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An improved pay-as-you-go pension system, in comparison with a notional defined contribution system: demographic, economic and policy characteristics

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Abstract

NDC (notional defined contribution) pension systems are commonly believed to strike the best balance between the needs and constraints of modern societies (pushing towards PAYG, pay-as-you-go) and the rigour of funding, together with its non-distortionary effects on the labour market.
In this paper, I propose an original solution to the pension problem, which ends up by being similar, but preferable, to NDC: IPAYG, or improved PAYG pension system. Its guiding principle is that "everything is relative", and this is applied consistently to both the economic and the demographic part of the problem. Depending on parametric (policy) choices, an infinite set of IPAYG arrangements is possible. All of them are viable, independently of the economic or demographic evolution, although not all of them are equally good. Optimizations issues, however, or how to select the best version of IPAYG, are not discussed in this paper.

Keywords: public pensions, population ageing, equity, redistribution, Europe

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JEL Codes

H55 Social Security and Public Pensions

H75 State and Local Government: Health • Education • Welfare • Public Pensions

J11 Demographic Trends, Macroeconomic Effects, and Forecasts

J26 Retirement • Retirement Policies

An improved pay-as-you-go pension system, in comparison with a notional defined contribution system: demographic, economic and policy characteristics

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1. Introduction

Pay-as-you-go (PAYG) pensions systems – the only type that I will discuss in this article, neglecting funded systems – are a considerable cause of concern wherever they exist. They were, and are being, created with a long list of good intentions, among which the most important are probably smoothing consumption over the life cycle and combating poverty in old age (Kohli and Arza 2011). Minimizing distortions in related fields, such as labour market participation and fertility (Fenge and von Weizsäcker 2010), or saving (Barr 2002) are also relevant themes, and so are concerns about redistribution, inter- and intra-generational equity, and the gender issue (Bonnet and Geraci 2009; Bonnet, Hourriez and Reeve 2012). Setting up a PAYG pension system is relatively easy, because contributions exceed payments in the first phase. However, keeping it on track once it matures has proved problematic: costs increase rapidly, outlays exceed revenues, and the demographic and economic variables stubbornly avoid all foreseen paths.

Despite their nature of "intergenerational compacts", which would call for fixed, or almost fixed, rules, pension systems have been revised very frequently, especially in times of economic crisis and under the pressure of population ageing (Carone et al 2016, Bonenkamp at al 2017, OECD 2019, Beetsma et al 2020, Guardiancich and Guidi 2020). The formally neutral expression "pension reform" has become a synonym for "tightening of conditions" in the past few decades, with higher contribution rates, lower benefits, later retirement, or a combination of the three. None of these changes is appreciated by voters, characterized by intergenerational selfishness (they care little about future generations; Boeri, Boersch-Supan and Tabellini 2002) and limited financial competence. This attitude is only partly compensated by greater acceptance of less generous conditions among the "financially literate", i.e. those who at least partly realize the problems that pension systems must face, especially in an ageing world (Boeri and Tabellini 2012, Fornero and Lo Prete 2019). Therefore, reforming (i.e., retrenching) pension systems is extremely unpopular, and this explains both delays in correcting them and the fact that adjustments are often just partial and insufficient (e.g. for France, Blanchet, 2020).

There are also exceptions, to be sure. Following an influential World Bank (1994) publication, and the 1980 reform of Pinochet's Chile, attempts were made to revert existing PAYG to pre-funded schemes, but this passage soon proved too costly, and eventually failed (Holzmann, 2017). Besides, the alleged theoretical superiority of funding can be, and has forcefully been, questioned (Barr 2002). The real issues lie elsewhere: they are about production and consumption of goods and services, and how pension systems can help enhance the former and smooth the latter. Ultimately, the issue is the maximization of welfare, although this is a slippery notion when a large number of birth cohorts is involved.

A new wave of enthusiasm emerged in the latter part of the 1990's for the new notional (or non-financial) defined contribution system NDC, which was actually adopted in a few countries (Sweden, Italy, Latvia, Norway, and Poland), and partly introduced in others (Greece). According to some scholars, NDC could become the EU standard, with a parametric diversification between nations that, among other advantages, would be consistent with the EU motto: "United in diversity" (Holzmann 2006, 2017).

In this paper, I will present an alternative to NDC, the "improved" PAYG pension system, IPAYG, which, as I show below, has all the merits of NDC, but performs better in a few respects, including the usually oversimplified demographic sphere. Section 2 briefly recalls the essential characteristics of NDC, section 3 introduces the IPAYG, and section 4 compares the two. In section 5, I discuss a few selected issues and some possible variants of IPAYG, with their pros and cons. In section 6, I present my conclusions.

2. NDC (Notional defined contribution) pension schemes: a reminder

NDC pension schemes mimic funded systems. Workers pay their (predefined) contribution into the system during their employment years, and accumulate a "virtual" capital. Their money is not really "stored" or invested: as the system is PAYG, current contributions are used to pay current pension benefits. However, due note is taken of past contributions, which after re-evaluation with a "proper" rate of interest, transform into a virtual capital K_s by the time workers (now "seniors", in my terminology and symbols) take their retirement, at age β (e.g., 65 years)

This virtual capital is then converted into an annuity (or yearly pension benefit for each senior, P_s) with a formula of the following kind

1) $$P_S = \frac{K_S}{e_\beta}$$

where e_β is life expectancy at retirement, or the average number of remaining years of life for those who retire at age β. Actual formulas are more complicated than (1), because they take into account additional elements (e.g., interests accruing on the not-yet used part of their virtual capital, survivors pensions, floors and ceilings), but I will skip these details here.

The main reasons why NDC pension systems are so popular among economists (less so in real life) are the following:

a) they introduce flexibility in the retirement age: the later workers leave the labour market, the more they have contributed (higher virtual capital K_s), the shorter their life as retirees (lower e_β), and the higher their yearly pension benefit P_s. This feature constitutes as a remarkable progress compared with once-widespread practices that penalized later retirement and encouraged early labour market exits, sometimes with the unwarranted hope that this would help curb youth unemployment (Gruber, Milligan and Wise 2010);

b) they aim at a strict and clear correspondence between contributions and benefits, again, a notable improvement over several alternative systems, typically very opaque, and sometimes even anti-redistributive, taking from the poor and giving to the rich. Noncompliance with fiscal laws now becomes less attractive, because contributions not paid today become lower pension benefits in the future;

c) they are (believed to be) viable by definition: if everybody takes back in benefits as much as they have put in as contributions, there cannot be imbalances between revenues and outlays (more on this below);

d) they are at least partly protected from the "political risk", i.e. a change of rules that, possibly under the umbrella of "urgency and necessity", may disrupt the system, favour some groups at the expenses of others (typically, future generations), and undermine trust in the intergenerational compact.

