private and time transfers mostly due to lower co-habitation levels with adult

children. Notwithstanding elderly bias in public spending, the twentieth century may also have been the Century of the Child, as Ellen Key (1909) predicted at its start.[19]

We cannot address such questions at this stage. We only used the two examples to demonstrate that families of related indicators frequently can tell more about sustainability and fairness than single indicators and sometimes even question widely held perceptions. The quest for the best indicator may turn out to be the quest for the best family of indicators.

Partitioning versus parametric characterisation of age distributions

Support ratios are cross-sectional indicators (see Table 1), which take their values from one period of time, *t*. This *t* is not necessarily the current period; it can be in the past or in the future. As a matter of fact, cross-sectional indicators are frequently applied in projections. However, even if *t* takes place in the future a cross-sectional indicator takes the value of one period at a time (or potentially a compound of two such measures) irrespective of where this period is in the timeline. In contrast, what we call long time-horizon indicators sum up information of the base period, *t*, as well as subsequent periods in one indicator. Whenever cross-sectional indicators are applied to characterise the future, they refer to the future. In contrast, long time-horizon indicators as present values include references to the future even when they are used to characterise the present. Cross-sectional indicators are central tendencies (medians or means), rates or subtractions whereas long time-horizon indicators are built on summations or integrals over a specified time period.

Most cross-sectional indicators partition the age distribution and compare its sections with each other (in the first three columns of Table 1). This is the most populous group in our collection (even if not in Table 1 but see the Appendix for details – available at request). The most frequently used partitioning is the triad of childhood, active or working age and old age. All related indicators are based on some simple or more chiselled definition of the three life stages. Some of them cover part of the population such as the various beneficiaries/contributors (or benefits/contributions) ratios characterising pension systems. Others range over the entire population including children as well. Partitioning of the age distribution can be based purely on age but more sophisticated partitioning methods include other pieces of information. They can be monetary but they can refer to other conditions such as health, level of education, labour market position or some institutional conditions as well.

Partitioning in its most frequent form cuts the life cycle at externally given demarcation ages, such as 15 years as the age of becoming adult and 65 years as the age of growing old. Such a simplification eases cross-country comparisons or projections but also distorts the results. The shift from childhood to adult life or from working age to old age occurs at different ages across countries and changes over time. An old man in Africa is not necessarily old in Sweden; a 16 years old woman could have been easily a housewife in ancient Rome but she would be considered a child in modern day Italy.

In a series of papers Warren Sanderson and Sergei Scherbov overcome this problem by introducing the concept of characteristic age.[20] They offer a general framework that translates various characteristics of people to years of age. Such characteristics can vary over a wide range of frequently used measures of population aging, including variants of remaining life expectancy, such as prospective old age thresholds for the entire population or various social groups (the average age of a social group at which their remaining life expectancy is a given threshold of years, usually 15 years) or the prospective median age (the age of a person in a population who sees as many people with higher and as many people with lower life expectancy than his/her own); survival probabilities, such as the probability of surviving the next 5 years; health conditions of the population as a whole (such

as the proportion of self-reported good/bad health) or that of various social groups (such as the average hand-grip strength).

The translation procedure requires two characteristic schedules. Average chronological ages of various social groups in a fixed age-specific characteristic schedule are related to chronological ages, called alpha ages, in another, variable characteristic schedule. With some simplification, this re-mapping creates iso-age contours by selecting the age equivalents of chronological ages in the variable characteristic schedule. Fixed schedules can be as different as a pre-set remaining life expectancy (such as 15 years); some demographic characteristic of a reference group, such as one of the two sexes, a nation, a group with a given level of education or a group in a given year. Variable schedules can be cross-country differences; changes over time or differences by age within one social group.

