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Ageing Europe – An Application of National Transfer Accounts for Explaining and Projecting Trends in Public Finances

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1. 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 persistence of current consumption patterns, came to the fore as a result of the changing age composition of society through 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 to the terms of intergenerational fairness. The connection between the two issues 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.

The aim of writing the paper is to facilitate the informed choice among indicators of economic sustainability and intergenerational fairness and the decision about their uses. As population ageing is becoming a growing concern, a number of new indicators have been recently 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; which are frequently misinterpreted; and possibly we do not have to most meaningful of them yet.

[1] We are grateful for comments by Alexia Fürnkrantz-Prskawetz, Bernhard Hammer, Miguel Sánchez Romero, Lili Vargha and participants of NTA workshops in Belo Horizonte, Barcelona and Vienna. The usual disclaimer holds. This paper was written as part of the AGENTA project. AGENTA (http://www.agenta-project.eu/en/index.htm), has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 613247.

Surveying the related literature we have collected over 80 indicators. We created a notation system and translated each indicator in order to make them comparable. The notation system is presented in Appendix 2. The list of indicators including references, verbal and mathematical definitions and occasional comments can be found in Appendix 1.

Our main effort is the establishment of a taxonomy (a system of similarities and differences) of the indicators in order to make their interpretation more straightforward. The taxonomy is summarised by a table consisting of 28 cells. We link related indicators both within and across cells. Some cells are overpopulated reflecting the focus of interest of the research community and policy makers. Some cells are empty. We include them anyway hoping that our taxonomy might to some extent reiterates Mendeleev's periodic table, which established relationships of chemical elements and advanced the discovery of some elements still unknown at the time the table was presented. In Section 5 we even make an attempt to create an indicator we have found no reference to, which we believe is relevant in the analysis of economic sustainability.

The structure of the paper is as follows. In Section 2 we briefly review related taxonomies which we borrowed from. In Section 3 we present a hierarchical taxonomy of the indicators. The text is organised by the five nodes of the taxonomy tree. We give examples to each of the seven end-nodes. In Section 4 we introduce a further dimension of four categories to the taxonomy arriving to a 28-cell table. In Section 5 we discuss the content of the table; show relationships among indicators; create families of indicators; demonstrate how the table can be used for inventing new indicators; and present calculations of selected indicators, which we find relevant but missing from current statistical standards or superior to currently existing indicators. Section 6 concludes the paper.

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2. Review of existing taxonomies

In this section we survey previous efforts to organise existing knowledge in the field of indicators of economic sustainability and intergenerational fairness.

Benz and Fetzer (2006) focus on the public sector and evaluate indicators measuring fiscal sustainability, both in the short and long term. They distinguish between traditional indicators of fiscal activity of government and indicators quantifying the long-term effect of policies. Although the two types share the same theoretical background empirical applications are different. Traditional indicators of government fiscal activity (such as public debt) capture only the short term effects of political decisions. They frequently ignore the dependence of public revenues and expenditures on the business cycle as well as other medium or long-term demographic, social and economic processes. Indicators covering the long-term effects of political decisions started to emerge in the beginning of the 1990s. Among them the most frequently applied approaches are Generational Accounting (Auerbach, Gokhale and Kotlikoff 1991) and the OECD indicator-set developed by Blanchard et al. (1990).

Fenge and Werding (2003) collect indicators measuring the consequences of population ageing for the public pension system and the general government. 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). Below we will explicitly use the "scope" dimension of their taxonomy.

They create a two-by-two table replicated here as Table 1. We also include their examples, such as 'net pension liabilities' by the OECD, which is the net present value of future entitlements and contributions less the existing assets; 'general government fiscal balances' also by the OECD, which extends the scope to a larger

set of government expenditures; 'generational accounts' by Auerbach, Gokhale and Kotlikoff (1991), which establishes a sustainability measure by comparing the present values of remaining lifetime net taxes by cohorts; and the 'implicit tax' of pay-as-you-go pension systems, which represent the net present values of lifetime contributions and old-age pensions at individual or cohort level.

Table 1: Inter-generational imbalances in public budgets: concepts of measurement

		Concepts looking at…	
		macro-level effects	micro-level effect
Calculations comprising…	general government budget	general government fiscal balances	Generational Accounting
	public pension schemes	net pension liabilities	tax implied in public pension schemes

Source: Fenge and Werding (2003).

Referring to classic references, Langenus (2006) distinguishes between three benchmarks of sustainability of the public sector. The first one requires the public debt ratio to converge to a finite value in order to avoid a continuously growing tax ratio. The second one requires the debt ratio to converge back to its initial level. Finally, the third one requires the present discounted value of all future primary surpluses to be equal to the current level of public debt. Based on Balassone and Franco (2000) Langenus (*ibid*) separates backward-looking and forward-looking measures. The former evaluate past developments of fiscal variables testing whether policies have been affected by the government budget constraint. The latter deal with fiscal sustainability of government programmes. The first group of forward-looking calculations are projections based on various macroeconomic and demographic assumptions. The second group consists of synthetic indicators, which are based on various items balancing the expected

unsustainability. The third type of forward-looking methods is generational accounting mentioned above.

Spijker (2015) goes beyond the strict focus on the public sector and differentiates among indicators by the domains covered. He differentiates among indicators by the domains covered. His taxonomy consists of five categories:

1. Purely demographic
2. Purely economic
3. Demographic and economic related
4. Health and disability related
5. Based on human capital.

He surveys existing indicators emphasizing that the choice between them should depend on the proper specification of the research or policy goals. Different indicators fit different purposes. The effects of population ageing on economic variables, such as consumption, saving and productivity, are best approached by purely economic indicators or by those that relate demographic and economic contents. Indicators based on human capital also frequently fit in here. In contrast, sustainability of the public care system can be best captured by purely demographic indicators or those with health and disability content.

3. Dimensions of taxonomy

Our taxonomy is hierarchical (see Table 2) with five nodes and seven end-points. In this section we describe and justify the nodes. At every point we give one example. In Section 4 we cross the end-nodes of the taxonomy tree by a further dimension of four categories. The resulting taxonomy table will include 28 cells altogether. Further details of the categories will be added in Section 5 where we put more content on the skeleton. Indicators falling into one cell are frequently similar by content; sometimes they are actually identical but go under different names. They are also related to each other both horizontally and vertically. We will group some of these relations suggesting families of indicators. Some cells of the

full table will seem overpopulated revealing the focus of interest of the research community and policy makers. Other cells are empty. We include them anyway as we believe the structure of the table can inspire the invention of new, potentially relevant indicators.[2]

Table 2: A taxonomy tree of indicators

Cross-sectional				Long-term horizon		
Partitioning of the population by			Parametric characterisation	Cohort		Population
Chronological age	+ Other non-monetary characteristics	+ Other incl. monetary characteristics		Remaining lifetime	Entire lifetime	

Node 1: How future is dealt with: cross-sections versus indicators of long-term horizon

The first dimension of our taxonomy is how the future is treated by the indicator. As it comes from the name, cross-sectional indicators contain information of a period of time. For instance, *demographic support ratios* [1] to [12], which some way or the other compare the number of active aged people with the number of the inactive aged, take their values from one period of time, *t*. This *t* is not necessarily the current period. It can be in the future such as a support ratio based on a population projection. As a matter of fact, cross-sectional indicators are frequently applied in projections. Indeed, the indicators taken up here as an example for this type, the expected future demographic support ratio based on expected future age distribution, have left academic circles or policy making centres and become common place. However, even if *t* takes place in the future a

[2] In order to help readability we refrain from using full references to the origin of the indicators in Sections 3, 4 and 5. Indicators will be named and referred to by their rank number in [x] brackets. In Appendix 1 we list all of them including definitions based on a unified notation system. This is where we also add full references wherever it is applicable. The notation system is presented in Appendix 2.

cross-sectional indicator takes the value of one period at a time irrespective of where this period is in the timeline.

In contrast, long-term horizon indicators sum up information of the base period, *t*, as well as subsequent periods in one indicator. As an example we mention the *implicit pension debt* [77], [78], a frequently used indicator of hidden financial burden, which is also on its way of becoming a standard procedure for statistical services.

In fact, the name of implicit pension debt refers to three related indicators (Holzmann, Palacios and Zviniene, 2004), which we will denote as IPD1, IPD2 and IPD3. IPD1 (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. The European Commission will collect this information from member state administrations in the future. IPD2 (closed-system liabilities) is the present value of future benefits less the present value of future contributions of plan members who have contributed 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, IPD3 (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.

Returning to the question of how future is dealt with, whenever cross-sectional indicators are applied to characterise the future, they refer to the future. In contrast, long-term horizon indicators as present values include references to the future even when they are used to characterise the present. Future is "included" in this type of indicators.

As seen in Appendix 1, where we give definitions of all indicators referred to in this paper, cross-sectional indicators are central tendencies (medians or means), rates

or subtractions whereas long-term horizon indicators are built on summations or integrals over a specified time period.