While NDC pension systems improve over most other theoretical or actually existing PAYG pension arrangements, they too have their shortcomings:

A) Revenues and outlays do not match on a yearly basis, and it is far from obvious that they do so in the long run. Apart from the implementation phase, which I will not discuss here, there are four main reasons for this possible (actually, practically unavoidable) imbalance: i) quasi-capital gains and losses; ii) life tables, iii) interest rates and iv) re-evaluation criteria. Let us briefly consider each of them.

   i) <u>Quasi-capital gains</u> have been identified long ago (Lee 1980), but they are frequently forgotten in the pension debate. They are given by the following formula:

2) $$\textit{Quasi capital gain} = P \cdot \Delta age \cdot \Delta S$$

where P = average pension benefit, Δage = difference between two average ages: at receiving benefits and at paying contributions; ΔS = variation in the number of seniors (pensioners), which can be negative in case of population decrease and create quasi capital losses. As Δage

is large (about 40 years), even small demographic variations translate into very large quasi-capital gains or losses.

ii) Life tables are an essential, if underrated, element of the pension conundrum, also in its NDC variant. Workers who retire at age β (e.g. 65 years) will survive for several years, about 20 on average, but the exact number is unknown at the time of retirement, when equation (1) is applied. The correct denominator e_β must be replaced by an estimate $\hat{e}_\beta$: when this proves incorrect, as it invariably does, imbalances emerge.

iii) Interest rates enter the picture because they concur to the determination and the evolution of the virtual capital K_s. As this is accumulated over the entire working life of a person (say, between 20 and 65 years) and is used little by little after retirement, even small mistakes in the choice of the interest rate may result in an imputed value $\widehat{K}_s$ that differs significantly from its correct counterpart, in equation (1). Once again, this leads to imbalances.

iv) Re-evaluation criteria of pension benefits also matter. Equation (1) is normally used to determine the initial amount of an annuity, but this must be paid for several years. Subsequent instalments are usually calculated starting from the first pension benefit and re-evaluating it, on the basis of some criteria (inflation, labour productivity, salary mass, ...) the choice of which may lead, in the long run, to a wide range of different results – and create imbalances in the system.

That revenues do not match outlays in an NDC pension system is so evident that a buffer reserve fund is frequently advocated in theory (Holzmann 2017), and may exist in practice (e.g. Sweden). The idea is that when this reserve fund shrinks, some corrective action must be taken, e.g. in the form of a proportional reduction of all pension benefits, to restore equilibrium.

B) Actuarial equity is the explicit aim of NDC schemes and it is fairly well approximated in practice, even if points *i*) to *iv*) above lead not only to imbalances but also to hidden forms of actuarial inequity. However, public pension systems may, and in fact do, pursue also other objectives, the first being redistribution from the rich to the poor (let us call this "social equity"), at least in the form of a minimum pension benefit. This facet must be inserted in NDC pension systems with ad hoc arrangements, not necessarily clear, consistent with the rest of the scheme, financially viable, or resistant to policy interventions (Holzmann 2017).

C) A reasonable ratio must exist between the standard of living of the average pensioner and that of the rest of society. This "cross-sectional equity", as I will call it, is usually measured ex-post, with an indicator known as replacement rate, of which unfortunately several versions exist: e.g. P/W and, in the OECD (2019) version, P/y (average pension benefit P divided by the average gross labour earning W, or by per-capita income y). For the sake of simplicity, let us consider only the case of an economic downturn, such as the financial crisis of 2008, or the current one, caused by the COVID-19 pandemic, and let us compare only two groups, the retirees and the adult population. A system that protects the old regardless of what happens in the labour market (unemployment, fewer hours worked and lower wages, etc.) is scarcely justifiable, and creates a blatant cross-sectional inequity: the retirees are relatively well off, at the expenses of the rest of society. Ad-hoc policy measures may be introduced to restore cross-sectional equity, but this is likely to create conflict, may well undermine the general logic of the system, and is in all cases at odds with the claim that NDC is immune to political risk.

D) The rich live longer than the poor. As pension systems transfer resources from the adult to the old years, they favour long-living population subgroups, who are often also better off economically (e.g. Bosworth and Burke, 2016). Corrective measures may be, and indeed are, advocated: however, their identification and integration into NDC may be problematic.

E) The standard (or minimum) retirement age β_t is chosen for the starting year *t*. However, as mortality changes over time, β_t should probably move, but NDC says nothing about this, and various solutions are possible – including *ad hoc* political interventions, not necessarily consistent with the original scheme.

In the light of these shortcomings (A to E), it may be worthwhile to consider an alternative: the improved PAYG pension system (IPAYG) described below, which, I contend, although following a different logic, ends up by being similar to NDC, but slightly better, as shown in Section 4.

3. The improved PAYG (IPAYG) pension system

3.1 How the system works

The proposed system (IPAYG: improved pay-as-you-go), of which I will present only the simplest possible version, distinguishes between three types of variables:

- policy choices, which become parameters in the 0-1 range, after they have been agreed upon. There are five of them. Ideally these could (and in my opinion should) remain constant over time, although changing them is always possible – see Section 5,
- exogenous variables, varying over time, of which six are the most important
- endogenous variables, determined by the joint action of the policy choices and the exogenous variables mentioned above. These are time-dependent. I will focus on 15 of them.

The five policy variables that must chosen (thus becoming constant parameters) are:

1) The *proportion* of life that the average individual spends as a young Y^*

2) The *proportion* of life that the average individual spends as an old person (or senior) S^* (of course, the average proportion of life spent as an adult is $A^*=1-Y^*-S^*$)
3) The *relative* amount of resources that the system transfers to the young y
4) The *relative* amount of resources that the system transfers to seniors s
5) The relative importance attributed to actuarial equity (Q) and to redistribution ($1-Q$) in the transfer system.

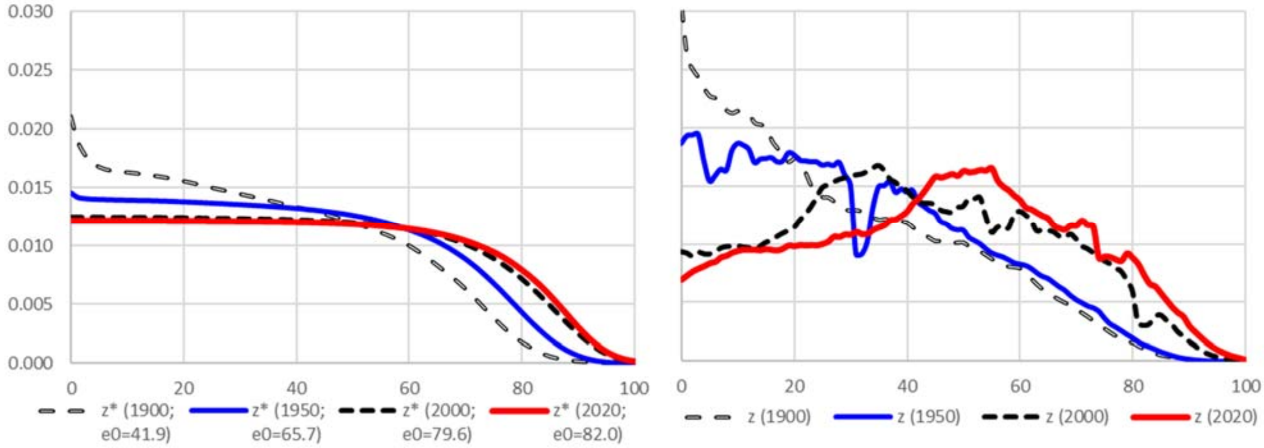
The six exogenous variables (the values of which must be known and updated each year t), are:

a) Survival conditions. These can be simplified in the latest cross sectional life table, one column only of which is of interest to us: the years of life lived $L_{x,t}$, or, more precisely, the transformed series $z^*_{x,t} = \frac{L_{x,t}}{T_0}$, giving the relative weight of the $L_{x,t}$ (in a life table, $\Sigma_x L_{x,t} = T_0$);
b) The age structure of the population $z_{x,t} = \frac{I_{x,t}}{I_t}$, i.e. the relative weight of persons (inhabitants) of age x, $I_{x,t}$;
c) The employed E_t (absolute number)
d) The average gross labour earning of the employed $W_{e,t}$;
e) The virtual capital of each of the seniors S, $K_{s,t}$. This is the same as in equation (1); however, while in the NDC pension system this figure is needed only once, at retirement, in the IPAYG pension system these variables need to be known and updated every year,
f) along with their average $K_t = \frac{\Sigma_s K_{s,t}}{S}$.

