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Automatic adjustment mechanisms in public pension reforms: Effects over fiscal sustainability, adequacy, and fairness

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Abstract

In response to population ageing, many countries have adopted automatic adjustment mechanism reforms that link retirement to life expectancy. Despite their benefits, there is limited research about non-fiscal consequences of these mechanisms. In addition, there is uncertainty about the extent to which an increase in life expectancy signals a capacity of individuals to remain active in the workforce. In this paper, we used an overlapping generations model to analyse the effects of such reforms over fiscal sustainability, adequacy, and fairness of public pension systems. We looked at three scenarios defined by the mechanisms indexing retirement age: a constant pensions fiscal balance, constant life expectancy after retirement, and constant disability-free life expectancy after retirement. Growth is exogenous in our standard model; however, we explore an alternative model with endogenous productivity partially determined by the age structure of the population. We illustrate the dynamics of our model by applying it to Argentina's public pension system. Our results show that linking retirement to life expectancy would not be enough to restrict the projected growth in the pension system's deficit. We also find that changes in productivity have limited effect on pension indicators, although the indexation system can amplify or buffer such effects.

JEL Codes: H55, I18, J11, J14

Keywords: Pension systems; Fiscal Sustainability; Population ageing; Healthy Ageing; Productivity; Overlapping Generations Models

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1 Introduction

Chronological population ageing will increase the share of the population above the retirement age at the expense of the working age population (United Nations 2017, Rouzet et al. 2019). For many countries these dynamics are projected to increase public pension spending and decrease contributions, making pension schemes fiscally unsustainable (Figure 1).

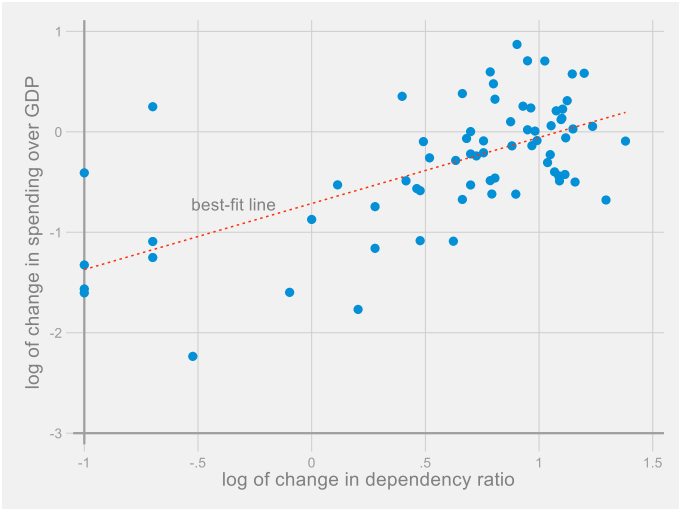

Figure 1 Projected increase in pension spending over GDP and old-age dependency ratio by country, 2018-2030.

Source: (IMF 2019), *United Nations World Population Prospects database, and authors own calculations*

Note: Dotted line shows the best fit line. Negative numbers are omitted to generate a logarithmic conversion.

In response, many countries adopted automatic-adjustment mechanisms (AAMs). AAMs create automatic links between demographic or economic developments and pension system parameter, particularly benefit levels (OECD 2012, 2019). In other words, they alter pension benefits and/or contribution formulas to account for pressures arising from demographic changes or other variables that affect the system's cashflow. Therefore, AAMs not only have the capacity to eliminate fiscal imbalances but can also ameliorate fiscal repercussions associated with uncertainty over projections by incorporating all possible scenarios into the calibration of parameters.

Other advantages of AAMs include their capacity to address time consistency problems between the government (as the regulator of the pension system) and the system's participants. The fiscal sustainability of pension systems is a long-term problem that requires tracking contributions and expenses throughout the life of its participants. However, governments have short-term incentives based on electoral cycles that usually last between four and seven years.

Furthermore, austerity policies such as reducing pension benefits or raising contributions are politically unpopular (Guardiancich and Guidi 2020). AAMs help solving this inconsistency by withdrawing the political cost of pension systems reforms from the government.

Despite the advantages of AAMs, there are two issues related to their calibration that we address in this study. First, there is scarce research on non-fiscal consequences of AAMs. AAMs do not eliminate the cost from future adverse demographic conditions. Costs are only reassigned and who will bear them depends on the mechanism's rules. For example, AAMs, that affect the contribution rate will impact contributors and those that modify the indexation formula will impact the beneficiaries. Furthermore, if the impact over these groups is too strong, policy-makers will be tempted to by-pass the mechanism. Examples of this unintended consequence are the strong political backlashes in Spain and Germany after their incorporation of AAMs (Boersch-Supan and Wilke 2004; de la Fuente, García-Díaz, and Sánchez 2017). Thus, to improve their functionality, we need to study the effect of AAMs on the adequacy and fairness pension systems (Alonso-García, Boado-Penas, and Devolder 2018).

The second problem is related to AAMs that link retirement to ageing typically using life expectancy. While increasing the retirement age appears to be a natural extension of improved life expectancy, the extent to which workforce participation can be pushed into later years is worthy of consideration. Life expectancy is a measure of quantity of life and is significantly longer than measures of quality of life such as healthy life expectancy and disability-free life expectancy (Jagger et al. 2008; Marmot and Bell 2012; Souza, Queiroz, and Skirbekk 2019).

Consequently, the aim of this paper is twofold. First, to develop a model that allows us to quantify the effects of AAMs on the fiscal sustainability, adequacy and fairness of pension systems. And second, to compare the effects of an AAM that links retirement to life-expectancy to one linked to disability-free life expectancy. For this task, we develop an overlapping generations model (OLG) that tracks the contributors and benefits from different age-cohorts of pension system participants. In addition, our modelling also contributes to the literature by exploring how the ageing-productivity relationship may affect pension systems.