Node 1.1: How information is gained from cross-sectional age distributions: partitioning of the population versus parametric characterisation

Some indicators in our taxonomy summarise the information comprised by the age distribution in one number, such as a median or a mean. Our example is the *turnover duration* [64] applied specifically for the age distributions of contributors and beneficiaries of a pay-as-you go pension scheme. Turnover duration in this context is the difference between two such parametric measures, 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. So the turnover duration is based on parametric characterisation of two age profiles; the two parameters are then compared to each other. The difference between the two weighted means indicates the average length of "maturation" of contributions in a notional account of a notional defined pension system.[3] In other words it signals the average time contributions "spend" in the "accumulation phase" in a notionally funded scheme. Multiplied by the actual amount of contributions it gives an indication of the accumulating stock of contributions of the system. In an alternative way to put it, it reflects the amount of notional wealth held by the pay-as-you-go pension system.

Differences between turnover durations reflect the variance in the underlying age distribution as well as in employment patterns. Among potential applications of the

[3] Notional 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.

turnover duration is the automatic balance mechanism of the indexation formula of the Swedish public pension system (Settergren, 2001). The formula in question adjusts benefits of retirees and notional wealth of contributors in an annual, incremental way in order to assure smooth and continuous adjustment to a sustainable path.

Some of the single-parameter indicators are based on demographic age-profiles other than the age distribution of the population. We take *prospective age* [53] as an example here. It received much attention in academic circles over the last years. To put it simply it measures the number of years still to be lived. It is applied in predicting the ramifications of population ageing (Sanderson and Scherbov, 2005). We specifically mention it here because it is based on the age-profile of mortality, not on the age distribution of population.

Nevertheless, instead of summarising the information on a distribution in one parameter, most cross-sectional indicators partition the age distribution and compare its sections with each other. The relevant partitioning in the context of this paper 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.

Node 1.1.1: Information content of partitioning: chronological age only or other information as well

Partitioning of the age distribution can be based purely on age, such as the frequently applied age groups of 0-19, 20-64 and 65+. Such a sectioning is attractive because it is simple; however this simplicity comes at a price. Demarcation points, such as between the ages of 19 and 20, are meant to indicate

major transitions between life stages, such as the entry to the labour market. Yet, in reality such an entry is a process not a point; in addition far from all people between the ages of 20 and 64 are working while there are also people still working after age 64.

Partitioning based exclusively on age may be more complex. Whereas the 0-19, 20-64, 65+ separation of age groups uses pre-defined demarcation points defined by expert consensus other similar indicators apply institutional information on age. In particular official standard retirement ages can loosen the rigidity of the above pre-defined borderlines such as in the case of the *pension cost dependency ratio* [13].

More sophisticated partitioning methods include other pieces of information. It can be monetary but it can refer to other conditions such as health, level of education, labour market position or some institutional condition as well. Potential examples are the *duration of working life* [59], a Eurostat indicator measuring the number of years a person aged 15 is expected to be active in the labour market throughout his/her life and which combines demographic data with labour market data; or the *economic support ratio* [37], which apart from age takes age patterns of the labour market (employment and wages) as well as consumption into account. We will return to the economic support ratio as part of an indicator family.

Since additional information extends rather than excludes information of demographic nature such indicators can be decomposed. We demonstrate it on the decomposition of the pension expenditure/GDP ratio, which is available in great variety in the literature. This measure is a standard reference in discussions on the effects of population ageing on sustainability of public budgets. Projections on its expected future values are of key importance in policy debates. One potential form it takes is:

Pension expenditure / GDP =

*= old-age dependency * coverage * replacement rate * 1/activity * 1/wage efficiency*

where

old-age dependency	*= # above retirement age / # in active age*
coverage	*= # pensioners / # above retirement age*
replacement rate	*= average pension / average wage*
activity	*= # employed / # in active age*
wage efficiency	*= (GDP / # employed) / average wage*

The decomposition equation, like peeling an onion, shows how various pieces of additional information can be flaked off one after the other on the way of getting to the old-age dependency ratio, the core indicator including purely demographic content. Coverage and the replacement rate are institutional characteristics (the latter even political to some extent), whereas activity is an indicator of the labour market and wage efficiency is that of the wider economic environment. Both the decomposition exercise and its components exist in many variants. Two recent efforts are European Union (2015) by the European Commission and Jarmuzek and Nakhle (2016) by the IMF. The institutional affiliations of these two references also reveal the extent to which decomposition became a professional standard in a key sustainability analysis.

In principle, similar decompositions can also be carried out on some of the parametric type of indicators as well.

Node 1.2: Level of disaggregation of indicators of long-term horizon: cohort versus population

After reaching the end of one line of the classification tree we return to the top in order to climb down on the other line. As mentioned above indicators of long-term horizon include components of the expected future while characterising the current situation.

As shown in Table 2 our first distinction along this line is 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 serve 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* [80], an indicator with frequent references in the academic literature (e.g. Gruber and Wise 1999, 2004, 2005) 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 IPD1 or the liability side of IPD2 or IPD3, depending on whether the definition allows new contributions and new entrants to the system. (The three variants of the implicit pension debt have been discussed above in this section). However, 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 without such wealth components. Also, pension wealth by cohort can tell winners from losers in a pay-as-you-go system. We will return to this shortly.

Nevertheless, some indicators have only population-level interpretations. For instance, the *sustainability gap* [84], the present value of expected aggregate future imbalances of the tax-transfer system, characterise the sustainability of the budget of the entire general government at once. It does not apply at the cohort level.

Node 1.2.1. Cohorts: remaining lifetime or entire lifetime

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.

In contrast, cohort level indicators are frequently fed with historic data. In fact, this is what distinguishes a proper analysis of intergenerational fairness from a sustainability test. Indeed, it often happens that the results of a sustainability study are 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 frequently 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.

This is acknowledged in the *generational imbalance* [62], a key indicator of generational accounting. 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 by the method). 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 easier to be interpreted as a sustainability measure or as a predictor of reforms.

Proper inter-cohort comparisons require data covering the entire lifecycles of the cohorts in question often involving collection of retrospective information and projections regarding the future. Once such a dataset is prepared various methods are available to quantify intergenerational equity. As an example here we refer to the *net transfer rate* [75], which projects the present value of net lifetime public transfers to the present value of lifetime earnings.

4. Scope of the analysis

In Section 3 we presented a taxonomy tree. We named and interpreted all nodes, and the resulting classes and subclasses. In Section 4 we add a new dimension to the taxonomy one that cuts through all categories above. This dimension is the scope or level of the analysis.

We distinguish four such levels, those of

- specific public programmes, such as education, health care or pensions
- general government (the entire tax-transfer system)
- market economy
- total economy, which combines market economy and the household economy.

The household economy is an economic sector mostly excluded from national accounts.[4] Its extent can be estimated by assessing the value of unpaid household labour. Indeed, for many types of economic analysis the household economy is marginal and the methodological uncertainties surrounding its measurement justify it being neglected. However, we find households too important to miss from the analysis of sustainability and fairness due to their contributions through rearing

[4] National accounts include parts of imputed unpaid household labor such as food production for own consumption and construction of the owner-occupied house.

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children and caring for the elderly. We will demonstrate it in Section 5 with the help of the *elderly-bias in social spending* indicator [47] showing that what seems to be dominance of older cohorts applies only in public spending but turns around once the scope is widened completely rewriting the widely held belief on the 'creeping gerontocracy' in developed economies. So despite the current scarcity of indicators falling into the last category of our four levels of analysis we included it anyway. We also intend to use it for underscoring the Mendeleev-potential of our taxonomy mentioned above.

Here we will use another example to introduce the 'scope' dimension, the family of support ratios. All members of this indicator family include the age distribution of the population but in addition to that they also take economic characteristics into account. The *fiscal support ratio* [25] weights demographic cohorts by their net contributions to the general government (taxes and social contributions less benefits) and calculates the ratio between net contributors and net beneficiaries. The *pension support ratio* [48] does the same but it is limited to the public pension system. In contrast, the *economic support ratio* [37] extends the scope to the entire market economy and applies age-profiles of labour income and consumption as weights. Finally, the *total support ratio* [39] extends the economic support ratio with age profiles of household labour produced and consumed.

The rationale of connecting related indicators or to extend the scope of the analysis from the pension system to the general government to the market economy and finally to the total economy is that sustainability conclusions can prove to be quite different at the various levels. Gál and Vargha (2015) using Hungarian data demonstrate that 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 included in the analysis. In a more sophisticated setting and on a much larger sample of countries Lee, Mason et al (2014) show that the required levels of fertility maintaining current patterns are quite different in the tax-transfers system as compared to the

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(market) economy as whole. Decreasing fertility is more of a threat for the general government than for the economy.

The 'scope' dimension in our taxonomy can establish families of related indicators. In that, it is similar to the decomposition exercises, illustrated above with the decomposition of the ratio of pension expenditures and GDP, which help finding the relationship between various indicators.

5. A taxonomy of indicators

In Table 3 we unify the dimensions of our taxonomy. Due to the large number of indicators the table is not filled. We present it here only to give an overview of the taxonomy as a whole. We split it to three parts, A, B and C, which we will detail below separately.