Based on these (5+6=) 11 variables, or parameters, all the dependent variables can be determined. Not all of them can be expressed with a formula: four derive from a manipulation of two series, $z^*_{x,t} = \frac{L_{x,t}}{T_0}$, and $z_{x,t} = \frac{I_{x,t}}{I_t}$, which form empirically. $L_{x,t}$ is the series of years of life lived in a (in this case, cross-sectional, in year t) life table, and is also the corresponding stationary population by age x: it is determined exclusively by current survival conditions. $I_{x,t}$ is the age distribution of the population, observed in year t. Both are systematically and readily produced by national statistical institutes: Figure 1 displays these series in selected years for Italy, which I am using here as an example because it was one of the first countries to introduce NDC, back in 1995.

Figure 1 – Years of life lived (a) and population by age, % distribution, Italy, 1900, 1950, 2000, 2020

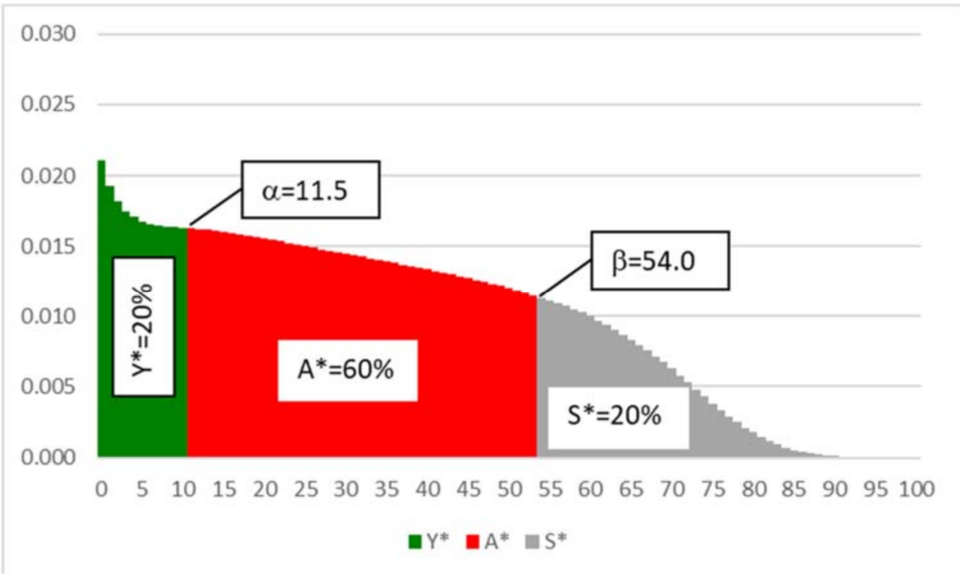
Panel a) z_x^* ***Years of life lived (% distribution)*** ***Panel b:*** z_x ***population by age (% distribution)***



Source: HMD and Istat (for 2020)

For the sake of the argument, let us assume that the first two policy choices are Y*=20% (average share of life spent as a young), S*=20% (average share of life spent as a senior), and therefore A*=60% (average share of life spent in adulthood), and let us focus on a specific year, e.g. 1900. Working on the $L_{x,1900}$ (or $z^*_{x,1990}$) series (Figure 1.a), the threshold ages α (separating the young from the adult years) and β (separating the adult from the old years) can be determined in such a way that the proportions Y* and S* turn out to be exactly the desired ones, as in Figure 2.

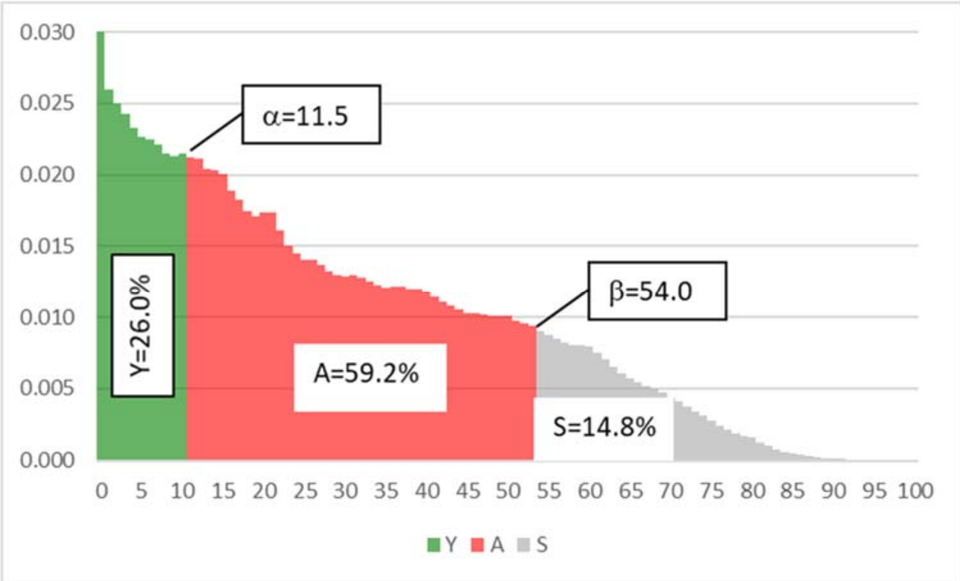
Figure 2 – Years of life lived, threshold ages α and β, and average shares of life spent as a young Y*, as an adult A* and as a senior S*. Italy, 1900 (when life expectancy at birth was e_0***=41.9)***



Source: HMD and author's calculations.

These threshold ages α_t and β_t must then be applied to the actual, current age structure $l_{x,1900}$ (or $z_{x,1900}$), to derive the shares of young Y_t, adult A_t and seniors S_t in the population, as in Figure 3.

Figure 3 – Threshold ages α and β, and relative weight of the young Y, adult A and senior S population. Italia, 1900 (e_0=41.9)



Source: HMD and author's calculations.

Once the proportions Y_t, A_t and S_t are known (three more dependent variables), the current (equilibrium) contribution rate can be calculated

3) $$c_t = \frac{s \cdot S_t + y \cdot Y_t}{A_t + s \cdot S_t + y \cdot Y_t}$$

where *s* and *y* are our policy parameters, on how *relatively* generous the system is towards the seniors (pension benefits *s*) and the young (child benefits *y*; see the appendix for the details).

It is also worthwhile to compute the *reference*, constant contribution rate

4) $$c^* = \frac{s \cdot S^* + y \cdot Y^*}{A^* + s \cdot S^* + y \cdot Y^*}$$

This is not normally used, but it may serve as a benchmark to assess whether the level of the actual (and variable) contribution rate is relatively high or low. c_t and c^* are two more dependent variables, which, of course increase when the system is "generous" towards its young and old component, either in terms of transfers (*y* and *s*) or in terms of shares of life (Y^* and S^*). Everything else equal, c_t increases in phases of demographic ageing (due, for instance to low fertility).