Sanderson and Scherbov collect a number of striking examples. Whereas the 15-year prospective old age threshold rapidly increased between 1960 and 2010 in East Asia (by nearly 12 years in China and nearly 11 years in Japan), the mortality crisis in Russia resulted in a stagnation. In a more colloquial language 66 was the new 54 in China; 73 was the new 62 in Japan; but 64 remained 64 in Russia if old age was defined as the age when the remaining life expectancy is 15 years. Another example is median aged Mexicans who were older in 2010 as compared to 1960 but they were further away from their death in that their remaining life expectancy was longer than their counterparts' 50 years before. In a similar way, iso-age contours can be drawn by level of education or self-reported health. As Sanderson and Scherbov show the gender difference in life expectancies vary much more by education in Eastern Europe than in Western Europe so highly educated Eastern Europeans become old more or less at the same age as Western Europeans but the demarcation line between working age and old age runs at a significantly lower age among poorly educated Eastern Europeans.

Other cross-sectional indicators circumvent the problem of ad hoc partitioning by avoiding it altogether. Such indicators give a parametric characterisation of the entire age distribution by comprising information in one parameter such as a weighted mean (column 4 in Table 1). Support ratios mentioned in the previous section belong in this group. Another example of this type is the *arrow diagram* sometimes called the Lee arrow named after its inventor.[21] It is built on parametric characterisations of two related age profiles. It is the difference between the mean age of consumers weighted by the amount of their consumption and the mean age of workers weighted by their labour income. It takes the shape of an arrow in its graphical representation of intergenerational relations (see Figure 3). It has a direction (depending on whether consumers or workers are older), length (depending on the age difference) and width (the current amount of per capita consumption). If it is negative (in a graphical representation an arrow heads to the left), consumers are younger than workers, or in a longitudinal interpretation consumption precedes production; if it is positive (the arrow heads to the right), workers are younger than consumers and it is production that precedes consumption.

For illustration we present a young and an old society, Indonesia and Germany, in Figure 3. In order to give the order of magnitude of the arrows we show consumption (C in the figure; drawn by the dotted lines) and labour income (YL; by continuous lines) by age. Both are per capita values and measured on the right-hand axes of the panels. However, the sign of the arrow can only be made out from population weighted values of consumption and labour income. They are presented as shaded areas and measured on the left-hand scales.

The dominant effect in young societies is that consumers build up debts in order to finance their consumption. Such a debt can be an implicit or even informal intra-familial debt. In contrast, the

dominant effect in an old society is that of saving and wealth accumulation. Robert Willis[22] and in a more general setting Ronald Lee[23] show that assuming a stable population the area of the arrow diagram gives an indication of the per capita demand for lifecycle wealth or, with some simplification, debt or wealth accumulating in the future. As such, the Lee arrow is a simple and powerful tool for sustainability analysis.

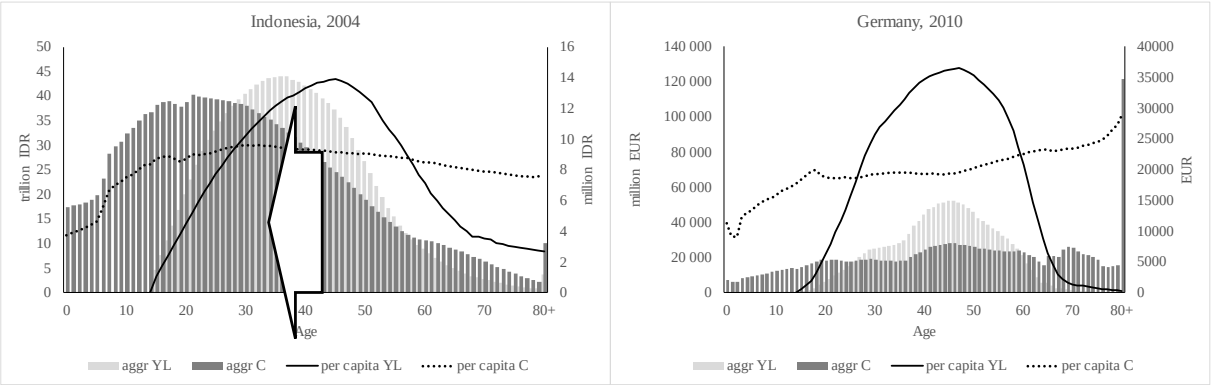

Figure 3: Per capita and aggregate labour income (YL) and consumption (C) by age and the resulting arrow diagram in a young and an old society

Source: Authors' calculation based on the international NTA database (www.ntaccounts.org) (Indonesia) and Istenič et al (2017) (Germany).