Table 3: A taxonomy of indicators of economic sustainability and intergenerational fairness

<table>
<tr><td rowspan="3"></td><td colspan="3">Cross-sectional</td><td rowspan="3">Parametric characterisation</td><td colspan="2">Long-term horizon</td></tr>
<tr><td colspan="3">Partitioning of the population by</td><td colspan="2">Cohort</td><td rowspan="2">Population</td></tr>
<tr><td>Chronological age</td><td>+ Other non-economic characteristics</td><td>+ Other incl. economic characteristics</td><td>Remaining lifetime</td><td>Entire lifetime</td></tr>
<tr><td>Specific public programmes</td><td colspan="3" rowspan="4">A</td><td rowspan="4">B</td><td colspan="3" rowspan="4">C</td></tr>
<tr><td>General government</td></tr>
<tr><td>Market economy</td></tr>
<tr><td>Total economy</td></tr>
</table>

A. Cross-sectional indicators based on partitioning the population

Details of Panel *A* of Table 3, including a selection of indicators, are presented in Table 4. Definitions of the indicators can be found in Appendix 1.

Our starting point here is the most widely used partitioning of the population by age, which identifies children with the 0-19 year old age group; active aged people with the 20-64 year old age group; and the elderly with those 65 years old or older. This partitioning is based on an expert consensus. Its advantage is obvious: these categories are easily available across most countries and long way back in history; they are also predictable with sufficient reliability for a relatively long period. However, its shortcomings are also clear. Transitions between the three main stages of the life course change over time, as they have changed historically and are expected to change further in the future. They are also different, sometimes significantly, across countries in one period of time. The reason why the length of life stages vary in time and space is that there are various factors, such as the education system, labour market, health and economic conditions, which distinguish a child from an adult and an active aged person from an elderly.

As a consequence, cross-country comparisons frequently give results difficult to interpret; projections based on the standard partitioning prove false retrospectively. Due to its crucial importance for sustainability analysis the research community has made extensive efforts in order to make the partitioning more empirically driven and enrich it with information relevant for sustainability and intergenerational fairness. Below we will give a selective review of their achievements.

Table 4: Cross-sectional indicators based on partitioning the population

	Cross-sectional		
	Partitioning of the population by		
	Chronological age	+ Other non-monetary characteristics	+ Other incl. monetary characteristics
Specific Public Programmes		**16.** Pension per Worker Ratio **17.** Pension System Dependency Ratio **18.** Pension Cost Dependency Ratio **48.** Pension Support Ratio	**40.** Total Current Pension Expenditure **41.** Public Pension Expenditure Ratio **42.** Benefit Ratio **43.** Aggregate Replacement Ratio **44.** Benefit Generosity Ratio
General Government		**19**. Economic Dependency Ratio **20.** Inactive per Active Ratio **21.** Non-Working Aged Dependency Ratio **22.** Real Elderly Dependency Ratio **23.** GDP Adjusted Real Elderly Dependency Ratio **24.** Tax Revenue Adjusted Real Elderly Dependency ratio **25.** Fiscal Support Ratio **26.** Rostock Indicator 2.	**45.** Elderly/Non-Elderly Spending Ratio **46.** Elderly/Non-Elderly Spending Share **47.** Elderly-Bias of Social Spending
Market Economy	**1-5.** Total Age Dependency Ratio **6.** Ratio of the Population Aged 65 or over **7-10.** Old Age Dependency Ratio **11.** Ageing index **12.** Parent Support Ratio	**14.**Proportion of the Population in Age Groups that have a Remaining LEXP 15 years or less **15.** Prospective Old Age Dependency Ratio **27.**Health Care Need Adjusted Prospective Old Age Dependency Ratio **28.** Health Care Need Adjusted Real Elderly Dependency Ratio **29.** Adult Disability Dependency Ratio **30.** Cognitive-Adjusted Dependency Ratio **31.** Cognitive functioning indicator based on Symbol-Digit test **32.** Ratio of Active Life Expectancy to Total Life Expectancy **33.** Old Age Healthy/Unhealthy Dependency Ratio **34.** Real Adult Disability Dependency Ratio **35.** Real Elderly Disability Dependency Ratio **36.** Health Care Cost Old-Age Dependency Ratio **37.** Economic Support Ratio **38.** Education-Weighted Dependency Ratio **49**. Lifecycle deficit	**50.** Human Capital Specific Old Age Dependency Ratio **51.** Intergenerational Tax Rate
Total Economy		**39.** Total Support Ratio	

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Augmenting age with additional information and making partitioning of the age distribution driven by data appears in our taxonomy table as connecting indicators horizontally. However, the table also gives way to establish vertical relationships by repeating an exercise in an ever wider scope. We have shown the family of support ratios above as an example. In this section we will present another related indicator family. First, however we show improvements to the standard partitioning.

The *Chronological age* column of Table 4 contains variants of the age dependency ratio. These indicators use only age as a base for partitioning the population. The demarcation points of the timeline separating the life stages are pre-defined by expert consent (all indicators between [1] and [12]). These indicators are very similar to each other; at times they have exactly the same content but run under different name; in other cases to the contrary, they have the same name but set the break-points elsewhere.

The *Non-monetary* column contains a number of proposals to add further content to partitioning. The suggestions are various in what additional information they include starting from mortality ([14], [15], [18]) sometimes extended with features of the labour market ([22]), the economy ([23]) or the tax-transfer system ([23]); to health or disability ([27], [28], [29], [30], [31], [33], [34], [35], [36]); to the labour market ([19], [20], [21], [26]); to education ([38]); to macroeconomic aspects of the market economy, such as labour income and consumption ([49]). These indicators all have it in common to take into account one or more features other than age that affect the transition from active age to old age. They lead to more insightful cross-country comparisons and potentially more intuitive projections.

We are demonstrating this with the help of partitioning the age distribution by the lifecycle deficit (LCD) curve. LCD is the difference between consumption and

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labour income.[5] It is positive in childhood and old age as children and the elderly consume more than they produce, and it is negative in active age when labour income exceeds consumption (making LCD a lifecycle surplus). The LCD curve offers a data driven partitioning of the age distribution of population. It separates those cohorts that receive net support from the rest of society from those that provide this support. It is therefore strongly associated with the intuitive definition of childhood, working age and old age. So it is edifying to see how different results such an approach gives from the standard expert consent.

In Table 5 we present the cutting points in selected member states of the European Union and the number and relative share of population allocated to another age-group than by the pre-defined demarcation points of 19/20 and 64/65.

First, the LCD approach allows variation across nations, which is rather intuitive. Why should transitions between major life stages occur at the same age everywhere? In our sample of countries the end of childhood (by LCD definition the highest age at which the representative person of a cohort still consumes more than he/she produces) varies between ages 23 and 26 and the start of old age varies between ages 58 and 63.

Second, transition from childhood to adulthood is set at a significantly higher age than the usual 19/20 cutting point. Even in Austria, which has the lowest value in the sample, people become economically productive only when they reach age 24. In Spain, Italy, Finland and the UK the corresponding age is 27. The share of people considered children by the LCD method but taken as adult by the standard age limits varies between 17 percent (France) and 29 percent (Slovenia) of the

[5] LCD is a key concept of National Transfer Accounts (NTA). NTA informs with age various national account categories, such as labour income (compensation of employees), consumption and the resulting LCD as well as the channels through which the gap between consumption and labour income is filled (such as capital income, property income and savings, private transfers and public transfers including both in kind and in cash transfers). NTA was established by Lee (1994a,b). An NTA Manual was published by the Population Division of the UN (United Nations 2013). A comprehensive introduction to the method, including theoretical foundations, comparative results and a wide range of country-studies can be found in Lee and Mason (2011).

LCD-child category. On the other edge, people become net consumers below the age of 65 everywhere in the sample, even in Sweden (at age 63). This gap of two years reclassifies 10 percent of the old (by the LCD definition). In Hungary the proportion allocated to the group of the working aged by the standard way but considered already old by LCD is as much as 37 percent.

Table 5: How many people are allocated to other age groups by the lifecycle deficit curve? (‘000,000)

	Transition from childhood to working age			Transition from working age to old age			Total allocated to other age-group	
	Age	Additional allocations as child	% of LCD-children	Age	Additional allocations as old	% of LCD-old	Number	% of total population
Germany	26/27	6.9	31	59/60	4.3	20	11.2	14
Spain	26/27	3.9	30	59/60	2.4	24	6.3	14
France	23/24	3.2	17	58/59	4.7	31	8.0	12
Italy	26/27	4.3	28	58/59	4.4	27	8.7	15
Hungary	24/25	0.6	24	57/58	0.9	37	1.5	15
Austria	23/24	0.4	19	57/58	0.6	30	1.1	13
Slovenia	25/26	0.2	29	57/58	0.2	33	0.3	16
Finland	26/27	0.5	28	58/59	0.5	34	0.9	18
Sweden	25/26	0.7	25	62/63	0.3	13	1.0	10
UK	26/27	5.9	28	58/59	4.5	32	10.3	17

Source: Authors’ calculation based on data from the NTA database (www.ntaccounts.org).
Note: Lifecycle deficit (LCD) is the difference between consumption and labour income. It separates childhood from working age and working age from old age. Following EU standards countries are arranged in the alphabetic order of their native names.

The LCD approach describes a reality largely different from the one based on the currently accepted expert consent. It makes cross country comparisons more realistic. By now the technology and research infrastructure exists to calculate it in a comparative setting without country-specific knowledge (Istenic and Sambt, 2016) making it prepared for more general use in statistical protocols.