Given not only the share A_t but also the absolute number of the adult population $[A_t]$ (another dependent variable) and the employed E_t (exogenous variable), the employment rate ε_t can be obtained

5) $$\varepsilon_t = \frac{E_t}{[A_t]}$$

This rate (a dependent variable) is usually not far from 2/3 (e.g. Goodhart and Pradhan, 2020). Multiplied by the average gross labour earning of the employed $W_{e,t}$, it gives the average gross labour earning of the *adult* population $W_{a,t}$, which is not only another dependent variable, but also, to the best of my knowledge, a new concept in this (or any other) field, the utility of which will emerge shortly

6) $$W_{a,t} = \varepsilon_t \cdot W_{e,t}$$

As the current contribution rate c_t is known from equation 3, the net average labour earning of the adult population $N_{a,t}$ emerges as

7) $$N_{a,t} = (1- c_t)W_{a,t}$$

This additional dependent variable is the *economic numeraire* of the system, to which the policy choices s and y must be applied, to obtain the average pension benefit P_t

8) $$P_t = s \cdot N_{a,t}$$

and the child benefit B_t

9) $$B_t = y \cdot N_{a,t}$$

While B_t is the same for every young person (and can be zero, if y=0), pension benefits vary, depending on past contributions, synthetized in the virtual capital of each senior $K_{s,t}$, with average K_t. Individual pension benefits will be paid according to the following formula

10) $$P_{s,t} = QP_t \frac{K_{s,t}}{K_t} + (1 - Q)P_t$$

This formula satisfies two basic requirements:

a) the average of all pension benefits $P_{s,t}$ is exactly the quantity P_t of equation (8), thus granting budget balance in every year t (see appendix), and

b) individual pension benefits reflect the exact degree of actuarial equity Q and redistribution (1-Q) that society prefers. When Q=0, $P_{s,t}$=P_t: all pension benefits are the same, regardless of past contributions (Beveridgean corner solution). Conversely, when Q=1, $\frac{P_{s,t}}{P_t} = \frac{K_{s,t}}{K_t}$: individual pension benefits are proportional to individual virtual capitals (full actuarial equity; Bismarckian corner solution). Intermediate solutions are possible, and in my opinion preferable: they depend on the policy choice Q ($0<Q<1$), which determines also the minimum pension benefit $P_{min,t}$=(1-Q)P_t.

Table 1 reports and classifies all the variables (or parameters) at play, highlighting when they come into play.

Table 1 – List and classification of the relevant variables in an IPAYG pension system

Step	Policy choices (parameters)	Exogenous variables	Endogenous variables
1	Y^*, S^*		A^*
2		$\mathbf{L}_{x,t}$	α_t, β_t
3		$\mathbf{I}_{x,t}$	$Y_t, A_t, S_t, \lvert A_t \rvert$
4	y, s		c_t, c^*
5		$E_t, W_{e,t}$	$\varepsilon_t, W_{a,t}, N_{a,t}, P_t, B_t$
6	Q	$\mathbf{K}_{s,t}, K_t$	$\mathbf{P}_{s,t}$

Note: x=age; t=time. Bold denote vectors. For the meaning of the symbols, see text.

3.2 Philosophy of the IPAYG system (or why it works)

Understanding the rationale of IPAYG is not so easy, in part because, depending on policy choices, it can take very different configurations, with early or late retirement, high or low average benefits, prevalence of redistribution or actuarial equity, inclusion or exclusion of child benefits, etc.

The single most important element of IPAYG is that everything is relative. Transfer promises, for instance, are not absolute: the future is unknown and the best that can be done is to spread the related risk to the entire society, guaranteeing that the *relative* economic position of the average pensioner (and of the young) will remain constant, at the s and y level explicitly chosen by society.

This position on the economic ladder is defined in relation to $N_{a,t}$ (equation 7), which is the numeraire of the system, because it encompasses all that may possibly affect the economic performance of society or, better, of the part of it that refers to the labour market. $N_{a,t}$ is the product of three factors: the employment rate ε_t and the average gross labour earning $W_{e,t}$ (equation 6) focus on the economic part of the story, while the third factor (1- c_t) reflects the demographic situation (population ageing) weighted with policy choices on the relative generosity of the system towards the non-working age classes, Y and S.

What can happen? Price variation, for instance, inflates all monetary variables, including wages and transfers, and proves neutral. All changes in unemployment and participation rates are captured by the employment rate ε_t. Labour productivity and wages $W_{e,t}$ will likely change, and $N_{a,t}$ will immediately follow suit. Population ageing, with its connected greater burden of pension obligations, transforms into a higher contribution rate c_t, which lowers $N_{a,t}$ and P_t (and B), everything else equal.

The same principle, everything is relative, applies to the length of life, whose future variations are unknown, both by amount and direction. Until recently, even the best demographers have systematically underestimated survival progress (Castiglioni, Dalla-Zuanna, and Tanturri 2020); the current COVID-19 pandemic, instead, reminds us that progress is not guaranteed. While we ignore what the future holds, we can decide to stick to fixed *proportions* of life to be spent in the three basic (socially defined) states envisaged by the system: young, adult and old (senior). This can be done using the latest cross sectional life table (or, better, an average of the latest T, e.g. three or five) as an approximation of the "normal" duration of life in that contest (country and period). While not perfect, this solution is very practical (life tables are routinely and timely produced by national statistical institutes), and all possible mistakes are promptly adjusted, as soon as a new life table is produced.

The definition of the three age classes serves one purpose only: the adult population cannot benefit from this type of intergenerational transfers, while the young and the old can, and, in relative terms, they will receive just as much as society has decided (y and s, respectively). Of course, a generous transfer system affects the contribution rate, which increases both in its actual and in its reference values (c_t and c^*, respectively).

Past age β, or before age α, working is not prohibited or discouraged. Nor is it "taxed" differently depending on age: in all cases, contributions are paid at rate c_t, and future pension benefits will correspondingly increase, along with individual virtual capitals K_s.

Precisely because everything is relative in IPAYG, the system is always in equilibrium: come what may, contributions match outlays, every year (see appendix). This implies, among other things, that there is no need for forecasts or projections of any kind: the relevant elements are either policy choices (i.e., fixed parameters) or observed (not predicted) variables.

Explicit child benefits are not generally observed in pension systems (despite the indications of some economists: e.g. Cigno and Werding 2007, Fenge and von Weizsäcker 2010, Fenge and Scheubel 2017). However, they exist in most modern welfare systems and their equivalent can be found also in several pension systems, e.g. in the forms of extra pension benefits granted to parents (see, e.g. Bonnet and Rapoport, 2020, for the French case).

Note, first, that this is merely an option: if $y = 0$ (policy choice), child benefits disappear. However, there are at least five good reasons to include them (i.e., to choose $y>0$ and thus set up a truly intergenerational transfer system): a) reduction of quasi-capital gains and losses; b) contrast to the implicit fertility-discouraging effect of all (credible) pension systems; c) redistribution; d) consistency; e) stabilization of c_t. Let us briefly examine each of them.

a. We have already discussed quasi-capital gains and losses (equation 2). If the system transfers resources also to children, and not only to seniors, the average age at receiving benefits declines, and so do Δage and quasi-capital gains and losses. The economic effects of demographic variations are correspondingly attenuated.
b. Children are costly, but they are also an asset in one's old age, and this is one of the reasons that keep fertility high in developing countries (see Rossi and Godard 2019

for a recent application, and a literature review, of this old notion). When alternative forms of economic support in old age are available, such as a good pension system, fertility is correspondingly discouraged. Child benefits are therefore arguably useful in a pension system, to counter its own fertility-depressing effect.

c. Contributions are paid in proportion to labour income, but child benefits are paid in an identical, flat amount to rich and poor children. In other words, child benefits are redistributive by nature and this feature can be used, together with (1-Q), to introduce the desired degree of redistribution in the transfer system.

d. The ultimate reason why pension benefits exist at all is that there is an age β (e.g. 67 years) beyond which it is considered socially acceptable (or even natural) not to have an occupation – and yet be entitled to some resources. The same logic can be applied to the young, who, up to a certain age α (e.g. 16 years) are not expected to work, but who nonetheless need resources to survive. In other words, with proper policy choices (y>0) consumption smoothing in IPAYG may work also "backwards": the system lends resources that the initially young beneficiaries will repay later on, with contributions taken from their future labour earnings.

e. The equilibrium contribution rate c_t varies over time. However, its variability is lower when child benefits are introduced, because in this case both terms in the numerator of equation (3) matter, and they tend to move in opposite directions. For instance, in periods of demographic ageing there are more elderly but fewer youngsters: this stabilizes c_t (see also Table 3).