The model is developed under four scenarios depending on the trajectory of the retirement age. In the first scenario (baseline) the retirement age is constant. In scenarios two and three, we incorporate an AAM that links retirement to either life expectancy or disability-free life expectancy. In the fourth scenario, the retirement age is the one that maintains a constant pension fiscal balance equal to its last historical value.

Additionally, we produce two versions of our model. In the standard model, growth is exogenously determined using historical data. In the endogenous model, we consider a robustness check by including a channel through which the age-structure of the labour force can affect total factor productivity (TFP).

The paper is structured as follows. In Section 2 we describe our methodology including the model and the AAMs. In Section 3, we illustrate the dynamics of our standard model by applying it to the Argentinian public pension system. We choose this country for its simple defined benefit system and data availability which allows us to focus on the results. Section 4 compares the results of the standard model with the endogenous version. Section 5 concludes.

2 The model

In this section, we describe our model, how we measure adequacy and fairness, and how we incorporate the AAMs into a pension model. Our standard model is based on previous work from Alonso-García et al. (2018) which develops an overlapping generations model to assess the impact of AAMs that affect the contribution rate and/or indexation of pensions. In comparison to their paper, we focus on reforms that increase the retirement age and use a characteristics approach to design our AAMs, which allows us to connect retirement to qualitative ageing indicators.

Our modelling also considers how the ageing-productivity relationship may affect pension systems. Many papers have pointed to negative but small effects (Acemoglu and Restrepo 2017; Bussolo, Koettl, and Sinnott 2015; Prskawetz et al. 2006; Sharpe 2011; Nagarajan, Teixeira, and Silva 2016). Thus, in our simplest model, we assume an exogenous and constant growth rate for productivity during the projection period. However, in Section 4, we consider a robustness check by linking productivity to ageing. To differentiate this extension and compare results with our main model, we label them as the standard and the endogenous models.

2.1 Model description

We start by defining the government's pension revenue (R_t) as function of the number of contributors (co_t), the average wage (w_t), and the contribution rate (cr_t).

$$R_t = co_t \cdot w_t \cdot cr_t \tag{1}$$

The number of contributors evolves in line with the working age population (those below the retirement age and over 20) wp_t, the labour force participation rate pr and the formality level f of the economy.[1] The average wage is determined by the gross domestic product (Y_t), the wage share (ws), and the size of the labour force (lf_t).

$$co_t = wp_t \cdot pr \cdot f \tag{2}$$

$$w_t = Y_t \cdot (ws/lf_t) \tag{3}$$

In our standard model, the domestic product grows at a constant exogenous rate $g_t = \bar{g}$ for all t. However, Section 5 contains a robustness scenario where g_t is transformed into a function $g_t = f(A, T)$ determined by the age structure of the population (vector A) and the productivity of each age group (vector T).

The number of total retirees (re_t in Equation 4) evolves with the population above the retirement age rp_t, the labour force participation rate and the formality rate of the economy. Retirees are divided between new beneficiaries (nr_t, those retiring in t), and existent beneficiaries (er_t those retired in previous years and still alive in t). This division is required because the benefits of each group are calculated differently and because certain reforms could affect only new retirees but not those already retired. For the same reason, we introduce a supra-index c to distinguish between cohorts of beneficiaries according to their retirement year.

$$re_t = rp_t \cdot pr_t \cdot f_t = nr_t + er_t \tag{4}$$

The government's pension spending (S_t) equals the sum of benefits paid to new retirees and existent retirees.

$$S_t = nr_t \cdot w_t \cdot rr_t + \sum_c er_t^c \cdot p_t^c \tag{5}$$

The sum of benefits for new retirees are calculated as the number of new retirees (nr_t) multiplied by the average wage and by the replacement rate (rr_t). For existing retirees, total benefits are calculated by adding-up the benefits corresponding to each cohort c, multiplying the average pension (p_t^c) of each cohort by the number of retirees in each cohort (er_t^c).

As shown in Equation 6, the average pension for any cohort c at any time t is obtained by multiplying their initial average pension $rr_{t-age_c+ra_c} \cdot w_{t-age_c+ra_c}$ (where $t - age_c + ra_c$

[1] The definition of formality used for the calibration of our model in section 4 is the percentage of employees paying contributions to the pension system.

refers to the retirement year of the cohort) by a product of the system's indexation parameter (γ_t). The indexation parameter is determined by local rules. For example, if pensions are indexed to inflation, γ_t would equal the inflation rate.[2]

$$p_t^c = rr_{t-age_c+ra_c} \cdot w_{t-age_c+ra_c} \cdot \prod_{t=t-age_c+ra_c}(1+\gamma_t) \tag{6}$$

Equations 2 to 6 are enough to calculate most indicators of interest. As shown in the next section, Equations 2 and 4 are used to project the coverage of the system, Equations 1 and 5 to project the fiscal flow of the pension system, and Equations 4 and 6 contain the variables to project the adequacy and fairness of the system.

2.2 Indicators of interest for assessment of pension systems

Coverage

We measure the system's active coverage as the number of contributors over the population between 20 years and the retirement age[3] and the beneficiaries coverage as the number of retirees divided by the population over the retirement age.

Fiscal sustainability

We assess the fiscal sustainability of the system (FS_{t_0}) by comparing the discounted flow of spending (from Equation 5) against the discounted flow of revenue (from Equation 1), both in percent of GDP. We discount the flows to a common year, t_0 using a discount rate r_t.[4]

$$FS_{t_0} = \sum_{t=t_0} (R_t - S_t)/Y_t \cdot (1+r_t)^{t-t_0} \tag{7}$$

Adequacy and fairness

We follow Queisser and Whitehouse (2006) to define fairness and adequacy indicators. The adequacy for a specific cohort is measured through the gross pension wealth (PW^c) which is

[2] If ra_c is the age at which a cohort can legally retire, then the current year minus the age of the cohort ($t - age_c$) equals the year they were born. Thus, $t - age_c + ra_c$ is the year at which they are entitled to retire. We later replace this expression by ret to simplify the equations when we are discussing one specific cohort.