One way of improving the analysis of sustainability and intergenerational fairness is to enrich the information content of age related indicators. We have shown some examples above. Such extensions connect existing indicators, or induce the invention of new indicators, horizontally in our taxonomy table by adding some

further content to pure demographic age. The other, vertical, way offered by the table is to enlarge the scope of analysis. In the previous section we have offered an illustration, the family of support ratios, to demonstrate that conclusions can be altered by zooming in or zooming out. Here we will present another case, which rewrites conclusions regarding intergenerational fairness.

The literature includes numerous attempts to compare public spending in the two inactive sections of the lifecycle. For instance, the *benefit generosity ratio* [44] compares per capita public spending in the relevant cohorts (e.g. pensions among the elderly, primary education costs among the cohorts in schooling age, etc.) across programmes. Variants of the *elderly/non-elderly spending ratios* [45], [46] and the *elderly bias in social spending* [47] compare all per capita age-specific public expenditures between the two dependent age-groups. The general conclusion across such calculations (Miller, Mason and Holz, 2011; Lynch, 2006; Vanhuysse, 2013) is that public spending favours the old; and this favouritism has been increasing over time (Tepe and Vanhuysse, 2010). However, Gál, Szabó and Vargha (2015) on Hungarian data and Gál, Vanhuysse and Vargha (2016) on European data show that the alleged 'gerontocracy' is an optical illusion. Indeed, public spending flows disproportionately to the elderly. However, if the scope is expanded and private transfers and time transfers are also added to the comparison, the balance turns over. Per capita public spending on the elderly is two-and-a-half times higher than that on children (see Gál, Vanhuysse and Vargha, *ibid*). By adding private transfers flowing between relatives within and between households the aggregate transfer package becomes largely balanced. Finally, if the scope is further extended and the household economy enters the equation the original proportion reverses. Now, children outdo the elderly receiving more than twice as much transfer per capita. The scope matters, obviously. The general government has a strong elderly focus in Europe; the market economy does not; and the total economy, which includes the value of unpaid household labour, as a whole tilts to children.

B. Cross-sectional indicators based on parametric characterisation

Panel *B* of Table 3 is enlarged and detailed in Table 6. It includes cross-sectional indicators that summarise the information of an age distribution or potentially other demographic age profiles, such as the age pattern of mortality, in one single number. Such a single measure could be a median or a weighted mean.

In the previous section we have introduced a specific definition of the turnover duration adjusted to the conditions of a pay-as-you-go pension scheme as the difference between the mean age of pensioners and the mean age of contributors, both means weighted by the respective monetary values, benefits and contributions. The turnover duration applies to a specific public programme, the pension system. Its counterpart at the level of the entire market economy is *Lee's Arrow* [68]. Lee's Arrow is the difference between the *mean age of consumers* [67] weighted by the amount of their consumption and the *mean age of workers* [66] weighted by their labour income. If it is negative (the arrow heads to the left) consumers are younger, or in a longitudinal interpretation consumption precedes production; if it is positive (the arrow heads to the right) producers are younger and it is production that precedes consumption. The dominant effect in young economies is that consumers build up debts in order to finance their consumption. Such a debt can be implicit or even informal intra-familial debt; the latter can be denominated in time instead of monetary terms. In contrast, the dominant effect in an old economy is that of saving and wealth accumulation. Willis (1988) and Lee (1994a) show that if the difference between the two weighted means, that is the length of Lee's Arrow, is multiplied by the actual amount of consumption in the time period of the cross-section it gives an indication of the accumulating aggregate debt or wealth in the future. As such, Lee's Arrow is a simple and powerful tool for sustainability analysis.[6]

[6] Settergren and Mikula (2006) proves the same relationship between the turnover duration and the accumulating notional contribution wealth.

Table 6: Cross-sectional indicators based on parametric characterisation

	Cross-sectional
	Parametric characterisation
Specific Public Programmes	**64.** Turnover Duration **65.** Accumulated Benefit Obligation
General Government	
Market Economy	**52.**Potential Years of Life **53.** Prospective Age **54.** Population Average Remaining Years of Life Expectancy **55.** Old Age Threshold Based on Remaining Life Expectancy **57.** Prospective Median Age **58.** Remaining Life Expectancy at Median Age **59.** Duration of Working Life **60.** Disability Free Life Expectancy **61** Healthy Life Years **66.** Mean Age of Earnings **67**. Mean Age of Consumption **68.** Lee's Arrow **69.** Miller's Silver Club
Total Economy	

Lee and Mason (2011b) compares results of the arrow diagram across countries and find a strong connection between sign and length of the arrow on one hand and age composition and level of development on the other. Hunter-gatherer societies have a strongly negative relationship between the ages of consumers and workers. Consumers are typically 10-11 years younger. This shortens to 8 years in South and South-East Asia; to 6 years in Latin America; and to less than 4 years in East Asia. In Japan consumers are on average already older than workers; so are in Western countries.[7]

As an indicator for cross-country comparisons *Miller's Silver Club* [69] applies the arrow diagram.[8] A society becomes a member of the Silver Club when its Lee's Arrow changes sign and consumers grow older than producers. In Table 7, we take a closer look on the sign and value of Lee's Arrows in selected European

[7] Patxot et al (2012) decompose Lee's Arrow by separating transfers flowing to children from transfers flowing to the elderly.
[8] The concept of the Silver Club was suggested by Timothy Miller.

nations. The period, in 2010, show the moment these societies came near or has just passed the threshold. The table shows Germany, France Italy, Hungary, Austria, Finland and the UK as already members of the Silver Club and Spain, Slovenia and Sweden near to the membership.

Table 7: Members of Miller's Silver Club among selected EU member states

	mean age of consumer	mean age of worker	length and sign of Lee's Arrow
Germany	46.3	43.9	2.4
Spain	41.9	42.0	-0.1
France	43.2	42.2	1.0
Italy	45.2	43.8	1.4
Hungary	42.4	41.5	0.8
Austria	43.1	41.8	1.3
Slovenia	41.1	41.8	-0.7
Finland	44.2	43.7	0.5
Sweden	43.5	44.5	-1.0
UK	42.8	42.6	0.2

Source: Authors' calculation based on data from the NTA database (www.ntaccounts.org).
Note: Lee's Arrow is the difference between the weighted mean age of consumers and that of workers. Miller's Silver Club is the group of countries with positive Lee's Arrow. Following EU standards countries are arranged in the alphabetic order of their native names.

C. Indicators of long-term horizon

Panel *C* of Table 3 contains indicators with long-term time horizon (see Table 8). Though seemingly separate from Panels *A* and *B* there exist horizontal connections between cross-sectional and long-term-horizon indicators. In addition, the Mendeleev-nature of our taxonomy table suggests the invention of further related indicators.

Table 8: Indicators of long-term horizon

	Long-term horizon		
	Cohort		Population
	remaining lifetime	entire lifetime	
Specific Public Programmes	**80.** Social Security Wealth **81.** Contribution Wealth	**71** Intergenerationally equitable retirement age **72**. Projected Benefit Obligation **73.** Benefit/tax ratio **74.** Pay-Back Period **75.** Net Transfer Rate	**63.** Implicit Pension Debt 1. **77.** Implicit Pension Dept 2. **78.** Implicit Pension Dept 3. **79.** Net Pension Liabilities **80.** Social Security Wealth **81.** Contribution Wealth
General Government	**62.** Generational imbalance (GI_AGK)	**76.** Implicit Tax	**82.** General Government Fiscal Balance **83.** Intertemporal Public Liabilities **84.** Sustainability Gap **85.** Sustainability Tax Quota **86.** Tax Gap Indicator **13.** Fiscal Imbalance **70.** Generational Imbalance (GI_GS) **56.** Saving Gap
Market Economy			*Consumption deficit*
Total Economy			

Above we have discussed the turnover duration that is the difference between the weighted average age of pensioners and that of contributors in a pay-as-you-go system. We have also mentioned that a time span such as the turnover duration multiplied by the value of contributions in the time period of the cross-section gives an indication of the accumulating stock of contributions of the system. In that the turnover duration is related to the *contribution wealth* [81]. Implicitly, we have touched upon the contribution wealth before too as the contribution side of the closed-system and the open-system definitions of implicit pension debt (IPD2 and IPD3). In fact, the turnover duration and the contribution wealth 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 (see Settergren and Mikula, 2006; Lee, 1994a; Bommier and Lee,

2003) and as such applies no references to the future. The contribution wealth even in its crudest form contains a discount factor.

There are vertical, scope-enlargement type of relationships among indicators in the table as well. The sustainability gap of the tax-transfer system (see in the previous section) is the generalised version of the implicit pension gap in its open-system version (IPD3) applying at the level of the general government. The sustainability gap can be further generalised at the level of the market economy. We have not found reference to such an indicator in the literature but as Mendeleev's table indicated the existence of elements that were discovered later, 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. It would give the extent of future consumption unfunded by labour. We added this indicator to Table 8 but did not number it and set it in italics as it has not been established yet.

The consumption deficit with content like this is related to Lee's Arrows the same way as the contribution wealth is related to the turnover duration. It 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 covered. Khoman and Weale (2008) 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. Lee, Mason et al (2014) 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. Moreover, there could be ways of maintaining current consumption patterns other than higher savings or higher fertility. Investments in education improve productivity and extend working lives. A further potential indicator based on education needs could be added to the indicator family in this currently empty cell of the taxonomy table.