In the IPAYG pension system, ageing "from above", as it is sometimes called, i.e. ageing caused by longer survival is (virtually) excluded. Longer life spans translate immediately and automatically into an increase of the threshold ages α and β which, by construction (equation 4) leaves the reference contribution rate c* unchanged. Transitory and minor effects on the actual contribution rate c_t may emerge, but we will ignore this detail here. What remains is ageing "from the middle" (caused by out migration) and especially "from below", caused by low fertility. As for migration, the effect is, at most, of second order (again, not shown here), and in all cases developed countries are currently net receivers of migrants, which means that they benefit from a (modest) demographic rejuvenation from these movements. Low fertility instead is a serious issue, the solution to which cannot be asked of a pension system. However, with IPAYG a cautious step in the right direction can be taken with the introduction of child benefits, whose main rationale, as mentioned, is countering the fertility-depressing consequences of a good pension system.

4. Comparing NDC to IPAYG

Notional defined contribution systems (or NDC) are often considered the best possible pension arrangement, for two main reasons:

- they mimic funded systems, but do not need to accumulate a large capital (strictly speaking, they need no capital at all, as they work on a PAYG basis), and
- they ensure actuarial fairness, creating a close correspondence between payments and benefits, thus reducing the incentive to evade contributions (e.g., to work in the underground economy), or to retire too early.

As for the age at retirement, an ancillary advantage is that NDC can start paying pensions at various ages, adjusting benefits in such a way as to be actuarially neutral: longer working careers are not discouraged. Finally, NDC is relatively easy to introduce, if a different type of PAYG pension system is already in existence.

All these advantages apply also to the proposed IPAYG system, which, in addition, does not suffer from the four main shortcomings of NDC listed at the end of section 2. Let us see why.

A) Revenues and outlays are identical, by construction (see eq. A.1 in the appendix), because the time-varying contribution rate c_t adapts automatically to the current demographic situation, increasing in line with the share of the "relevant" dependent population (i.e., the old and, if child benefits are included, the young). The effects of these demographic variations on the contribution rate c_t are discussed in section 5. As budget balance is always guaranteed on a yearly basis, the system is viable by construction, and can be maintained unchanged forever (although modifications are possible: see section 5). Besides:

i) <u>Quasi-capital gains</u> and losses can be drastically reduced with the introduction of child benefits and the corresponding reduction of Δage in equation 2.

ii) <u>Life tables</u> are no longer an issue, together with the never-ending debate on which to use: cross-sectional (readily available, but not necessarily representative of what will happen to cohorts) or longitudinal life tables (which will be known only when a birth cohort is extinct). With IPAYG the problem vanishes: the system uses only cross-sectional, observed life tables, but updates this information every year, each time adjusting threshold ages, and, consequently, population shares and contribution rates.

iii) <u>Interest rates</u> do not enter the picture. IPAYG never uses them. Closer scrutiny reveals that there is an implicit (or natural) interest rate, which is the rate of variation of the numeraire of the system (the quantity $N_{a,t}$ – not shown here). The important point, however, is that it is not needed for the functioning of the system.

iv) Re-evaluation criteria are never needed. Individual (pension and child) benefits are determined each year with equations (8) and (9), and they evolve in line with the numeraire $N_{a,t}$.

B) Apart from the redistributive effects of child benefits, actuarial equity can be perfect (if Q=1), totally absent (if Q=0), or anywhere in between (if 0<Q<1). Within IPAYG, this policy choice is made explicit. In this, as in any other respect, the proposed IPAYG system is fully transparent.

C) Cross-sectional equity (i.e. a reasonable and socially accepted ratio between the average incomes of the three age groups, young, adults and seniors) is a relevant socio-economic aspect that no other pension system, to the best of my knowledge, keeps under control by design. IPAYG does, with the parameters s and y (benefitting seniors and young, respectively). Unless explicit change is introduced, cross-sectional equity will remain forever at the socially preferred level, in all economic and demographic scenarios.

D) The rich live longer than the poor, and this leads to anti-distributive effects in all pension systems based on pure actuarial equity (see, e.g. Sanchez-Romero, Lee and Prskawetz 2020; Haan, Kemptner and Lüthen 2020). With IPAYG, however, redistribution can be integrated into the system, and "fine-tuned" to attenuate or even reverse this effect: with Q<1, with y>0, or, better, with a combination of the two.

E) With NDC it is not so clear how the standard (or minimum) retirement age β_t should evolve over time. Conversely, it is with IPAYG: in combination with α_t, β_t should evolve in such a way that the policy choices Y* and S* (and therefore also A*) remain constant over time. (See also the next section.)

5. Details and a few possible variants of IPAYG

5.1 On the evolution of α and β (threshold ages) over time

Within IPAYG, the "natural" evolution of the threshold ages α and β is the one introduced above: they follow survival, in such a way that the average shares of life spent in the three states (young, adult and old, or, in symbols, Y^*, A^* and S^*) remain those preferred by society. For instance, in the case of Italy, and assuming that the policy choices are Y*=S*=20% (and therefore that A*=60%), in the past 119 years, threshold ages should have evolved as shown in Table 2.

Table 2 – Life expectancy, threshold ages and shares of young, adult and senior population if Y*=S*=20% and A*=60%. (Example referred to Italy, 1900-2020)

	1900	1950	2000	2020
e_0	41.9	65.7	79.6	82.0
α	11.5	14.3	16.0	16.5
β	54.0	60.0	65.5	67.0
Y	27.1%	25.4%	15.3%	14.4%
A	58.0%	62.5%	67.1%	65.8%
S	14.9%	12.0%	17.6%	19.8%

Source: HMD, Istat (for 2020) and author's calculations.

Note that nothing is projected, or forecasted, in this table or in the entire IPAYG system: all dependent variables (α_t, β_t, Y_t, A_t and S_t, in this case) derive from policy choices (Y^* and S^*) or independent variables (cross sectional life tables and population by age), and all adjustments are automatic.

Note also that $Y_t \neq Y^*$, $A_t \neq A^*$ and $S_t \neq S^*$. This happens because the reference values, with an asterisk, are constant in this example (my preferred choice, incidentally), while the corresponding actual variables change every year. The distance between the two may be relatively large in certain historical periods (demographic transition, very low fertility nowadays, etc.) but it declines once these turbulences are over. Besides, simulations (not shown here) indicate that this distance tends to diminish even further in all "standard" (i.e., not extreme) scenarios, which suggests that reference values are very close to the long term average of their corresponding real homologues. However, even if they were not, the system would not be affected: it would simply work with a less-than-optimal combination of policy parameters.

Several objections may be raised at this point. One, for instance, is that relying on a single cross-sectional life table may lead to unacceptable "jumps" in the threshold ages. While theoretically correct, this objection is not very compelling in practice, because life tables change very slowly in all developed countries. In all cases, some smoothing mechanism is certainly to be recommended, such as a moving average over the past three or five years: I have thus far referred only to the latest life table for reasons of simplicity.

Another possible objection is that there is no need to adjust both α_t and β_t: it may suffice to let only the latter vary (β_t, the retirement age), which, incidentally, would contribute to reduce its increase, when e_0 improves. While this is a perfectly acceptable alternative policy choice, it is logically and historically inconsistent. Logically, because if the collectively preferred shares of life in the three states (Y^*, A^* and S^*) are independent of e_0, variations in e_0 should not affect them. If, instead, these policy choices depend on e_0, this relation should be made explicit, and the ensuing rules applied. Historically, this decision appears inconsistent because, with the expansion of the average length of life, the young have delayed their entry into the labour market and prolonged their education, by much more than the increase of α_t in Table 2.