A direct application of the arrow diagram for population ageing is membership in the *Silver Club*.[24] A society becomes member of the Silver Club at the moment its Lee arrow changes sign and consumers grow older than producers. In Table 2, we present signs and lengths of the arrow diagram for selected European countries, the European Union as a whole as well as other regions of the World. The names of Silver Club members are set in boldface.[25]

Table 2. Weighted mean ages of consumers and workers and the lengths and signs of the resulting Lee arrows

	mean age of consumer	mean age of worker	length and sign of the Lee arrow
Germany	46.7	43.9	2.7
Spain	42.3	42.0	0.3
France	43.3	42.2	1.1
Italy	45.1	43.8	1.3
Sweden	43.4	44.5	-1.1
UK	44.1	42.6	1.5
European Union	42.3	42.4	-0.1
US	41.8	44.0	-2.2
East Asia	36.8	40.5	-3.7
Latin America	33.9	40.0	-6.1
South and South East Asia	31.2	39.4	-8.2
Africa	26.1	39.5	-13.4

Source: European figures: authors' calculation based on data of Istenič et al (2017). Other figures are from Lee and Mason (2011b).
Note: EU: 26 member states in 2010.

Silver Club membership signals and important stage of population ageing when the first demographic dividend is about to turn negative and the phase for harvesting a potential second dividend is about to open. The first dividend is a consequence of the temporarily growing proportion of working age population just when rapid population growth stops and cohorts larger than the cohorts of their parents start to have less children. This period creates opportunities for higher labour supply (as child raising does not demand so much work any longer) and for higher consumption and investments (as fewer children have to be raised by potentially more workers). This dividend is positive as long as the relatively large cohorts are in working age and turns negative once they retire. However, there is a chance for a prolongation of growth. If the additional resources due to higher labour supply and less downward transfers to children are saved rather than consumed a second dividend can be harvested. Silver Club membership signals this opportunity, which is, unlike the automatism of the first dividend, is not more than that, an opportunity. Its realisation depends on the quality of public policies, reliability of the financial sector and willingness of the public to save.

Another closely related indicator, called in pension economics the *turnover duration* of a pay-as-you-go scheme is a counterpart of the Lee arrow with a narrower scope.[26] In this context, turnover duration is the difference between the average age of pensioners weighted by the amount of their benefits and the average age of contributors weighted by the amount of their contributions. The distance of the two weighted means indicates the average length of "maturation" of contributions in a notional account of a non-financial defined contribution system.[27] In other words it signals the average time that contributions "spend" in the "accumulation phase" in a notionally funded scheme. Multiplied by the period amount of contributions it gives an indication of the accumulating stock of contributions of the system. Expressed in an alternative way, it reflects the amount of notional wealth held by the pension system. Differences between turnover durations reflect the variance in the underlying age distribution as well as in employment patterns. One of the potential applications of the indicators is the automatic balance mechanism of the indexation formula used in the Swedish public pension system.[28] The formula in question adjusts benefits of retirees and the notional wealth of contributors in an annual, incremental way in order to assure smooth and continuous adjustment to a sustainable path.

Absentees: missing companions of existing indicators

As shown in Table 1, the turnover duration, a cross-sectional indicator, is related to the *contribution wealth*, or the present value of future contributions of a pay-as-you-go system, which is an indicator with a time-horizon. They are two approaches to quantifying the same thing, a stock of wealth building up from a future stream of revenues. The turnover duration is based on stronger assumptions and as such applies no references to the future.[29] The contribution wealth even in its simplest form contains a discount factor. It is a constituent part of an increasingly popular sustainability indicator, the *implicit pension debt* (IPD).[30] This name refers to three related indicators. *Accrued-to-date liabilities* is the present value of future pensions based on eligibilities collected by plan members so far. It gives the cost of closing the system now. No new contributions are expected to be paid in the system, consequently no new eligibilities emerge. *Closed-system liabilities* is the present value of future benefits less the present value of future contributions (the contribution wealth introduced above) of plan members who have paid so far. This measure contains future contributions and new obligations arising from such future contributions. The imaginary institutional setting underlying this interpretation is closing the pension system before new entrants. Finally, *open-system liabilities* is the net of the two present values of future streams of benefits and contributions on condition that the system lasts forever.