So far we have used Table 8 to set forth horizontal, content-wise connections between indicators as well as vertical, scope-wise relationships. We have even pointed to possible holes in the network, which could induce new inventions with potential relevance for analysis. In the remaining paragraphs of the subsection we will emphasise one more aspect of the taxonomy, the conceptual separation of sustainability and intergenerational fairness. Long-term-horizon indicators can contain time of the future starting from the base year of the analysis. They can also include retrospective information from time preceding the base year. Such a difference more or less separates sustainability issues from those of intergenerational fairness. For a proper analysis of the latter entire lifecycles of individuals or cohorts are required. Column 2 of Table 8 contains a few of such indicators. They 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* [75], 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* [73] or its variants, e.g. the *implicit tax rate* [76]. 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 (see for instance Hills, 1995 for the UK and Bommier et al, 2010, for the US).

6. Conclusions

In this paper we established a taxonomy of indicators of economic sustainability and intergenerational fairness and meted out over 80 related indicators in its classes. We found overlaps in the literature (e.g. indicators under different names having the same content, or its opposite, indicators under the same name, which have different definitions); offered a conceptual separation of economic sustainability and intergenerational fairness in the taxonomy; established relationships among indicators and brought them together in indicator families; suggested ways of inventing new indicators; and explicitly included the household

economy (the economic value of unpaid and unregistered household labour) in the taxonomy.

As for the latter we demonstrated how adding the household sector alters widely held beliefs, such as the growing 'grey power' in developed societies, and how differently population ageing affects the system of public redistribution, the (market) economy and the total economy (which includes both the market economy and the household economy).

We also named indicators that have great potential for the measurement of economic sustainability and intergenerational fairness, such as the partitioning of the population by the lifecycle deficit (LCD) curve. LCD is the difference between consumption and labour income. It partitions the age distribution in a way strongly resembling the intuitive definitions of childhood (consumption exceeding labour income), working age (to the contrary, labour income larger than consumption) and old age (consumption is once again surpasses labour income). The LCD curve separates age groups that are dependent on others from those whom other cohorts depend upon. We present calculations showing how different conclusions are derived from the data driven partitioning of the LCD curve compared to those based on standard partitioning (0-19, 20-64, 65+).

In addition, we also present new calculations on Lee's Arrow in a sample of European countries. Lee's Arrow is the difference between the mean ages of consumers and workers, both means being weighted by the respective sums of consumption and labour income. The length and sign of the arrow (whether it is consumers who are older than workers or the opposite) gives a simple but strongly intuitive indication of saving behaviour and wealth accumulation. The dominant effect in economies of young consumers is that consumers build up debts in order to finance their consumption. Such a debt can be implicit or even informal intra-familial debt; the latter can be denominated in time instead of monetary terms. In contrast, the dominant effect in an economy of old consumers is that of saving and wealth accumulation. We show that European economies are old in that consumers are older than or nearly as old as workers in sharp contrast with most other regions of the World, where consumers are still significantly younger.

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Appendix 1. List and definitions of indicators

1. **Total Dependency Ratio 1**
   - *Notestein et al. (1944)*

$$TDR1 = \frac{N_{0-14} + N_{65+}}{N_{15-64}}$$

2. **Total Dependency Ratio (2-5)**
   - *UN, World Population Prospect*

$$TDR2 = \frac{N_{0-19} + N_{65+}}{N_{20-64}}$$

$$TDR3 = \frac{N_{0-19} + N_{70+}}{N_{20-69}}$$

$$TDR4 = \frac{N_{0-24} + N_{65+}}{N_{25-64}}$$

$$TDR5 = \frac{N_{0-24} + N_{70+}}{N_{25-64}}$$

3. **Age Dependency Ratio**
   - *The World Bank*

$$ADR = \frac{N_{0-14} + N_{65+}}{N_{15-64}}$$

4. **Dependency Ratio**
   - *UN*

$$DR = \frac{N_{0-14} + N_{65+}}{N_{15-64}}$$

5. **Total Age Dependency Ratio 1-2 (Age Dependency Ratios)**
   - *EUROSTAT*

$$TADR1 = \frac{N_{0-14} + N_{65+}}{N_{15-64}}$$

$$TADR2 = \frac{N_{0-19} + N_{60+}}{N_{20-59}}$$

6. **Ratio of the Population Aged 65 or over (RPOP65+)**
   - *EUROSTAT*

$$RPOP65+ = \frac{N_{65+}}{N}$$

7. **Old Age Dependency Ratio 1-2**
   - *EUROSTAT*

$$OADR1 = \frac{N_{65+}}{N_{15-64}}$$

Funded by the Seventh Framework Programme of the European Union

$$OADR2 = \frac{N_{60+}}{N_{20-59}}$$

8. Old Age Support Ratio (OASR)

— *OECD*

$$OASR = \frac{N_{65+}}{N_{20-64}}$$

9. Old Age Dependency Ratio (3-7)

— *UN, World Population Prospect*

$$OADR3 = \frac{N_{65+}}{N_{15-64}}$$

$$OADR4 = \frac{N_{65+}}{N_{20-64}}$$

$$OADR5 = \frac{N_{70+}}{N_{20-69}}$$

$$OADR6 = \frac{N_{65+}}{N_{25-64}}$$

$$OADR7 = \frac{N_{70+}}{N_{25-69}}$$

10. Potential Support Ratio 1-5

— *UN, World Population Prospect*

$$POTSR1 = \frac{N_{15-64}}{N_{65+}}$$

$$POTSR2 = \frac{N_{20-64}}{N_{65+}}$$

$$POTSR3 = \frac{N_{20-69}}{N_{70+}}$$

$$POTSR4 = \frac{N_{25-64}}{N_{65+}}$$

$$POTSR5 = \frac{N_{25-69}}{N_{70+}}$$

11. Ageing Index (AI)

— *UN*

$$AI = \frac{N_{60+}}{N_{0-14}}$$

12. Parent Support Ratio (PSR)

— *UN indicator*

$$PSR = \frac{N_{85+} \times 100}{N_{50-64}}$$

— PSR is used to assess the demands on families to provide support for their oldest-old members

— Since the people in the numerator and those in the denominator are not necessarily related by kinship ties, the parent support ratio should be taken only as a rough indicator of changes in the family support system required for the oldest old

13. Fiscal imbalance (FI)

— *Gokhale and Smetters (2003)*

— FI is the current level of debt held by the public plus the present discounted value of future expenditures less the present discounted value of future receipts

— FI can be calculated for the entire government and also for subprograms

— $FI_t = PVE_t + PVR_t - A_t$

PVE_t =the present value of projected expenditures under current policies at the end of period t.

PVR_t =the present value of projected receipts under current policies (all- including future-generations' net payments)

A_t =current net financial assets

14. Proportion of the population in age groups that have a remaining life expectancy (RLE) 15 years or less (Prop. RLE15-)

— *Ryder (1975); Siegel and Davidson(1984)*

— *Sanderson and Scherbov, Lutz and Ryder* consider the age which RLE equals 15 years as the threshold of elderly dependency

$$Prop.RLE15 = \frac{N_{\epsilon_{i\leq 15}} * 100}{N}$$

15. Prospective Old Age Dependency Ratio (POADR)

— *Sanderson and Scherbov (2005)*

— Here the population with RLE15 and less is divided by the population below this age threshold but above age 20; the age range of the working age population is thus slightly shifted upwards to exclude a large student population most of whom are not (fully) active in the workforce, but include young-old people who could potentially work when the age at old-age threshold is higher than 65

$$POADR = \frac{N_{\epsilon\leq 15} * 100}{N_{a\geq 20}^{\epsilon\leq 15}}$$

16. Pensioner per worker ratio (PWR)

— *Bongaarts (2004)*

$$PWR = \frac{N_{a>65} + P_{a\geq mr|a\leq 64}}{W}$$

17. Pension System Dependency Ratio (PSDR)

— *EUROSTAT*

$$PSDR = \frac{P * 100}{W}$$

18. Pension Cost Dependency Ratio (PCDR) 2

- *Sanderson and Scherbov (2015)*
- The ratio is the number of people at or above the intergenerationally equitable retirement age to people between ages 20 and that retirement age
- The intergenerationally equitable retirement age is based on three criteria:
  - members of each cohort receive as much in pension payouts as they pay into the pension plan
  - the generosity of the pension system, measured as the ratio of average pension receipt to the incomes of people who pay into the pension system, after the pension tax, is the same for all cohort
  - the pension tax is the same for all cohorts
- Criterion (1):
- $\overline{Y_{CH}} \times t_p \times (T_{20} - T_\alpha) = \overline{P_{CH}} \times T_\alpha$
  - $\overline{Y_{CH}}$ =the average annual income of cohort members
  - t_p =the pension tax rate
  - T_{20} =the number of person-years lived from age 20 onward in the cohort's life table
  - T_α =the number of person-years lived from the intergenerationally equitable normal retirement age α onward
  - $\overline{P_{CH}}$ =the average annual pension payment
- Criterion (2):
- $\overline{P_{CH}} = \beta \times (1 - t_p) \times \overline{Y_{CH}}$
  - β = generosity of the pension system; the ratio of the annual pension payment to the income of people contributing to the pension system, after the pension tax
- Combining the two criteria:
  - $$\frac{T_\alpha}{T_{20} - T_\alpha} = \frac{t_p}{\beta \times (1 - t_p)}$$
- If β and t_p are fixed, this equation determines the intergenerationally equitable normal retirement age α