Another possible objection is that people dislike uncertainty, while the proposed arrangement apparently introduces a lot of it. For any given senior, for example, pension benefits $P_{t,s}$ may vary from year to year, depending on $N_{a,t}$ and on K_t, even if the senior's personal virtual capital $K_{t,s}$ remains unchanged (equations 8 and 10). Similarly, retirement age β_t evolves over time in a way that individuals are probably incapable to predict. For instance, with reference to Table 2, young workers first entering the labour market in 1950 (e.g., at 10 years, which was possible back then) may well plan to retire at 60 years (which was correct, by the standards of 1950), but in fact, when they reach 60 years of age, in 2000, they find that the retirement age has been postponed, to more than 65 years. The objection is poorly phrased, however. Uncertainty is in the nature of things, both in economic and demographic terms. IPAYG keeps uncertainty under control as much as possible, by immediately spreading the effects of unforeseen changes to all society. For instance, it is true that the numerical value of both variables ($P_{s,t}$ and β_t) varies over time, but it is precisely these variations that preserve the substantive value of both pension benefits (which move in line with the numeraire) and the standard retirement age, given the current survival conditions. As for the retirement age, if people accept (actually, do their best) to live longer, they should also be prepared to work more years: in IPAYG the two quantities (length of life and length of adult life) evolve consistently: "extra" years of life are apportioned between work and leisure exactly as "base" years were (i.e., before the improvement in survival).

In all cases, it is always possible to buy an annuity in the private market, to cover the "uncertain years". For instance, let us refer to our hypothetical workers who entered the Italian labour market at age 10, in 1950 and planned to retire at 60 years. They may buy the right to do so privately: they start paying a premium in 1950, or shortly after, and acquire the right to receive a benefit between 60 and β years. β_{2000} is unknown in 1950, and this is where insurance companies step in: when year 2000 arrives, our workers, now aged 60 years, will start to receive their private annuity, which will expire five or six years later, in 2005/6, when our workers (now retirees) reach 65/66 years, the retirement age of the time.

The market for "standard" (i.e. lifelong) private annuity is relatively thin and costly, for several reasons, among which the great uncertainty that surrounds the length of individual lives. This uncertainty is increased by self-selection: it is mainly those who have reasons to believe that the will live longer than average who have an interest in such products (Lambregts and Schut 2020). In the case of IPAYG, instead, self-selection plays no role, and uncertainty is greatly limited. The unknown variable is a collective, not an individual one (e_0) and it translates into β (age at retirement) only partially. For instance, in Table 2, between 2000 and 2020 e_0 increases by 2.4 years, but β increases by 1.5 years only.

Another possible objection is that with NDC, workers can retire when they please (past a minimum age, of course), and their pension benefit will be adjusted in an actuarially fair way, following equation (1). While this is possible, I would not recommend it, because it would make the system less transparent, more difficult to manage, more costly and, ultimately, worse. It would also invade a field that I think belong more correctly to private insurance companies. Finally, it would be of much less utility than commonly believed: with IPAYG, pension benefits start to be paid at age β, but workers can retire at *any* age. If they retire before age β, the private arrangement illustrated above will help them cover their needs during the "intermediate" years (between retirement and age β). If they retire later, for some time (the years between β and retirement) they will receive a double income, from the labour market ($W_{s,t}$, on which they will pay pension contributions, remaining with $N_{s,t}$,) and from the pension system ($P_{s,t}$).

5.2 On the variability of the contribution rate c_t

One of the reasons why budget balance is always guaranteed in IPAYG is that the contribution rate adjusts automatically to the demographic situation, preserving the socially preferred cross sectional equity (constant y and s). It may be objected that this creates uncertainty on the cost of labour, and may therefore negatively affect the functioning of the labour market. While this is true, of course, equation (3) shows that an increase in the contribution rate c_t, given y and s (cross-sectional equity) merely reflects a worsening of the demographic situation, typically population ageing. This is what makes society worse off, and if the corresponding costs were not made explicit (through higher c_t) they would manifest themselves in other forms, e.g. (outside the logic of IPAYG) through lower pension benefits or greater public debt.

As the contribution rate varies over time, it is theoretically possible to determine its long-term average (which turns out to be very close to c^* – not shown here), and impose that constant contribution rate, instead of the varying one. This creates a reserve fund that will expand in demographically favourable periods and shrink in others, with surpluses and deficits that will roughly cancel out the long run. This, incidentally, is what happens in almost all actual pension systems, where both the contribution rate and the rules that lead to the formation of pension benefits are constant – at least until the pension debt remains manageable.

As with existing pension systems, however, this solution (constant c_t) has two main downsides. The first is that the real long-term average of c_t is unknown *a-priori*: it will emerge only several years later, when it is too late to correct past mistakes. The second, and more important, is that even if the exact value for this average is chosen (very close to c^*), demographic imbalances may be strong and last for several decades (demographic inertia). As the sums that are involved in the pension game are huge, even small relative imbalances are sizeable in relation to the GDP of any country. If these imbalances are reiterated for several decades, as it usually happens, the corresponding debt (or accumulated capital) rapidly becomes unmanageable.

An illustrative example is shown in Table 3, where, for the sake of the argument, I have expanded the case of Table 2, introducing two possible scenarios regarding cross sectional equity. In scenario A, there are no child benefits (y=0) and transfers towards the elderly are generous (s=0.8). In scenario B, child benefits are envisaged (y=0.2), but transfers towards the elderly are reduced (s=0.6), in such a way that the reference contribution rate remains the same (c*=21.05%). Over time, the actual (equilibrium) contribution rate c_t varies. In periods of demographic bonus (favourable age structure, with high share of adult population), c_t is below its reference value c^*, even largely below it (e.g. 1950). Notice that this favourable period has lasted for more than a century, but is practically over nowadays: according to all demographic forecasts, it will be followed by an (almost) equally long period of demographic "malus", when $c_t > c^*$.

This tells us three things. The first is that demographic phases can be exceedingly long by "human" (political or economic) standards, and their cumulated consequences may easily grow out of control. Second, the comparison between c_t and c^* reveals how good (or bad) the demographic phase is. Third, c_t varies over time, but much less so when child benefits are introduced: the standard deviation of c_t is about half as large in the latter case (Table 3). This happens because, while the relative share of the adult population tends to remain approximately constant, Y_t and S_t (shares of the young and seniors, respectively) may vary considerably, but they typically do so in opposite directions. If non-trivial child benefits are included in the intergenerational transfer system, the variability of the equilibrium contribution rate diminishes substantially.

Table 3 – Reference and actual contribution rate in two scenarios, with different policy choices regarding cross-sectional equity (y and c) (example referred to Italy, 1900-2020)

	1900	1950	2000	2020	Std.dev. of c_t
		Scenario A) y=0; s=0.6			
c^*	21.05%	21.05%	21.05%	21.05%	
c_t	17.04%	13.34%	17.36%	19.39%	*2.18%*
		Scenario B) y=0.2; s=0.6			
c^*	21.05%	21.05%	21.05%	21.05%	
c_t	19.83%	17.02%	18.51%	19.74%	*1.14%*

Note: This is a prosecution of the example of Table 2.

5.3 Varying policy choices?

With IPAYG, well-pondered policy choices may remain unaltered forever: the system is auto regulating, always in equilibrium, with outlays equalling contributions. Besides, it will always preserve its initial, socially preferred characteristics, in terms of shares of life spent in the three states (Y^*, A^* and S^*), cross-sectional equity (y and s), and compromise between actuarial equity and redistribution (joint action of y and Q). In other words, changes are never needed and the "political risk" (Barr 2002) is minimized.

Change is possible, of course, but it has its downsides, much in the sense indicated by Auerbach, Gokhale, and Kotlikoff (1994). Although the system is organized on a PAYG basis (i.e., it works cross-sectionally), it does have cohort implications. Simulations (not shown here) indicate that the IPAYG system works well also by cohorts: it tends to guarantee intergenerational equity. When this is impossible, because of quasi-capital gains or losses, the system spreads these imbalances among cohorts at least as well (meaning "as much") as other popular arrangements (e.g. defined contribution or defined benefit), and markedly better than alternatives when sizeable child benefits are introduced. Also, the IPAYG system is better than its competitors in absorbing demographic variations, such as fertility swings and longer survival – where "better" means that intergenerational inequities are more widely spread, and therefore minimized.