[3] We use 20 as the bottom threshold because it is a common age used in the literature (Sanderson and Scherbov 2015; United Nations 2017).

[4] Long-run discount rates play a central role for economic valuation of public policy; unfortunately, there is little direct empirical evidence on how households discount payments over very long horizons (Giglio et al. 2014). As a benchmark, for regulatory action with "intergenerational benefits or costs," the U.S. Office of Management and Budget recommends a wide range of discount rates, between 3 and 7 percent (Amaglobeli and Shi 2016). However, a $100 bond that matures in 50 years would be worth almost 6.7 times more today if discounted with a rate of 3 percent than with a rate of 7 percent. For comparatively purposes we will use the rate proposed by Giglio et al. 2014, 2.6 percent, which is the rate used by the IMF on its notes on "how to assess fiscal implications of demographic shifts" (Amaglobeli and Shi 2016).

calculated as stock of all pension payments discounted using inflation (π_t), time value (using r_t), and probability of survival after retirement for the specific cohort (equivalent to one minus the mortality rate after retirement of each cohort mr_t^c).

$$PW^c = \sum_{t=t-age_c+ra_c}\left[p_t^c \cdot \prod_t \frac{(1-mr_t^c)}{(1+\pi_t)(1+r_t)}\right] \tag{8}$$

Pension wealth is typically measured as a ratio over the average wage at retirement $w_{t-age_c+ra_c}$.

The fairness of the system is measured as a ratio between the gross pension wealth and the stock of lifetime contributions discounted using inflation and r_t. $t - age_c + 20$ is the year at which every cohort entered the labour market, assuming all cohorts start working at 20 years of age.

$$F^c = PW^c / \sum_{t=t-age_c+20}[w_t cr_t \prod_t (1+\pi_t)(1+r_t)] \tag{9}$$

2.3 AAM and the characteristics approach in the model

Notice that every time the retirement age appears in our model, it has a sub-index t or a supra-index c. That is because the retirement age is only fixed in the baseline scenario. We describes below how we set the retirement age in the other three scenarios.

2.3.1 Life expectancy and disability-free life expectancy

The characteristics approach is a method develop by Sanderson and Scherbov (2013) to build ageing indicators using demographic and qualitative characteristics of the population. For example, instead of a fixed "older-age threshold" determined by the number of years elapsed since birth, an individual will transition into "older-age" when their life expectancy drops below an arbitrary threshold. The main assumption behind this proposal is that the threshold to "older-age" is not be fixed; instead, it is determined by characteristics that are important for ageing and that are captured or proxied by life expectancy. As life expectancy is projected to increase for many populations, the "older-age" threshold will also increase.

Following this reasoning, many countries proposed reforms to their pension systems that link the retirement age to life expectancy. We introduce the characteristic approach into our model to assess this type of reform.

Following the notation in Sanderson and Scherbov (2013), let $C_t(\alpha_{k,t})$ be a function known as the schedule of characteristics that translates chronological age α_t into characteristics k_t.

$$C_t(\alpha_t) = k_t \tag{10}$$

Equation 10 can be inverted to obtain the schedule of chronological ages α_t associated with each value of the characteristic k_t at time t. This indicator, $\alpha_{k,t}$, is known as alpha-ages.

$$\alpha_{k,t} = C_t^{-1}(k_t) \tag{11}$$

In our model, $\alpha_{k,t}$ will be the schedule for the retirement age conditional on projections of characteristics k_t (life expectancy).

The underlying assumptions for the indicator proposed by Sanderson and Scherbov and for the reforms that index retirement to life expectancy may be over-optimistic. Even though there is a consensus about projected positive trends for life expectancy, the quality of life during the extra years of life is still uncertain. The comparison of different studies is inconclusive with contradictory results for the same populations and even more variation when comparing different countries (World Health Organization 2015; Crimmins and Beltrán-Sánchez 2010). Thus, the extent to which workforce participation can be pushed into later years is worthy of consideration. However, the characteristics approach is a flexible methodology that allows replacing the underlying characteristics k_t with any indicator (or set of indicators) that the researcher considers relevant, for example, disability-free expectancy.

In Wachs et al. (2020) we used disability prevalence data to explore different theoretical healthy ageing scenarios based on several assumptions about the relationship between disability prevalence and ageing. We will use the projections from that publication to complement our analysis of retirement age indexation in this study. Hence, we will replace k_t with a minimum value of disability-free life expectancy and $\alpha_{k,t}$ with the age schedule at which disability-free life expectancy falls below k_t. The assumptions and methods for those calculation using follow the Sullivan method (WHO 2014) are available in Wachs et al. (2020).

Figure 2 shows an example of the characteristics approach, comparing a fixed older-age threshold of 65 (green line) with two alpha-age indicators, one based on life expectancy and one based on disability-free life expectancy. The red line tracks the alpha-age at which disability-free life expectancy is constant across time. The blue line does the same but for life expectancy. There is also a yellow line that tracks a constant fiscal balance scenario which is described in the next subsection.

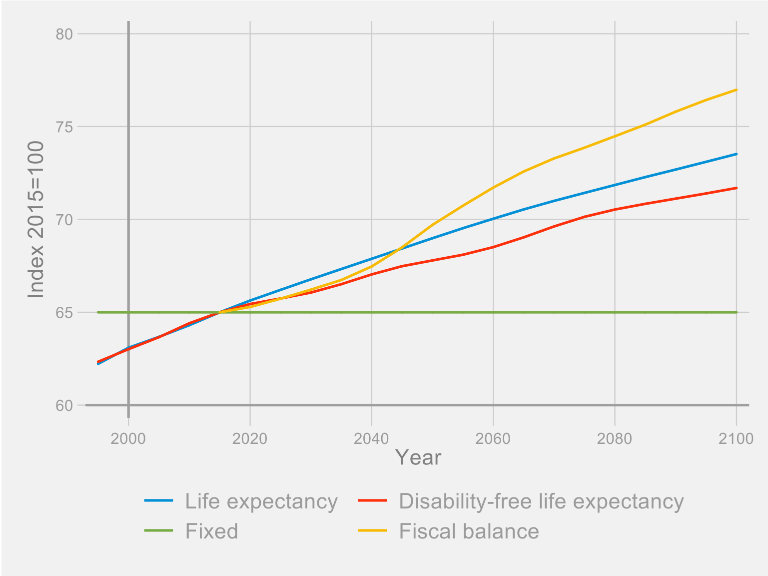

Figure 2 Fixed retirement age, constant-balance retirement age, and alpha-age trajectories associated with constant life expectancy and disability-free life expectancy after retirement.