$$PCDR = \frac{T_\alpha}{T_{20}}$$

19. Economic Dependency Ratio (EDR)

- *OECD*

$$EDR = \frac{P + UE}{W_{\alpha \geq 15}}$$

20. Inactive per active ratio (IAR)

- *Vaupel and Loichinger (2006)*

$$IAR = \frac{(P + UE + IA) * 100}{W}$$

21. Non-Working-aged Dependency Ratio (NWDR)

- *Tyers and Shi (2007)*

$$NWDR = \frac{NW_{a \geq 61}}{W_F}$$

22. Real Elderly Dependency Ratio (REDR)

- *Sanderson and Scherbov (2008)*

$$REDR = \frac{N_{\epsilon \leq 15} * 100}{W}$$

23. GDP Adjusted Real Elderly Dependency Ratio (REDR_GDP)

- *Spijker et al (2015)*
- Real Elderly Dependency Ratio considers everyone in paid employment as equally productive; but REDR_GDP takes the different productivity into account

$$REDR - GDP = \frac{N_{\epsilon \leq 15} * 1000000}{GDP}$$

24. Tax Revenue Adjusted Real Elderly Dependency Ratio (REDR_TAX)

- *Spijker et al (2015)*

$$REDR - TAX = \frac{N_{\epsilon \leq 15} * 1000000}{t}$$

25. Fiscal support ratio (FSR)

- *Miller (2011)*
- FSR is the ratio of the number of taxpayers, weighted by age-specific per capita public transfer outflows, to the number of beneficiaries, weighted by age- specific per capita public transfer inflows.
- FSR is determined by the population age distribution and the age profiles of per capita taxes paid and benefits received for all in-kind and cash transfer programs, including education, health care and pensions

26. Rostock indicator 2.

- *Vaupel and Loichinger (2006)*

$$RI2 = \frac{\sum Wh}{N}$$

27. Health Care Need Adjusted Prospective Old Age Dependency Ratio (POADR5TTD)

- *Riffe et al (2014), Spijker (2015), Spijker et al (2015)*
- remaining life expectancy (RLE)=population average at a particular age (cohort level)
- Time To Death (TTD)=remaining years of life at any age (personal level)

$$POADR5TTD = \frac{N_{\epsilon_{i \leq 15} | TTD < 5}}{N_{a \geq 20 | \epsilon \leq 15}}$$

28. Health Care Need Adjusted Real Elderly Dependency Ratio (RED5TTD)

- *Spijker et al (2015)*

$$RED5TTD = \frac{N_{\epsilon_{i\leq 15}|TTD<5}}{W}$$

29. Adult Disability Dependency Ratio (ADDR)

- *Sanderson and Scherbov (2010)*

$$ADDR = \frac{Di_{a\geq 20} \times 100}{WDi_{a\geq 20}}$$

- ADDR increase less rapidly than the OADR (Old Age Dependency Ratio) or POADR (Prospective Old Age Dependency Ratio)
- This ratio is not strictly an Elderly Dependency Ratio

30. Cognitive-Adjusted Dependency Ratio (CADR)

- *Skirbekk, Loichinger and Weber (2012)*
- the indicator is based on age variation in cognitive functioning
- premise: cognitive ability levels predict individual productivity better than any other observable individual characteristics and they are increasingly relevant for labour market performance
- method: immediate word recall; standardized question

$$CADR = \frac{BCF_{a\geq 50}}{N_{15-49} + GCF_{a\geq 50}}$$

- Bad cognitive functioning: recalling fewer than half of the words in the test; Good cognitive functioning: recalling at least half of the words
- Result: Although continental European countries have a larger population share above the age of 65 than China, the value of CADR is lower in Europe.
  These countries are effectively younger; they have a lower share of seniors with poor cognitive performance.
- An increase in cognitive performance among successive cohorts has been observed in many countries
- Improvement can be expected (in Europe); reasons: mortality decline, universal education, improved nutrition, better economic conditions

31. Cognitive functioning indicator based on Symbol-Digit Test

- *Bordone, Scherbov and Steiber (2015)*
- Point of departure: individuals aged 50+ born into more recent cohorts perform better in terms of cognition than their counterparts of the same age born into earlier cohorts.
  - consequence of expansion of education, improvements in medical care, nutrition, visual and technical environments (Flynn effect)
  - cognitive functioning can be considered an important measure of differential ageing across cohorts and population groups
  - good cognitive functioning is one of the central components of successful ageing

- Symbol-Digit Test (SDT): nine graphical symbols, each assigned to a number between 1 and 9 - the appearance of one of the nine symbols – asking respondents to match it with the correct digit as quickly as possible – the number of correct responses were calculated after 30 sec (SDT30), after 60sec (SDT60) and after 90sec (SDT90)
- they used other tests
- results:
  - the better educated have significantly higher scores in all cognitive tests
  - the analysis confirms the presence of a significant Flynn effect, controlling for sex, age and education

32. Ratio of Active Life Expectancy per Total Life Expectancy (ALE/LE)

- *Manton, Gu and Lamb (2006)*

$$ALE/LE = \frac{\Sigma \epsilon 1_{a \geq 65 | a \leq 85} \times 100}{\Sigma \varepsilon_{a \geq 65 | a \leq 85}}$$

33. Old-Age Healthy/Unhealthy Dependency Ratio

- *Muszynska and Rau (2012)*
- Decomposition of the OADR into an old-age healthy dependency ratio and an old-age unhealthy dependency ratio
- research question: whether potential improvement in health and disability could compensate for ageing process

$$HODR = \frac{HP_{a \geq 65}}{N_{15-64}}$$

$$UHODR = \frac{UHP_{a \geq 65}}{N_{a \geq 15 | a \leq 64}}$$

34. Real Adult Disability Dependency Ratio

- *Spijker et al (2015)*

$$RADDR = \frac{Di_{a \geq 20} \times 100}{W}$$

35. Real Elderly Disability Dependency Ratio

- *Spijker et al (2015)*

$$REDDR = \frac{Di_{\epsilon \leq 15} \times 100}{W}$$

36. Health Care Cost Old-Age Dependency Ratio

- *Sanderson and Scherbov (2015)*
- it is assumed that the period of rapidly increasing health care cost begins at five years before death

37. Economic Support Ratio (ESR)

- *Cutler, Poterba, Sheiner and Summers (1990), Lee and Mason (2011b)*

— economic support ratio is the ratio of cohort sizes weighted by the per capita consumption and labour income in the national economy, respectively

$$SR_t = \frac{\sum_a y_l(a,t_0)\,N(a,t)}{\sum_a c(a,t_0)\,N(a,t)}$$

38. Education-Weighted Dependency Ratio (EWDR)

— *Striessnig and Lutz (2014)*

— an extension of the conventional total dependency ratio based on the assumption that every person of working age will make the same contribution to the support of the dependent population

— the population is divided into three categories; different weights apply to each of them both with regard to the dependency burden (due to the cost of education) and to differential support that people of working age can supply for those not of working age

$$EWDR = \frac{EWC + PA}{EWW}$$

— EWC=Education-Weighted Children:

— $EWC = (N_{a=0-5} \times E_{a=0-5}) + (N_{a=6-10} \times E_{a=6-10}) + (N_{a=11-18} \times E_{a=11-18}) + (N_{a=19-25} \times E_{a=19-25})$

— Education-Weighted Workforce:

$$EWW = N^{Prim}_{a=16-57} ED1weight + N^{Sec}_{a=19-61} ED2weight + N^{tert}_{a=26-65} ED3weight$$

— $PA = N^{prim}_{a=58+} \times pencost + N^{sec}_{a=62+} \times pencost + N^{tert}_{a=66+} \times pencost$

— all retirees get the same weight (pencost), but the ages of labour market entry and exit are education-specific

39. Total Support Ratio

— *Gál and Vargha (2015)*

— The effective number of consumers over the effective labour force (both the market economy and the household economy included)

40. Total Current Pension Expenditure (TCPE)

— *EUROSTAT*

$$TCPE = \frac{\sum PA * 100}{GDP}$$

41. Public Pension Expenditure Ratio (PPER)

— *Bongaarts (2004)*

$$PER = \frac{\sum PA}{\sum W_G}$$

42. Benefit ratio (BR)

— *EUROSTAT*

$$BR = \frac{\sum PA}{\sum W_G}$$

43. Aggregate Replacement Ratio (ARR)

— *EUROSTAT*

$$ARR = \frac{MePA_{a=65-74}}{MeW_{Ga=50-59}}$$

44. Benefit Generosity Ratio (BGR)

- *Miller, Mason, and Holz (2011)*

$$BGR = \frac{E}{\tilde{B}} / \frac{GDP}{N_{20-64}}$$

- BGR is the relative cost of benefits per person at risk
- potential beneficiaries (persons at risk) are defined by the relevant age for consuming education, pension benefits or health care, respectively
- in order to facilitate cross-country comparison BGR is measured in relation to the average productivity (GDP) of the working-age population (aged 20 to 64)