The concept of IPD became rather influential in the last years. It left the academic circles and the research community and it is on the way of becoming a standard statistical tool regularly published by official agencies. However, we are not aware of any calculations of its potential counterparts, concepts like an *implicit education capital* or *implicit health capital*. We added them to Table 1 but set them in italics as they have not been established yet. Both would quantify human capital that has been created and can be mobilised in the future to extend working lives and in this way counterbalance the implicit debt of a pay-as-you-go scheme. It is intuitive that investments in education and health have an impact on effective retirement age decades later. However, a budget planning procedure armed with the IPD indicator but having no measures of implicit education capital and implicit health capital would give the red signal to additional investments in education or health care. The current versions of IPD reflect human capital investments only indirectly, in the form of an exogenously chosen growth rate of productivity, and so they do not reflect growth in the human capital base of the pension system induced by additional education or health spending. Clearly, an otherwise rich and useful indicator, such as the IPD, employed in this way would trigger wrong policies.

As the name reveals, IPD applies to a specific public programme. It can be generalised and defined with a larger scope. The equivalent of open-system liabilities at the level of the general government is called the *sustainability gap*.[31] It is the present value of expected aggregate future imbalances of the tax-transfer system and it is frequently applied as a by-product of generational accounting. We will briefly return to this below.

In principle, the sustainability gap can be further generalised at the level of the economy although we have not found reference to such an indicator in the literature. Nevertheless, an indicator with a related content could be invented. It would be a sort of accumulating *consumption deficit* defined as the difference between the present values of future consumption and future labour income (or potentially, future primary income, which also includes revenues from capital and property). It would give the amount of future consumption unfunded by labour (and, in the alternative definition, capital). This indicator is also set in italics in Table 1. The relationship between the consumption deficit and the arrow diagram of the previous section resembles to the relationship mentioned above between the contribution wealth and the turnover duration, although the fact that consumers can be both younger and older than workers (the arrow diagram can change sign), whereas contributors are always younger than beneficiaries, makes some differences. The consumption deficit with a content outlined above would be relevant in sustainability discussions and indirectly in intergenerational issues as well. A sizeable consumption deficit indicates the life path of future generations be different from that of currently living generations.

Calculations pointing to an indicator such as the one called here consumption deficit have been suggested. They differ in the way the consumption deficit is balanced. Eshan Khoman and Martin Weale[32] calculates additional savings required in maintaining current consumption patterns in France, Italy, Spain and the UK. An alternative way of filling the gap is higher fertility. Ronald Lee, Andrew Mason and their co-authors,[33] mentioned before, present fertility rates required to reserve current consumption patterns in a sample of 40 countries. Both models can serve as a base for creating indicators related to the consumption deficit.

Sustainability versus fairness

In Table 1, we distinguished among long time-horizon indicators between those referring to a cohort or the entire population. Conclusions based on one or the other are rather different. Whereas indicators containing information on the entire population all at once are applied in sustainability

analysis, cohort figures can also serve for intergenerational comparisons and in this way the analysis of intergenerational fairness. Although some indicators can be interpreted both at cohort level and at population level the analyses they are applied in are different. Our example here is *pension wealth*, sometimes called *social security wealth*, an indicator with frequent references in the academic literature[34] but also used by international agencies such as the OECD. Pension wealth is the expected present value of the future stream of benefits in a pay-as-you-go pension scheme. Defined as a system-level indicator it is the same as the above mentioned accrued-to-date interpretation of the implicit pension debt or the liability side of the other two interpretations. However, the pension wealth can also characterise a cohort. Such an indicator can be useful in the analysis of the wealth portfolio of members of pay-as-you-go schemes as well as in the explanation of saving behaviour. Cohorts counting on sufficient pension wealth may behave differently than cohorts having no such wealth components in their portfolio. Also, pension wealth by cohort can tell winners from losers in a pay-as-you-go system.

Population level indicators hardly contain retrospective information. They are typically used in sustainability analyses, which are based on current and future data. In special cases "current" may be set in the future, as future base years can also be selected, for instance, when the researcher wants to quantify the increasing costs for future generations of a postponement of reforms.