Source: UN Population Prospects Database, Global Burden of Diseases Study, and authors own calculations.

Note: The calculations of alpha trajectories are described in the methodology and appendix sections.

To make all curves match in 2015, both alpha-trajectories track the age at which the measured characteristics (life expectancy and disability-free life expectancy) equal its value in 2015 for an individual with 65 years of age. For example, a 65 years old individual in 2015 is projected to have the same disability-free life expectancy as 67 years old individual in 2045. The retirement age in the four scenarios of our results section will follow the trajectories of the curves in Figure 2.

A limitation in our model is related to a possible endogenous relationship between health and retirement. The disability-free life expectancy trajectory builds upon disability prevalence projections that do not accounting for feedback from retirement to disability prevalence. However, if, retirement affects health, our alpha ages in Figure 2 should not be independent from eligibility reforms.[5]

[5] Eibich (2015) discusses a positive effects of retirement on health channelled through relief from work-related stress and strain, increased sleep duration, and increased physical exercise. Rohwedder and Willis (2010) founds a negative influence of retirement on health through the worsening of cognitive abilities. (Nishimura, Oikawa, and Motegi 2018) explained these and other opposing empirical results on this subject through methodological comparisons, however, there is no unified view on the impact of retirement on various health indexes (Feichtinger et al. 2012).

2.3.2 *Constant fiscal balance*

In our fourth scenario, the retirement age for the projections is the one that maintains the pensions balance over GDP constant at its last historical value.[6]

Using Equations 5 and 1 we can derive the change in government revenue and spending over GDP as follows,

$$\frac{R_{t+1}}{R_t} = \frac{co_{t+1} \cdot w_{t+1} \cdot cr_t}{co_t * w_t * cr_t} = \frac{co_{t+1} \cdot w_t \cdot (1+g) \cdot cr_{t+1}}{co_t * w_t * cr_t} \tag{12}$$

$$\frac{S_{t+1}}{S_t} = \frac{p_{t+1} \cdot re_{t+1}}{p_t \cdot re_t} = \frac{p_t \cdot (1+\rho_t) \cdot re_{t+1}}{p_t \cdot re_t} \tag{13}$$

Note that we simplified the calculation of spending using an average pension for all retirees (p_t) instead of the average pension by cohort (p_t^c). The average pension can be derived dividing total spending (Equation 5) over the number of retirees (Equation 4). Additionally, g_t and ρ_t are the growth rates of wages and pensions, respectively.

To maintain a constant fiscal balance, Equation 12 should equal Equation 13.

$$\frac{co_{t+1} \cdot (1+g_t) \cdot cr_{t+1}}{co_t \cdot cr_t} = \frac{(1+p_t) \cdot re_{t+1}}{re_t} \tag{14}$$

Reorganising terms and assuming that the contribution rate stays constant we get Equation 15 which is the necessary condition to maintain a constant balance in the pension system: changes in the ratio of contributors to retirees should match changes in the ratio between the average pension and the average wage growth rates. In our fourth scenario, the retirement age increases in an amount such that this condition is met.

$$\frac{\frac{co_{t+1}}{ret_{t+1}}}{\frac{co_t}{ret_t}} = \frac{(1+\rho_t)}{(1+g_t)} \tag{15}$$

Using Equation 6 we can see that, if pensions for existing retirees are indexed to wages, then $(1+\rho_t) = (1+g_t)$. Thus, to maintain a constant fiscal balance, the contributors-beneficiaries ratio should stay constant across time. If, pensions are indexed to a parameter that grows slower than wages, which is a common case, a constant fiscal balance can be achieved with an increasing contributors to beneficiaries ratio.

[6] This is an arbitrary target set by the authors; however, it can be understood as a decision by policy makers to maintain the short-term fiscal outlook over the long-term. This is useful as a benchmark for all other comparable reforms that affect the fiscal balance.

3 Application of the standard model

In this section, we exemplify our methodology by applying it to Argentina's public pension system. We chose this scheme because it is typical define benefit system. Additionally, for the past 20 years, the country has experienced a battery of pension reforms and continuous social unrest related to their social spending policy. Nevertheless, its pension system remains fiscally unsustainable in the long term (Acosta Ormaechea, Wachs, and Espinosa-Vega 2017).

3.1 Assumptions and data sources

Table 1 summarises the main assumptions used to calibrate our model for the Argentine pension system. Historical data and projections of demographic variables (population and mortality rates) come from the United Nations Population Prospects Database. Historical data for macro-variables (GDP, consumer prices, and unemployment) comes from the IMF's World Economic Outlook database while projections are based on average historical growth rates.

Table 1 Argentine pension system assumptions and data sources

Variable	**Source**
population by age	UN, WPPD
mortality rate after retirement by age	UN, WPPD
unemployment rate	IMF, WEO
gross domestic product	IMF, WEO
consumer price index	IMF, WEO
contribution rate	OECD, PAG
replacement rate	OECD, PAG
beneficiary's coverage rate (those with contributary pension)	Anses
retirement age	Anses
average individual pension (annual amount in local currency)	Anses
average individual salary (annual amount in local currency)	Anses
formality rate (employees paying contributions)	IADB, LMSSIS
labour force participation rate	IADB, LMSSIS
labour force entry age	IMF (2017)

Note: National Administration of Social Security (Anses), World population prospects (WPPD), Labour Market and Social Security Information System (LMSSIS), World Economic Outlook (WEO), Pensions at a Glance (PAG), Legislative and Documentary Information (Infoleg). A complete dataset and its application to our model is available in the online appendix.