45. Elderly/Non-Elderly Spending Ratio (ENSR)

- *Lynch (2006)*
- Elderly spending includes pensions and services for the elderly, adjusted for the number of elderly persons (defined to be those either aged 65 and above or those in formal retirement)
- Non-elderly spending includes primarily unemployment benefits, active labour market policies, family allowances and family services, adjusted for the number of non-elderly persons (defined to be those aged bellow 65)

$$ENSR = \frac{\frac{\sum PA + \sum SA}{N_{65+}}}{\frac{\sum UBA + \sum ALA + \sum FAA + \sum FSA}{N_{0-64}}}$$

46. Elderly / non-elderly spending share (ENSS)

- *Tepe and Vanhuysse (2010)*
- The total (non-adjusted) spending share of two clearly pro-elderly programs (pensions and survival benefits) within a larger group of six welfare programs consisting in addition of (non-adjusted) spending on less clearly pro-elderly programs such as incapacity benefits, family programs, active labour market programs and unemployment benefits.
- The ENSS does not include health and education spending, since they cannot be clearly attributed to elderly vs. non-elderly generations

$$ENSS = \frac{\sum PA + \sum SBA}{\sum PA + \sum SBA + \sum IBA + \sum FAA + \sum ALA + \sum UBA} \times 100$$

47. EBISS- Elderly-bias in social spending (EBISS)

- *Vanhuysse (2013)*
- On the elderly oriented spending side (the numerator), the following public spending programs were included:
  - 1. old age related benefits in cash (pensions, early retirement pensions, other cash benefits)
  - 2. survivors benefits in cash and in kind

- 3. disability pensions
- 4. occupational injury and disease related pensions
- 5. early retirement for labour market reasons

— On the non-elderly oriented side (the denominator) the following public spending programs were included:
  - 1. family benefits in cash (family allowances, maternity and parental leave, other cash benefits) and in kind (day care/home-help services, other in kind benefits)
  - 2. active labour market programs (employment services and administration, labour market training, youth measures, subsidized employment, employment measures for disabled)
  - 3. income maintenance cash benefits
  - 4. unemployment compensation
  - 5. education spending for all levels of education from early childhood to university

— To adjust for demographic structure, the resulting elderly/non-elderly social spending ratio in each country has been multiplied by the country's old age support ratio (the number of persons aged 20-64 over the number of persons aged 65+)

$$EBISS = \frac{\sum P_O A + \sum SBA + \sum IBA + \sum P_H A + \sum P_e A}{\sum FBA + \sum ALA + \sum IBA + \sum UEA + \sum EA} \times \frac{N_{20-64}}{N_{65+}}$$

— Public health spending has not been incorporated into the EBISS calculations, as it is difficult to allocate precisely which share of health spending goes to which age groups- as the most health spending goes to older citizens in all countries, consequently EBISS underestimates the pro-elderly bias of welfare spending

— the correlation coefficient between the EBISS values and the old age support ratio (in 2007, OECD countries) is negative; EBISS is a consequence of policy choices not of demographic constraints

48. Pension Support Ratio (PSR)

— Pension support ratio is the ratio of cohort sizes weighted by the per capita pension contributions and benefits, respectively.

49. Lifecycle Deficit (LCD)

— *Lee (1994b), Lee and Mason (2011a)*

— LCD is the difference between consumption and labour income. It is positive in childhood and old age as children and the elderly consume more than they produce, and it is negative in active age when labour income exceeds consumption (making LCD a lifecycle surplus).

— The LCD curve offers a data driven partitioning of the age distribution of population. It separates those cohorts that receive net support from the rest of society from those that provide this support. It is therefore strongly associated with the intuitive definition of childhood, working age and old age.

50. Human Capital Specific Old Age Dependency Ratio (HC_OADR)

— *Philipov et al (2014)*

- the indicator is based on multi-state population projections by level of education

$$HCOADR = \frac{N_{65+} adjusted\ for\ education, specific\ median\ gross\ public\ pensions}{N_{20-64} adjusted\ for\ age, education\ and\ gross\ income}$$

- it is assumed that the indicator is strongly linked with other important factors such as economic growth, level of un/employment, economic in/activity, ability to work and health, part time employment, wage and pension differentials by length of working life, pension schemes, saving and spending, consumption patterns, labour-force participation of elderly people, age at retirement and entry into the labour force

51. Intergenerational Tax Rate

- *Miller (2010)*
- aggregate lifecycle deficit (LCD) for youth and elderly / GDP

52. Potential Years of Life (PYL)

$$PYL = \frac{\sum \epsilon_N}{N}$$

$$PYL = \frac{\sum \epsilon_{CH}}{CH}$$

53. Prospective Age (Standardised Age)

- *Sanderson and Scherbov (2005)*
- forward-looking definition of age – everyone with the same prospective age has the same expected remaining years of life, regardless of the number of years that they have already lived
- cohort prospective age: the expected number of years of remaining life for people in the same cohort

54. Population Average Remaining Years of Life Expectancies (PARYLE)

- *Lutz (2009)*
- the age-specific remaining life expectancies are weighted by the proportions of the population at each age whose average is then taken to obtain the average remaining years of life of population members

55. Old age threshold based on remaining life expectancy

- *Sanderson and Scherbov (2005)*
- age in which remaining life expectancy equals 15 years (AGE_RLE15)
- $a_{\epsilon=15}$

56. Saving gap

- The difference between the 'capital formation' and the 'saving' of an economic sector over a given period

57. Prospective Median Age (PMA)

- *Sanderson and Scherbov (2005)*
- the prospective age of median-aged persons

58. Remaining Life Expectancy at Median Age

- *Sanderson and Scherbov (2005)*
- the remaining life expectancy at median-aged persons

59. Duration of working life

- *EUROSTAT*
- The indicator measures the number of years a person aged 15 is expected to be active in the labour market throughout his/her life. This indicator is calculated with probabilistic model combining demographic data (life tables) and labour market data (activity rates for every age groups)

60. Disability-Free Life Expectancy (DFLE); Health-Adjusted Life Expectancy (HALE)

- *OECD*
- Disability-free life expectancy is the average number of years an individual is expected to live free of disability if current patterns of mortality and disability continue to apply
- it is distinguished: 1.) functional limitation-free life expectancy, 2.) activity restriction-free life expectancy

61. Healthy Life Years (HLY) (Disability-free Life Expectancy)

- *EUROSTAT*
- it measures the number of remaining years that a person of a certain age is still supposed to live without disability
- the indicator is calculated following the Sullivan method; it is based on prevalence measures of the age specific proportion of population with and without disabilities and on mortality data
- Activity limitation data includes a global question on activity limitation known as the General Activity Limitation Indicator

62. Generational imbalance (GI_AGK)

- *Auerbach, Gokhale and Kotlikoff (1991)*
- Generational imbalance is the difference between the present value of net lifetime taxes to be paid by the new-born cohort and the corresponding value to be paid by future generations provided that the new-born will run a life-path drawn by the age profile of net taxes in the base year, whereas future generations will have to pay for (or will receive) the accumulating sustainability gap left behind currently living generations.

63. Implicit pension debt (IPD1: accrued-to-date liabilities)

- *Holzmann, Palacios and Zviniene (2004)*
- 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.

64. Turnover Duration

- *Settergren and Mikula (2006)*
- Turnover duration is a measure of the average amount of time, in years, that the pension system has until it must liquidate a pension obligation earned during the year in question and is calculated as the difference between the earnings-weighted average age of workers contributing to the system and the pension weighted average age of those drawing annuities

- TD reflects the fertility trends and population growth, wage patterns, labour force participation, retirement patterns and mortality.
- $TD = A_r - A_c$
- A_r =benefit-weighted average age of retiree
- A_c =contribution-weighted average age of contributor
- $TD = \frac{V}{C}$
- V (pension liabilities)=the present value of future pension benefits to all persons to whom the system has a liability at the time of evaluation less the present value of future contributions by the same individuals.
- C =contributions (it depends on the size of population by age, the wage pattern, the average wage, the required contribution rate for a financial stable system

65. Accumulated Benefit Obligation (ABO)

- The present value of total pension benefits based on the assumption that the pension plans is to be terminated immediately, applying the pension formula using existing compensation levels.

66. Mean age of earning (A_{yl})

- Lee (1994a), Lee and Mason (2011 a,b)
- Average age at which goods and services are being produced by workers.
- A_{yl} is determined by the age distribution of the population and the age profile of per capita labour income

67. Mean age of consumption (A_c)

- Lee (1994a), Lee and Mason (2011 a,b)
- Average age at which goods and services are being consumed.
- A_c is determined by the age distribution of the population and the age profile of per capita labour consumption

68. Lee's Arrow

Lee (1994a), Lee and Mason (2011 a,b)

- The arrows describe the way resources are shifted across the lifecycle and forward and backward over time.
- Each arrow is plotted with its tail at the population-weighted average age of earning labour income (or making a transfer) and its head at the average age of consuming (or receiving a transfer). The width of the arrow equals the size of the relevant per capita flow.

69. Silver Club

- *Miller (2010)*
- the calendar year when the mean age of effective consumers exceeds the mean age of effective workers

70. Generational imbalance (GI_GS)

- *Gokhale and Smetters (2003)*
- GI measures the amount by which benefits to past and current generations (including prospective benefits of current

generations) exceed their tax payments (including prospective tax payments by current generations) in present value.