By contrast, cohort level indicators are often fed with historical data. In fact, this is what distinguishes a proper analysis of intergenerational fairness from a sustainability test. Indeed, the results of a sustainability study are frequently interpreted in terms of intergenerational fairness saying that current patterns are so much unsustainable that the adjustment will unfairly affect future generations. While such predictions may sound convincing proper statements on intergenerational fairness cannot be made without covering the entire lifetime of cohorts in the comparison, which usually requires retrospective data. Proper inter-cohort comparisons require data covering the entire lifecycles of the cohorts in question often involving the collection of retrospective information and projections regarding the future.[35]

Once such a dataset is prepared various methods are available to quantify intergenerational equity. Such indicators can be based on subtractions (net present values of lifetime inflows and outflows such as taxes and benefits or labour income and consumption) such as the *net transfer rate*, which projects the net present value of lifetime benefits and taxes on lifetime earnings. Alternatively, they can be ratios of present values such as the *benefit/tax ratio*. Such calculations have been published for public pension systems of numerous countries but only a handful of net transfer rates of the entire tax-transfer system have been calculated so far.[36]

However, without lifecycle data no real inter-cohort comparisons can be made rendering conclusions on intergenerational fairness futile. This is tacitly acknowledged in the *generational imbalance*, a key indicator of generational accounting.[37] Although the method is based on calculating present values of net taxes through the remaining lifetime of each cohort, currently living and future, generational imbalance compares such present values only of the new-born cohort and the future generation (future cohorts are not distinguished from each other but treated as a single cohort). That is, the imbalance is established between two full lifetimes. Remaining lifetime balances of all other living cohorts are neglected by the indicator in the end, and are taken into account only in the calculation of what is in fact the sustainability gap of the tax-transfer system (see above). This gap is what is charged on future generations making their lifetime present values different from that of the new-born. Even this acknowledgment by the method makes it difficult to interpret it in terms of intergenerational fairness. Generational imbalance compares two highly abstract lifecycles after all; it is better be interpreted as a sustainability measure or as a predictor of reforms.

Conclusions

As population ageing is becoming a growing concern, a number of new indicators measuring the consequences on economic and financial sustainability and intergenerational fairness have been suggested by the research community. The increasing number of measurement tools also led to efforts of surveying them. Following this stream, we established a taxonomy of over 80 indicators in order to find overlaps and connections as well as to facilitate the invention of new indicators. The development of new statistical standards, such as the National Transfer Accounts, as well as newly opening datasets will likely lead to further inventions, which in turn will most likely revise exploratory tools such as our taxonomy. At this stage, our main conclusions can be summed up in two points. First, we found that the same type of indicator measured at different levels, such as the general government, the (market) economy or the total economy, which includes both the market economy and the household economy, often leads to different conclusions. A family of related indicators frequently can tell more than a single indicator. The quest for the best indicator may turn out to be the quest for the best indicator family. Secondly, we found that conclusions on sustainability and intergenerational fairness derived from indicators limited to the 'visible' world of current statistical standards can be misleading. The value of investments in human capital or intra-familial transfers of cash and time are so important in this field that they frequently change and sometimes even revise the results of the analysis. Ignoring them can lead to misleading conclusions.

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ENDNOTES

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[2] Sustainability is a broad concept including environmental and social issues as well. In this paper we limit ourselves to indicators of the financial/economic aspects of sustainability and intergenerational fairness.

[3] Gál/Monostori 2016.

[4] Fenge/Werding 2003.

[5] Spijker 2005.

[6] Further, our taxonomy table was also influenced by the taxonomies of Balassone/Franco 2000; Benz/Fetzer 2006; and Langenus 2006.

[7] General government is a statistical term referring to the combination of the central (federal and state) government, local governments, social security and other public funds.

[8] The total economy, measured by what Ironmonger/Soupourmas (2012) call the Gross Economic Product, consists of the market economy, described by aggregates such as the GDP, and the household economy, that is the value of products and services produced by unpaid household labour applying household facilities. Estimates of the size of the household economy range between 25 percent and as much as 80 percent of GDP depending on calendar year, country and measurement method. The household economy is large even in industrialized countries. The sheer size and the age profile of household labour (see Vargha/Gál/Crosby-Nagy 2017) make the inclusion of such estimates highly relevant for sustainability measures.