The rest of the variables (contribution rate, replacement rate, beneficiaries coverage rate, retirement age for the baseline scenario, active coverage rate, and the labour force participation rate) come from Argentinian government official sources (Anses, and Infoleg), or from the Inter-American Development Bank's Market and Social Security Information System, and are kept constant at their last historical value during the projection period. Additionally, the labour force entry age is set at 20 as in Acosta-Ormaechea et al. (2017).

The online annex available at https://bit.ly/39Xd18g contains detailed information (in Excel "xlsx" format) of the data used in the projections presented in this paper. This annex includes both the data from the primary statistical sources used and our own data calculated for the model calibration.

We start with an initial cohort in 2015 divided in two groups, new and existent retirees in 2015 because historical data of average pension by cohort is not publicly available. The average pension for new retirees is calculated using the average wage and the replacement rate, as in Equation 4, and the pension for the existent retirees is calculated as a residual using Equation 4 and total pension spending in 2015. The consequence of this approach is that we cannot track the contribution and benefit flows of cohorts retired before 2015.

3.2 Results

Figure 3.a shows the trajectory of the retirement age under the four scenarios discussed in Section 3.1: fixed retirement age; retirement age indexed to life expectancy after retirement; retirement age indexed to disability-free life expectancy after retirement; and the retirement age that keeps a constant pension system balance at its last historical value. The detailed description for the calibration of these trajectories is available in the Section 2.

The difference in the retirement age trajectories is substantial. The retirement age that would keep life expectancy after retirement constant increases nine years between 2015 and 2100. However, such increase would not be enough to avoid a raise in the fiscal deficit. To achieve that goal, the retirement age should increase three more years, which would not only be politically difficult, but also biologically challenging, as disability-free life expectancy grows at a lower rate. Of course, there is great uncertainty regarding the projections of disability-free life expectancy and an assessment incorporating uncertainty would be more appropriate to analyse that scenario in detail.

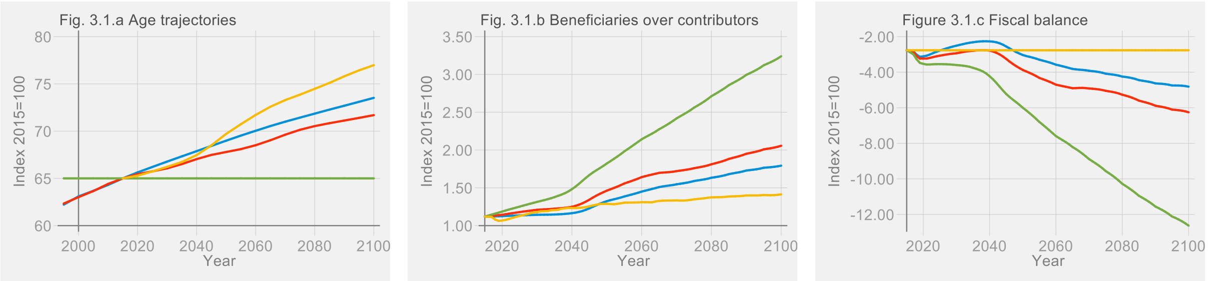

Figure 3 Projections for Argentina, (2015-2100)

Source: See Table 1 Argentine pension system assumptions and data sources

Figure 3.b shows how changes in eligibility affect the beneficiaries to contributors ratio. These projections are obtained using Equations 2 and 4 of our model. Since the increase in the retirement age decreases beneficiaries while raising taxpayers the order of the curves in Figure 3.b is the opposite of that in Figure 3.c. Note also that the constant deficit curve in Figure 3.b is not flat but has a slight positive slope. This is because, in Argentina, pensions are partially indexed to the inflation rate. Therefore, a constant balance can be reached even with growth in the beneficiaries to contributors ratio (see Equation 15).

Figures 4 shows the discounted accumulated fiscal deficit between 2015 and 2100 (Equation 7) and indicators of adequacy and fairness for an individual who joins the labour market with 20 years in 2015 (Equations 8 and 9). A raise in the retirement age increases the contribution period while decreasing the period receiving benefits. Therefore, measures that reduce the deficit also reduce the pension wealth and fairness. This trade-off is visible in Figure 4 where scenarios are organized from lower to higher retirement age in 2100.

With a fixed retirement age, the discounted accumulated fiscal deficit would amount to almost 200 percent of GDP in 2015, while for the cohort entering the labour market in 2015 the fairness would equal 1.25 and the pension wealth ratio to the average wage would equal 15.5. On the opposite side, with a constant balance, the discounted accumulated fiscal deficit would amount almost 97.2 percent of GDP in 2015, while for the cohort entering the labour market in 2015 the fairness would equal 0.47 and the pension wealth ratio to the average wage would equal 9.8.

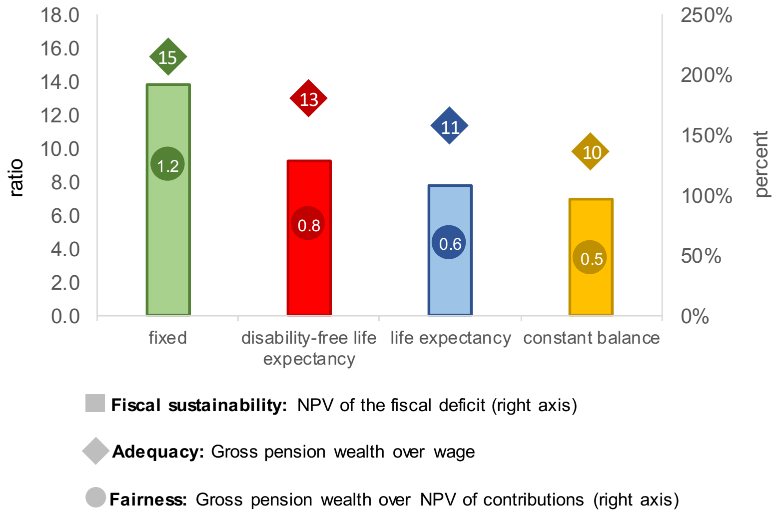

Figure 4 Indicators of interest for Argentina, (2015-2100)

Source: See Table 1 Argentine pension system assumptions and data sources.