- $GI_t = PVE_t^{CO} + PVR_t^{CO} - A_t^{CO}$

  PVE_t^{CO} =the present value of projected outlays that will be paid to current generations

  PVR_t^{CO} =the present value of projected tax revenues from the same generation

  A_t^{CO} =current assets

71. Intergenerationally equitable retirement age

- *Sanderson and Scherbov (2015)*
- The intergenerationally equitable retirement age is based on three criteria:
  - members of each cohort receive as much in pension payouts as they pay into the pension plan
  - the generosity of the pension system, measured as the ratio of average pension receipt to the incomes of people who pay into the pension system, after the pension tax, is the same for all cohort
  - the pension tax is the same for all cohorts
- Criterion (1):
- $\overline{Y_{CH}} \times t_p \times (T_{20} - T_\alpha) = \overline{P_{CH}} \times T_\alpha$
  - $\overline{Y_{CH}}$ =the average annual income of cohort members
  - t_p =the pension tax rate
  - T_{20} =the number of person-years lived from age 20 onward in the cohort's life table
  - T_α =the number of person-years lived from the intergenerationally equitable normal retirement age α onward
  - $\overline{P_{CH}}$ =the average annual pension payment
- Criterion (2):
- $\overline{P_{CH}} = \beta \times (1 - t_p) \times \overline{Y_{CH}}$
  - β = the generosity of the pension system; the ratio of the annual pension payment to the income of people contributing to the pension system, after the pension tax
- Combining the two criteria:
  - $$\frac{T_\alpha}{T_{20} - T_\alpha} = \frac{t_p}{\beta \times (1 - t_p)}$$
- If β and t_p are fixed, this equation determines the intergenerationally equitable normal retirement age α

72. Projected Benefit Obligation (PBO)

- An estimate of the present value of the future liability of an employee's pension. The PBO assumes that the employee will continue to work and make contributions to the pension plan. It

also assumes that contributions will increase as the employee's salary also increases.

73. Benefit/tax ratio

— PVB/PVT=present value of lifecycle benefit/present value of lifecycle contributions

74. Pay-Back Periods (PBP)

— the length of time the representative member of a cohort has to wait after retirement to get back contributions

75. Net Transfer Rate (NTR)

— Net present value of benefits over the present value of life time earnings

76. Implicit tax (IT)

— *Sinn (1997)*
— useful for understanding the general effects of pay-as-you-go pensions for the intergenerational distribution and also for demonstrating the particular impact of ageing on individual who belong to different age-cohorts
— IT=the difference between life-time contributions and old-age pensions at an individual level, both discounted to net present values of some period t.

77. Implicit Pension Debt 2 (IPD2)

— *Holzmann, Palacios and Zviniene (2004)*
— IPD2- projected liabilities of current workers and pensioners – based on the assumption that pension schemes continue their existence until the last contributor dies, while no new entrants are allowed; both the future contribution of existing members and their new rights are therefore allowed under current rules (closed-group method)

78. Implicit Pension Debt 3 (IPD3)

— *Holzmann, Palacios and Zviniene (2004)*
— IPD3 - open system liabilities – same as IPD2 but it also includes the present value of contributions and pensions of new scheme members

80. Net Pension Liabilities

— *OECD*
— *same as the implicit pension debt (IPD3)*

81. Social Security Wealth

— *Feldstein (1974)*
— Present value of expected future social security benefits

82. Contribution Wealth

— Settergren and Mikula (2006)
— Present value of expected future social security contributions

83. General Government Fiscal Balance (GGFB)

— *Leibfritz et al (1995), Roseveare et al (1996)(both OECD)*
— extending the idea of measuring implicit public liabilities to a larger set of activities

- Aim: To examine the impact of demographic changes; assuming that current government expenditure and revenue policies continue

84. Intertemporal Public Liabilities (IPL)

- *Benz and Fetzer (2006)*
- $$IPL_0 = D_0 + \sum \frac{E_j - R_j}{(1+i)j}$$
- IPL comprises the present value of the entire public debt that emerged in the past and will arise in the future

85. Sustainability gap (SG)

- *Bonin (2001), Bonin and Patxot (2004)*
- $$SG = \frac{IPL}{GDP}$$
  - The sustainability gap not only refers to the debt that arose in the past, but also takes into account future liabilities
  - The sustainability gap can be separated into two parts: explicit and implicit debt. The explicit debt refers to the current debt and shows which part of the future liabilities is based on the fiscal policy of the past. The implicit debt displays the present value of all future primary deficits and shows which part of these liabilities is to be expected in the future in view of current fiscal policy.

86. Sustainability tax quota

- *Benz and Fetzer (2006)*
- One possibility to restore sustainability is through a proportional increase of all future taxes and contributions and correspondingly in the tax quota i.e. the tax revenue to GDP ratio.
- Sustainability tax quota measures the required increase in the tax-quota that is needed in order to achieve sustainability
- $$\theta = \frac{IPL_0}{\sum T_j \frac{1}{(1+i)^j}}$$

87. Tax gap indicator (OECD method)

- *Blanchard, Chouraqui, Hagemann and Sartor (1990)*
- evolution of the ratio of debt to GNP depends on two sets of factors:
  - those reflecting current spending, transfer and tax rules, is the primary deficit
  - those reflecting the inheritance from the past, which is the product of the ratio of accumulated debt to GNP times the difference between the real interest rate and the growth rate; if this difference is positive, a primary surplus is needed to maintain a constant ratio of debt to GNP
- „a good indicator of sustainability is one which sends clear and easily interpretable signals, when current policy appears to be leading to a rapidly growing debt to GNP ratio"
- their indicator is defined as the gap between the sustainable tax rate and the current tax rate

- when the indicator is positive, it signals the need for either increases in tax and/or decreases in spending and transfers at some stage in the future
- three indicators are constructed – each associated with a different time horizon
    - short-term gap: is associated with a very short time horizon (namely one year); it can be constructed without the use of forecasts
    - medium-term gap: which relies on projections of activity, government spending and transfers over the following five years
    - long-term gap: which is based on an horizon of 40 years, focusing primarily on the implications of population ageing

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Appendix 2. Notations

1.	Age	X_a
2.	Time	X_t
3.	Year	X_i
4.	based year	Y
5.	Population (total)	N
6.	Cohort	CH
7.	Elderly People 1.	N_{60+}
8.	Elderly People 2.	N_{65+}
9.	Elderly People 3.	N_{70+}
10.	Elderly People 4.	N_{85+}
11.	Elderly People 5.	$N_{65\text{-}85}$
12.	Young People 1.	N_{0_14}
13.	Young People 2.	N_{0_19}
14.	Young People 3.	N_{0_24}
15.	Working-Age Population 1.	N_{15_64}
16.	Working-Age Population 2.	N_{20_64}
17.	Pensioners	P
18.	Workers	W
19.	Full-time equivalent workers	W_F
20.	Non-Workers	NW
21.	Old_Age Pensioners	P_O
22.	Unemployed People	UE
23.	Inactives	IA
24.	People at or above Retirement Age	$N_{RET\text{-}AGE}$
25.	People at or above Min. Age of Eligibility	N_{MINRET_AGE}
26.	Contributors	C
27.	Tax Payers	TP
28.	Beneficiary	B
29.	Population at risk of benefit	$\tilde{B}$
30.	Effective Labour Force	EL

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31.	Effective Number of Customers	EC
32.	Healthy Population	HP
33.	Unhealthy Population	UHP
34.	Population with Disabilities	Di
35.	Population without Disabilities	WDi
36.	Population with Bad Cognitive Functioning	BCF
37.	Population with Good Cognitive Functioning	GCF
38.	Pensions	PA
39.	Old Age Pensions	$P_O A$
40.	Occupational Injury and Disease Related Pensions	$P_H A$
41.	Early retirement for Labour Market Reason	$P_E A$
42.	Services for the Elderly (amount)	SA
43.	Unemployment Benefit (amount)	UB
44.	Active Labour Market Policies (amount)	ALA
45.	Family Allowances (amount)	FAA
46.	Family Services (amount)	FSA
47.	Family Benefits (amount)	FBA
48.	Survivors Benefits (amount)	SBA
49.	Income Maintenance Cash Benefits (amount)	CBA
50.	Incapacity Benefits (amount)	IBA
51.	Educational Related Benefits (amount)	EA
52.	Educational Cost	E
53.	Earnings before taxes	W_G
54.	Annual income	y
55.	Life Expectancy	ϵ
56.	Life Expectancy ≤ 15	$\epsilon_{i \leq 15}$
57.	Life Expectancy in the post retirement period	ε p

58.	Active Life Expectancy	ϵ_1
59.	Money-weighted average age of retiree	A_R
60.	Money-weighted average age of contributor	A_C
61.	GDP	GDP
62.	Tax revenue	t
63.	Pension tax rate	t_P
64.	Pension liabilities	V
65.	Contributions (in pension system)	$\tilde{C}$
66.	Age specific productivity	γ
67.	Age specific consumption	α
68.	Present Value	PV
69.	Discount Rate	r
70.	Government expenditure	E
71.	Revenues	R
72.	Interest payments on the public debt	iD
73.	Public debt	PD

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