[9] Miller 2011.

[10] Cutler/Poterba/Sheiner/Summers 1990.

[11] Although we include representatives of each main regime type we do not explore their differences here. Albertini / Kohli /Vogel (2007) and Albertini /Kohli (2013) show that private transfers among adult children and their parents differ along a North-South scale in Europe. Whereas they take place mostly within the household in Mediterranean countries, Scandinavian children leave relatively early and receive net support from their parent in the form of inter-household transfers.

[12] Vargha/Gál/Crosby-Nagy 2017.

[13] Calculation of the support ratio family and other intergenerational indicators was made possible by the National Transfer Accounts (NTA) methodology. NTA, a new chapter in the development of national accounting, introduces age into age-insensitive National Accounts (NA). In the standard form of NA, revenues flow among institutions such as households, corporations and government. In NTA they flow among people in different age. NTA was established by Lee 1994a,b. The United Nations (2013) has published a revised manual. A comprehensive introduction to the method, including theoretical foundations, comparative results and a wide range of country-studies can be found in Lee/Mason 2011a. NTA age profiles can be downloaded from www.ntaccounts.org (global data) and http://www.agenta-project.eu/en/dataexplorer.htm (European data).

[14] Lee/Mason/members of the NTA Network 2014.

[15] See also Gál/Vanhuysse/Vargha 2018, and specifically Kotlikoff/Burns (2012) on older generations gaining ground, Vanhuysse (2013) on pro-elderly bias in public spending and Preston (1984) on the shifting elderly/children ratio in public transfers.

[16] Gál/Vanhuysse/Vargha 2018.

[17] Gál/Vanhuysse/Vargha 2018.

[18] Gál/Vanhuysse/Vargha 2018.

[19] Gál/Vanhuysse/Vargha 2018.

[20] Sanderson/Scherbov 2010, 2013, 2014, 2016.

[21] The arrow diagram was developed by Ronald Lee (see Lee, 1994a; Lee/Mason, 2010).

[22] Willis 1988.

[23] Lee 1994a.

[24] The concept of the Silver Club was suggested by Timothy Miller.

[25] The table contains entries for the European Union as a whole. These values are simple averages of 26 out of the 27 member states in 2010 (with Malta missing). Altogether 17 of them were Silver Club members and 7 others were on the edge. Only Cyprus and Ireland were still a few years away.

[26] This definition of the turnover duration was developed by Settergren/Mikula 2006.

[27] Non-financial defined contribution (NDC) systems of pay-as-you-go financing imitate funded schemes in that they set up individual accounts on which contributions are credited. The accumulating notional wealth grows by new contribution inflows and a notional interest, which in one way or the other is related to the period rate of return of the system.

[28] Settergren 2001.

[29] See Settergren/Mikula 2006; Lee 1994a; Bommier/Lee 2003.

[30] Holzmann/Palacios/Zviniene 2004.

[31] Bonin (2001), Bonin/Patxot 2004.

[32] Khoman/Weale 2008.

[33] Lee/Mason/members of the NTA Network 2014.

[34] See the series edited by Gruber/Wise 1999, 2004, 2005.

[35] Intergenerational transfers, both public and intra-familial, reallocate resources flowing in opposite directions, from the working age population to children (forward) and from the working age population to the elderly (backward). This connects forward transfers (childcare, education, etc.) in time t and backward transfers (pensions, health care) in time t+1. Due to its immense data needs or reliance on simulation methods, most indicators of economic sustainability and intergenerational fairness avoid addressing this feature directly even though it would hold out a combined interpretation in terms of sustainability and fairness. A recent proposal, the human capital investment gap (Hammer et al 2016), still in the experimental phase, aims at this combination by giving the unsustainability measure in terms of inadequate investments of one generation in the human capital of a subsequent generation.

[36] See for instance Hills (1995) for the UK and Bommier et al. (2010) for the US.

[37] Auerbach/Gokhale/Kotlikoff 1991.

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