Note: Fairness and Pension wealth measured for an individual entering the labour market at 20 in 2015 and retiring at the ages determined by the specific scenarios. Instead of a ratio, Fairness is displayed as percent of total discounted contributions to measure it on the same axis as the accumulated discounted deficit. Pension wealth measured as a ratio of average wage at retirement, as shown in Equation 8. Flows are discounted using CPI and a discount rate of 2.6 percent as in Giglio et al. (2014).

4 Robustness scenarios with endogenous growth

In our standard model, growth is determined exogenously by a constant rate $\bar{g}$ based on historical data. In this section, we change this assumption and explore what happens if productivity is affected by the age-structure of the labour force.

4.1 Endogenous model

To endogenize economic growth, taking into account the interaction between population aging and productivity, we follow the work of Feyrer (2007) which, to our knowledge, is the most cited study exploring the ageing-productivity relationship at the macro level (National Research Council 2013; Maestas, Mullen, and Powell 2016). To test this relationship, Feyrer uses panel fixed effects regressions to determine the significance of changes in the shares of labour force age-groups over the growth rate of GDP. Equation 16 shows Feyrer's main specification, where the logarithm of TFP (A), in any year (t) and for any country (i), is explained by the share of 10-year age groups ($\Delta W_{a,i,t}$) in the labour force, the old-age dependency ratio ($OADR$), country fixed effects (μ_i), time fixed effects (η_t), and the error term ($\epsilon_{i,t}$).

$$\Delta \log A_{i,t} = \alpha + \beta_a \Delta \sum_{age\ group=10}^{60} W_{a,i,t} + \beta_{OADR} \Delta OADR_{i,t} + \mu_i + \eta_t + \epsilon_{i,t} \qquad (16)$$

The sub-index a in $W_{a,i,t}$ refers to the labour force age-groups which in Feyrer's specification are divided in 10-year age-groups from 10 to 19 to 50 to 59, plus those older than 60. As the addition of the proportions $W_{a,i,t}$ adds-up to one for each country-year pair, one group must be excluded in the regression analysis. Feyrer arbitrarily chooses the 40 to 49-year-old age group because it generally has the highest coefficient when included. By omitting this group, significant coefficients of other age-groups indicate that they are significantly different from the implied zero coefficient on the 40 to 49 group.

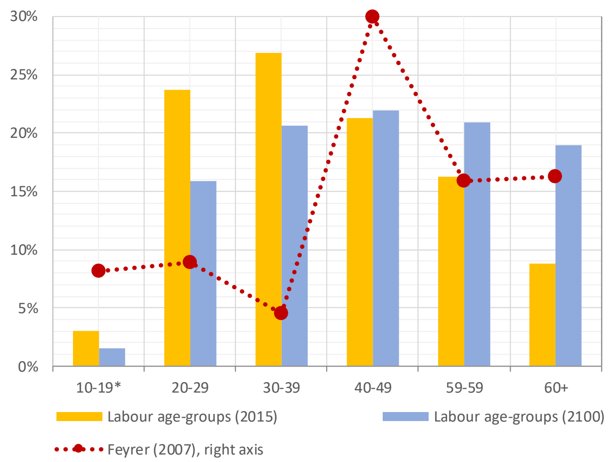

Figure 5 Coefficients estimated by Feyrer (2007) and labour force shares in our baseline scenario (2015 and 2100).

Source: Coefficients from Feyrer (2007), Table 1, column 2; labour force age-groups calculated by the authors using UN Population Prospects database and ILO Standardized participation rates.

Note: Feyrer bottom age-group is 10 to 19; however, the youngest age-group in ILO is 15 to 19. The figure shows the age-group according to ILO data.

The red dotted line in Figure 5 shows the vector of coefficients β_a in Feyrer's main specification. All coefficients are negative and significant at typical confidence levels, which means that an increase in the relative size of the 40-49 group is associated with higher productivity. A value of -3.8 for the 30-39 group implies that a 5 percentage point shift from the 30-year age group to the 40-year age group is associated with over a 19 percent increase in per worker output. In our endogenous model, the effect of the labour force age-structure on productivity is calibrated using the results from Feyrer (2007), Table 1, column 2 (also visible in our Figure 5). These coefficients are multiplied by the differential in the shares of labour force age-groups ($\Delta W_{a,i,t}$) to project the growth rate of TFP ($\Delta \log A_{i,t}$).

As the AAM reforms studied in this paper increase the retirement age, we must make an assumption about labour force participation for those individuals in age-groups that were eligible for retirement in the baseline scenario, but that are not under reform scenarios, because their participation can potentially affect growth. For this purpose, first, we calculate the ratio in labour participation between the 60-64 and 65+ age-groups in Argentina. Then, we apply the inverse of this ratio to those individuals that become not eligible for retirement after the reform. As we will see below, given the age-productivity pattern found by Feyrer changes to this assumption have marginal effect on our results.

Figure 6 summarises how a reform that increases the retirement age affects the fiscal balance through the channels in our model. Green arrows indicate channels that improve the balance, red arrows indicated those that worsen it, and blue arrows can have both effects. Yellow arrows are used for channels that are included when growth is made endogenous.