However, all of these nice properties are no longer guaranteed when there is a change of rules. Here, intergenerational consequences may be large or small, depending on the extent of the change and on the length of the implementation phase (the more rapid, the more concentrated on just a few cohorts the economic consequences will be, in terms of gains and losses). In all cases, these changes are never neutral, and the typical consequence is that some birth cohorts gain (usually, those who vote now), at the expenses of others (usually those who will vote in the future).

In short: changes in pension rules should always be considered with suspicion and introduced with extreme caution (preferably, I should say, with qualified majorities, as required by constitutional changes). IPAYG does not prevent them, but the fact that it never *needs* them confers this system a great advantage over its competitors.

5.4. What if exogenous variables are in fact endogenous, and is IPAYG consistent with welfare maximisation?

The proposed definition of exogenous variables is, admittedly, questionable. Pension systems exert their effects at least on the economic ones (listed in lines 5 and 6 of Table 1), i.e. earlier or later retirement and propensity to work in the underground sector, evading contributions, and probably also on the demographic ones (especially fertility and migration). This, however, is true of any

pension system. The real question, therefore, is whether a specific pension system provides the right stimuli to maximize welfare, permitting citizens to choose their preferred balance between work and leisure, ideally also favouring private saving, boosting the efficiency of financial markets, etc.
Does IPAYG pass this test? Before answer this question, consider that IPAYG is not just *one* system: it is a set of infinite possible pension systems, each characterized by its own mix of policy variables. Among these infinite possible choices, some are "trivial" (think, for instance of y=s=0: the pension system simply disappears), and some are patently absurd and inefficient, for instance those that foresee too long periods of retirement (high S*), very generous pension benefits (high s), and scarce attention to actuarial equity (low Q).
The real question here is how to maximize collective welfare, within the range of possible choices. This is something that I do not discuss here, in part for reasons of space and in part because I feel that this would be premature: it can and should be done once the general basic principles have been "digested". After all, NDC is believed to be a superior form of pension system, although it can be (and currently is) applied in several different versions (higher or lower contribution rate, age at retirement, etc.) and although in its case, too, a legitimate issue of welfare maximisation could be raised.

5.5 Survivor pension

Survivor pensions may be considered a historical accident, may soon disappear (OECD 2018, Ch. 7), and have already done so in a Denmark (since1984) and Sweden (since 1991; Holzmann 2006). While helpful in combating poverty, survivor pensions suffer from at least two important shortcomings: 1) they implicitly assume that one member of the couple (typically the man) works for the market, while the other (typically the woman) is in charge of domestic chores, within an ever-lasting marriage. This may have been true for some time in the past, but it is surely no longer the case in developed countries; 2) they implicitly penalize unmarried individual and favour (married) couples, transferring resources from the former to the latter.
Both with NDC and with IPAYG, survivor pensions can easily be dropped. It suffices to split between partners all the contributions paid by married (or otherwise officially recognized) couples. Both members of the couple thus form their own pension rights during their adult years. Upon retirement, at age β_t, each partner separately, and independently of their current living arrangement (not necessarily identical to that of the time when contributions were paid), will touch their own pension benefit. All the other properties of the pension system remain unchanged.

6. Conclusions

Pension systems are complex objects, but they are also an important element of daily life. Therefore, technical aspects, while important, should not become so complex as to hide the basic mechanism of the transfer game, a social construct that affects everybody, in developed, and increasingly so also in developing countries (Niño-Zarazúa 2019). Everybody should be capable to understand what happens, what forces are at play and what basic choices have been made. These choices should be flexible enough to adapt to the varying demographic and economic circumstances of the future, but their variability should also be limited, to minimize the political risk and the destabilizing effects of too frequent or abrupt changes.

Long-term viability is a major issue, and so is the complex interference of pension systems with other societal mechanisms: participation in the labour market, migration for work reasons, fertility, saving and accumulation of capital, etc. Resource redistribution, between and within birth cohorts is another non-secondary aspect to consider.

How to strike the best balance between simplicity and proper functioning is still an open issue, and various theoretical and practical solutions have been proposed over time. The most recent and possibly the best thus far is NDC, the notional defined contribution pension system.

However, a further step may be possible, because the IPAYG (improved pay-as-you-go) pension system presented here is not worse than NDC in any respect, and it is better than NDC in several senses: it guarantees budget balance, incorporates the socially preferred degree of redistribution, does not create "vintage pensions" (pensions benefits originally sufficient to grant a decent living, but progressively less so), separates policy choices (in the form of five, well defined parameters) from technicalities, brings to the fore and keeps under control the most relevant policy variables (starting from cross-sectional equity), adjusts automatically to all possible economic and demographic change, and does not require forecasts (ad-hoc adjustments, expert committees, revisions, etc.) of any kind. On top of that, it is simple (as simple as possible, at least), it circumvents a series of obstacles (interest rates, for instance) and, perhaps most importantly, redistributes among all parts of societies (young, adult and old population) all the possible future economic or demographic risks and uncertainties, while at the same time minimizing political risks.

Finally, as NDC, it can be adopted in a wide variety of forms, depending on parametric choices: it could therefore become the standard of EU countries ("United in diversity"), each free to select their preferred national form.

Appendixes

Appendix A: How IPAYG formulae are derived

The budget balance of the system requires that

A.1) $$E_t\, W_{e,t}\, c_t = [S]_t\, P_t + [Y]_t\, B_t$$

Inflows, on the left, are the product of the number of the employed (E), multiplied by their average labour earning (W_e), multiplied by the contribution rate. Outlays, on the right, are given by the number of seniors ([S], absolute number) multiplied by their average pension benefit. If child benefits exists (B_t), they enter the picture, together with the young in the population ([Y], absolute number). All the variables are time dependent.
Let us first introduce a new variable, the average labour earning of the adult population

A.2) $$W_{a,t} = \varepsilon_t \cdot W_{e,t}$$

which incorporates both the average labour earning of the employed W_e and the employment rate ε

A.3) $$\varepsilon_t = \frac{E_t}{[A_t]}$$

where [A] indicates the absolute number, not the proportion, of the adult population. Therefore, eq. (A.1) can be rewritten as

A.4) $$[A]_t\, W_{a,t}\, c_t = [S]_t\, P_t + [Y]_t\, B_t$$

Or perhaps more clearly as

A.5) $$A\, W_a\, c = SP + YB$$

dropping the subscript t for the sake of simplicity and dividing both sides by the total population, to transform absolute numbers into proportions.
As both pension P

A.6) $$P = sN_a = sW_a(1 - c)$$

and child benefits B

A.7) $$B = yN_a = yW_a(1 - c)$$

are a fixed proportion of the net labour earnings of the adults N_a, equation (A.5) becomes

A.8) $$A\, W_a\, c = SsW_a(1 - c) + YyW_a(1 - c)$$

Simplification and reorganization of terms lead to

A.9) $$c_t = \frac{s \cdot S_t + y \cdot Y_t}{A_t + s \cdot S_t + y \cdot Y_t}$$

Which is eq. (3) in the main text.
Every year, individual pensions are paid as weighted averages of two parts

A.10) $$P_{s,t} = QP_t\frac{K_{s,t}}{K_t} + (1-Q)P_t$$

The right-hand part of equation (A.10), identical to equation (8), with weight (1-Q), is a constant P, with average P (dropping the subscript t, for the sake of brevity). The left-hand part, with weight Q, is $P\frac{K_s}{K}$, the average of which, over [S] seniors, is P (because $\sum K_s = NK$). Therefore, the average of P_s is P, every year.