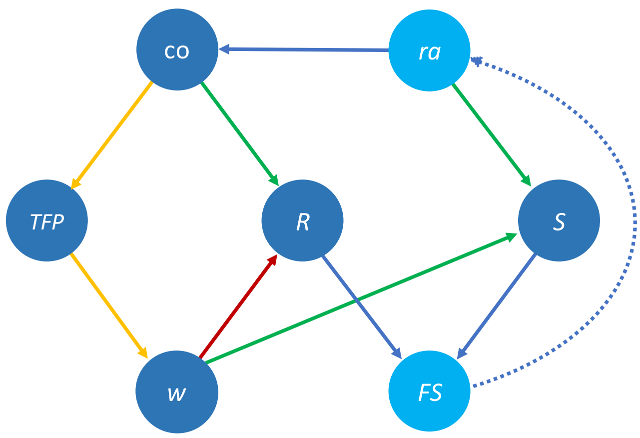

Figure 6 Endogenous model diagram.

Source: Own elaboration.

In our standard model, an increase in the retirement age (ra) decreases the number of beneficiaries, reducing spending (S_t), and increases the number of contributors (co_t), increasing revenue (R_t). Both channels improve the fiscal outlook (FS_t). In the endogenous model, the rise in ra increases the share of older workers, affecting TFP and wage growth rates. If the effect over TFP is negative, wages' growth rate will drop, reducing contributions, thus worsening the fiscal balance. Lower wages also reduce spending, because benefits at retirement and their indexation are determined by wages.[7] Last, the doted blue line shows the connection between the fiscal balance and the retirement age that is activated in the constant balance scenario.

4.2 Results

Figure 7 below summarizes the productivity and demographic dynamics in this section. In the baseline scenario with no change in eligibility parameters, the share of workers above the age of 60 will more than double, from 8.8 to 18.9 percent of the total labour force between 2015 and 2100 (Figure 7.a). However, most of the increase will be compensated by a decrease in younger workers (those below 39). In addition, workers with the average highest productivity according to Feyrer's productivity profile in Figure 7 (those aged 40-49) will peak in 2035 and then slowly decrease. Combining these labour force projections with the productivity profile from Feyrer yields a geometric average TFP growth rate of 0.76 percent between 2015 and 2100 (column two in Figure 7.c), which it is substantially lower than the historical annual TFP growth rate of 1.2 percent.

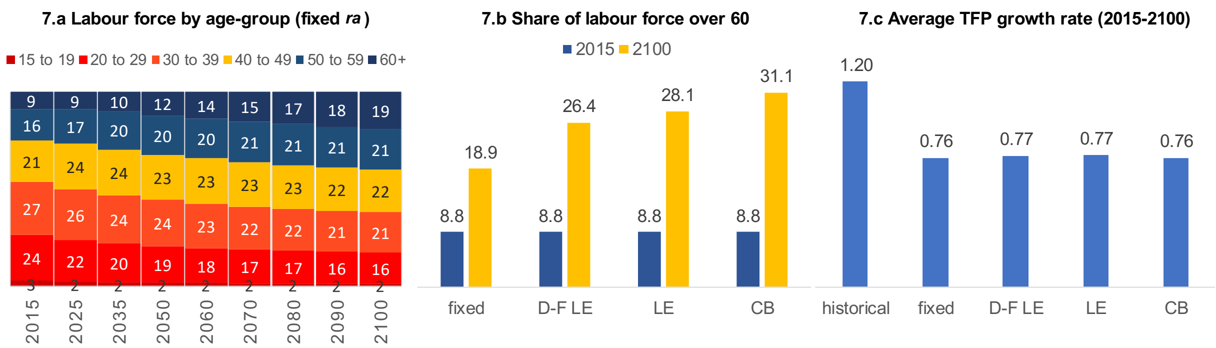

Figure 7 Productivity and demographic dynamics in the endogenous model.

Source: Own calculations.

Note: Panel 4.3.a assumes a fixed retirement age. Disability-free life expectancy (D-F LE), life expectancy (LE), constant balance (CB).

For other scenarios where the AAM raises the retirement age, the share of 60+ workers increases substantially, especially in the constant balance scenario (Figure 7.b). However, in the age-productivity profile found by Feyrer, older workers are less productive than those

[7] The indexation parameter is key to determine the effect of changes in growth over the fiscal balance. As shown in equation 15, if pensions are indexed to wages, the fiscal outlook is not affected by changes in the growth rate of GDP. However, when benefits are indexed to a different rate, e. g. inflation, a decline in growth affects only the calculation of the initial pension.

between 40 and 49, but more productive than all other age-groups. Thus, the increase in the retirement age has a small but positive impact on average TFP compared to the baseline in the endogenous model (columns 3 to 5 in Figure 7.c).

Table 2 shows our indicators of interest (fairness, pension wealth and the fiscal deficit) under the different scenarios and comparing the standard and the endogenous models. It follows from the information on the table that lower economic growth has a negative but minor effect on all indicators. Below we explore the algebra of our indicators to explain why this happens.

Table 2 Indicators of interest under standard and endogenous growth models

Scenario	Fairness		Adequacy (gross pension wealth)		Discounted deficit (2015-2100)	
	Standard	Endogenous	Standard	Endogenous	Standard	Endogenous
Fixed	1.2	1.1	15.5	15.2	192%	200%
Disability-free LE	0.8	0.7	12.9	12.8	128%	134%
LE	0.6	0.5	11.3	11.3	108%	113%
Constant balance	0.5	0.4	9.8	9.8	97%	97%

Source: Own calculations.

The indicator of adequacy, expressed by Equation 8, measures the stream of benefits received by an individual over average wage at retirement. Using Equation 6 we can re-write it as:

$$\frac{PW^c}{w_{ret}} = \frac{\sum_{t=ret}\left[rr_{ret} \cdot w_{ret} \cdot \prod_{t=ret}(1+\gamma_t) \cdot \prod_t \frac{(1-mr_t^c)}{(1+\pi_t)(1+r_t)}\right]}{w_{ret}} \quad (17)$$

To simplify, we replaced sub-index $t - age_c + ret.age_c$ by ret indicating parameters measured at time of retirement. This expression can be further simplified, as w_{ret} is a constant term that appears both in the numerator and denominator. The only remaining place where growth could be present in Equation 17 is the indexation parameter, γ_t. Hence, lower growth can reduce adequacy because it affects the growth rate of pensions for a retired individual. In Argentina, pensions are only partially indexed to wages; hence, slower growth slightly lowers adequacy. The decline would be higher if pensions were totally indexed to wages and null if pensions were indexed to inflation.[8]

Our indicator of fairness can also be re-written using Equation 6. However, the analysis is more complicated than for adequacy because the denominator is determined by the stream of

[8] A key assumption in these dynamics is that wages are a linear function of growth (equation 3). Further research may propose other functional forms for this relationship or even utilize a distribution of wages to explore how inequality affects the sustainability, adequacy, and fairness of pension systems.

contributions paid throughout the life of a worker, which is a function of all wages earned (Equation 18). Thus, a drop in growth lowers the numerator of Equation 18 (pension wealth) but also the denominator (the present value of contributions).

$$F^c = \frac{\sum_{t=ret}\left[rr_{ret} \cdot w_{ret} \cdot \prod_{t=ret}(1+\gamma_t) \cdot \prod_t \frac{(1-mr_t^c)}{(1+\pi_t)(1+r_t)}\right]}{\sum_{t=t-age_c+20}\left[w_t \cdot cr_t \prod_t (1+\pi_t)(1+r_t)\right]} \quad (18)$$

If pensions are indexed to wages, lower growth will most likely reduce fairness because slower growth affects the initial pension ($rr_{ret} \cdot w_{ret}$) and the indexation parameter (γ_t), both factors that determine the value of pension wealth. However, if pensions are not indexed to wages, the outcome will depend on the sign and magnitude of the relationship across time between the labour force age-structure and productivity -i.e. how population ageing affects the trajectory of contributions ($w_t \cdot cr_t$) and the initial pension ($rr_{ret} \cdot w_{ret}$). A strong negative relationship would create a higher differential between wage growth rates while contributing and at retirement; thus, a worsening of fairness by definition.

Last, the easiest way to understand what happens to the fiscal balance when growth changes is by looking at Equation 15. If pensions are indexed to wages, we get $(1 + \rho_t) = (1 + g_t)$; thus, a change in growth does not alter the condition for a constant balance. In other words, the balance is decupled from growth. However, the equation also shows that, if pensions grow at a slower pace a drop in g_t worsens the fiscal balance.

An easier way to understand these dynamics is by looking at changes in benefits and contributions. In our model, lower growth will always deteriorated government revenue, as contributions are carved from wages and wages are linked to growth. However, this is not the case for spending, as benefits are not always indexed to wages. In Argentina, the effect of growth is nuanced because pension benefits are only partially indexed to wages. Table 2 shows that this is the case in all our scenarios, except by obvious reasons, in the constant balance scenario.

4.3 Discussion

As expected, our model shows the trade-off between different objectives of pension systems. All else equal, the higher the retirement age, the greater the improvement in the fiscal balance, and the higher the impact over the adequacy and fairness for pension system participants. Consequently, the model can be calibrated to find the space that meets a series of criteria regarding fiscal and adequacy goals. On one extreme, the model can be calibrated set the retirement age at a level that assures a maximum deficit. On the other, the model could be inversely calibrated, fixing a minimum adequacy and obtaining the associated retirement age and fiscal result.

Our endogenous growth model provides important insights on the interaction between population ageing, productivity, and pension systems. We find limited effects of ageing through the productivity channel over pension indicators; however, the indexation system is a key parameter regulating this relationship. In general, countries where pensions are fully indexed to growth will experience higher variations in fairness, adequacy, and fiscal sustainability due to changes in growth.

The results from the endogenous growth model should be taken with caution, as these are obtained assuming a fix age-productivity profile across time. Part of the literature suggests this relationship may be improving across time, those aged 70 today have the characteristics of those aged 60 in the past. Hence, a fix profile could be interpreted as a wort case scenario.

5 Concluding remarks

The world is undergoing a demographic transition which for many countries entails an increase in the ratio of pension beneficiaries to contributors. In response, many governments adopted AAMs which put the parameters of pension systems in auto pilot, assuring fiscal sustainability even under changes on demographic or economic conditions. Nevertheless, almost any measure that addresses fiscal issues will be to the extent of pension system participants. In this paper, we develop an overlapping generations model that tracks the contributions and benefits of pension system participants by cohort to measure the impact of AAMs on the adequacy and fairness of the system.

We focus on AAMs that increase the retirement age which is the most common type of AAM. Most AAMs affecting eligibility are linked to life expectancy which is an important factor behind population ageing. However, reductions in mortality may not be associated with improvements in non-fatal health characteristics, for example disability. We incorporate the characteristics approach into our model to calibrate our AAM using different health characteristics related to ageing. We look at two different reforms, one that fixes life expectancy after retirement and one that fixes disability-free life expectancy after retirement.

Previous literature has explored the possibility of an endogenous relationship between health and retirement. For our model, this would imply that an increase in the retirement age based on our disability-free or life expectancy scenarios could potentially affect the alpha trajectories. As expected, our model shows the trade-off between different objectives of pension systems. All else equal, the higher the retirement age, the greater the improvement in the fiscal balance, and the higher the impact over the adequacy and fairness for pension system participants.

Population ageing could also affect the fiscal sustainability of pay-as-you-go pension systems through its interaction with productivity. On this issue, our endogenous growth model provides important insights. In general, the three indicators of interest will deteriorate due to decreasing productivity; however, the pension indexation system is a key parameter regulating this relationship: countries where pensions are fully indexed to growth will experience higher variations in fairness, adequacy, and fiscal sustainability due to changes in productivity. These results should be taken with caution, as we assume a fix age-productivity profile across time for the endogenous model.

Finally, we think that there is room for further research. In particular, our model could also be expanded to include within-cohort health heterogeneity. For example, a methodology as the one developed by Tyrowicz et al. (2018) could be used to study the effects of AAM reforms over inequality due differences in disability prevalence. Another natural extension would be to look at other types of AAMs.

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