Appendix B: Antecedents of IPAYG

While IPAYG is, to the best of my knowledge, entirely original in its architecture (apart from my own previous publications on this topic, e.g. De Santis 2015), some elements of it derive from ideas that have circulated for some time in the literature. Perhaps the most important is Musgrave's (1981) proposition that the average pension be a fixed proportion of the average net labour earning (P/N_e, in my notation). This idea has later been labelled "risk sharing" (Gonnot, Keilman and Prinz 1995) or "Musgrave's rule of intergenerational fairness" (Vidlund et al 2017). The basic principle (risk sharing) is the same, IPAYG applies it differently: what remains constant in it is s=P/N_a, which improves over Musgrave's original idea in that it keeps into account also the employment rate, and not only labour productivity and the contribution rate.

Besides, IPAYG guarantees consistency between individual and average pension benefits, an issue that the specialized literature has systematically ignored, and does so incorporating explicitly the socially preferred degree of redistribution towards the poor (1-Q), which is also a novelty, I believe.

The idea of moving threshold ages when survival conditions change is also not new, and several variants have been proposed over time (Sanderson and Scherbov 2016), none of which, however, is identical to that of IPAYG, although in most cases results turn out to be similar. Besides, as far as I know, nobody has ever considered that both threshold ages should be adjusted when e_0 changes: not only β (retirement age), but also α, the age that separates the young from the adult population.

Appendix C: Notes on the practical introduction of IPAYG

IPAYG is not just a theoretical exercise: it has been conceived with an eye at its possible practical applications. If a country should ever move in that direction, more steps would be taken than are discussed here. What is needed is:

a) a consensus that IPAYG is better than alternative PAYG pension systems (and this is what this paper is about)

b) the choice of the preferred policy variables, among the infinite possibilities

c) a decision on how to pass from the current arrangement to IPAYG

Nothing is said in this paper about points (b) (parameter optimization, given country preferences) and (c). As it happened with NDC (notional defined contribution) at the time of its adoption in the five countries that introduced it, several different options are available, in most cases guided more by local specificities (e.g., policy preferences and economic constraints) than by theoretical considerations. And this is why I am skipping this discussion, here. Let me just not that one of the requirements that economists expect of pension systems is that they do not become an excessive burden on the economy. With IPAYG, this can be kept under control, and becomes another constraint. Let us assume that the relative share of labour income on the GDP ($A \cdot W_a$/GDP) is 2/3. As the contribution rate (i.e, the "economic burden" of a pension system), is applied to the salary mass, the relative weight of the pension system on the economy will be (about) 2/3 of c_t. For instance, if c_t=24%, pensions/GDS~16%. If this ratio is considered too high, policy decisions (parameters) should be such as to lead to lower values of c_t. It should also be kept in mind that ex-ante, only the reference values of the contribution rate is known c^*. Actual values c_t oscillate around this reference value, approximately by ±5% (not directly shown here; see however Table 3) - so that, for instance, if c^*=24%, real contributions rates will normally fall between 19% and 29%.

Interest rates need not appear explicitly in IPAYG. The only place where they may be needed is in the calculation of individual virtual capital K_s (eq. 10). However, this is not strictly necessary. For every year in the past τ ($\tau<t$), individual contributions have been paid ($C_{i,\tau}$): the average of these contributions is known (C_τ, average across the adult population), and the ratios $\chi_{i,\tau}=C_{i,\tau}/C_\tau$ can be calculated for very individual i and every year τ. The sum of these ratios $\chi_{s,\tau}$ (for all seniors, over their entire life) can be considered their virtual capital $K_s=\Sigma_\tau\ \chi_{s,\tau}$. The average of these virtual capitals should not be far from (β-α), that is the duration of the adult life, but an exact correspondence is not to be expected, in part because both β_t and α_t change over time, and so does their difference, and in part because of differential mortality. The rationale of this way of calculating of virtual capitals (not the only possibility, to be sure) is double. First, it makes calculations considerably simpler and, second, it implicitly assumes that all past years are equally important: the only thing that matters is the relative (contributive) situation of every individual compared to that of the average adult of that year (τ).

Alternatives are possible not only in the calculation of virtual capitals: in my opinion, all of them are worse than what is presented here, but some of them may appear appealing. Let us briefly consider a few:

1) The threshold ages α and β could be adjusted over time with different criteria (i.e. not aimed at preserving the three shares of life: Y*, A* and S*): for instance, not touched at all; or leaving α

constant and letting β vary; or adopting one of the criteria listed in Sanderson and Scherbov (2016). In all cases, the reference contribution rate c^* would not remain constant over time (it would become c^*_t), and the actual contribution rate c_t would oscillate around this moving reference values.

2) Individual flexibility in the age at retirement, keeping β_t as a point of reference and not as a precise threshold, is likely to be a strong request, especially in the countries where, together with NDC, this flexibility was introduced, although with several limitations. With IPAYG, ordinary calculations need to be re-done every year and are therefore considerably more complex than with NDC, which does them only once for each pensioner, at the time of retirement. The introduction of this individual flexibility would therefore complicate matters much more than it may seem. What could be done, instead, is to introduce an age interval β'-β", with, for instance, β'=β-3 and β"=β+3. Between β' and β", these mature workers would touch only half their pension benefits - together with their labour earning if they keep on working, or as an alternative to it, if they actually retire at age β'. This arrangement would prove manageable (not shown here) because it would be applied universally, not to individual cases, and it would be consistent with the idea of a gradual withdrawal from the labour force, e.g. with a few final years of part-time work that could be used to facilitate labour force turn-over.

3) The IPAYG version presented in this paper assumes that the pension system works in perfect budget equilibrium, with revenues always matching outlays. This constrain can be relaxed, accepting that revenues cover only a certain proportion J of expenses (e.g. J=95%), with J becoming the sixth policy parameter. This solution, which I do *not* favour, could be justified arguing that the pension system is also a public good, for which public subsidy, taken from general taxation, is admissible. If J is added to formula (A.1), all other formulae can be easily derived (not shown here).

4) As the contribution rate c_t oscillates over time around its reference value c^*, a country could decide to apply the constant long-term average c*, incurring debts and surpluses over time, but these would alternate and level off in the long run. Incidentally, this is what real pension systems (try to) do: they determine by law both the contribution and the criteria for determining individual pension benefits, and *hope* that revenues and outlays more or less match, at least over time. The appealing part of this arrangement is that one element of the cost of labour (the contribution rate c*), becomes constant and makes the future more predictable. However, this is not a good idea, for two reasons. The first is that the correct long-term average of the theoretically necessary contribution rates c_t is unknown: it is close to c^* but its precise value cannot be determined ex ante, because it turns out to be a *weighted* average of c_t, with weights given by the salary mass of

each future year *t*. The second reason is that, even if the correct, constant, long-term average of the c_t series were used, disequilibria in this field, even if relatively small, are large in absolute terms, very sizeable with respect to the economic capacity of a country (as measured by its GDP, for instance), and the may persist for several decades. The case of Italy of Table 3, for instance, shows that a period of demographic bonus may last for over a century, creating a huge cumulated surplus (larger, and in some cases much larger than the GDP), impossible to manage, i.e. to save and to invest productively. Worse still in periods of demographic malus: the order of magnitude of the cumulated imbalances is the same, but this time with a negative sign.

5) More than just one IPAYG pension system is possible in each country: e.g. separating dependent and independent workers, blue from white collars, males from females, etc. These classifications can become as detailed as wished and can be combined at will - each specific sub-system with its policy parameters, its independent variables (starting from group-specific life tables) and its consequences (pension benefits, age at retirement, etc.). Grave difficulties would have to be solved to justify these subgroups, to explain why *N* of them have been chosen (and not *N*+1, N+2, ...), to keep track of group-specific changes in all of the independent variables, and to properly treat individual who change group during their life (e.g. because of labour or geographical mobility). Of all the variants listed here, this wold be the worst, in my opinion, and by far.

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