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AUTOMATIC ADJUSTMENT MECHANISMS AND BUDGET BALANCING OF PENSION SCHEMES

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Abstract

This article is dedicated to the study of the Automatic Adjustment Mechanisms (AAMs) which can be used to monitor pension systems. The objective of the paper is twofold. First, we identify different types of automatic adjustment rules adopted (or which could be adopted) by the main developed countries and we discuss how these adjustments contribute to better solvency. Unfortunately, they are not sufficient to guarantee an intertemporal balanced budget. That leads us to discuss the opportunity to use stronger AAMs: Automatic Balance Mechanisms (ABMs). Second, we build a "smooth" ABM (S-ABM) which would result from an optimal tradeoff between increasing the receipts and reducing the expenditures. The ABM obtains from minimizing an intertemporal cost function under the constraint of an intertemporal budget balance. We then apply this ABM to the case of the United States to evaluate the adjustments necessary to ensure financial solvency. These assessments are made under various assumptions about forecast time horizon, time preference and weighting of social costs associated with increased revenue or lower expenditure.
Keywords: pension scheme sustainability, automatic balance mechanism, dynamic optimization.
JEL codes: C61, H55, H68.

Introduction

Most of governments are reluctant to reform the national pension systems because they fear this might induce too high political costs. In effect, the political debate about the pension issue may often be a source of conflicts (Blanchet and Legros, 2002; Marier, 2008; Weaver and Willén, 2014; Wisensale, 2013). As a consequence, the governements tend to procrastinate and to postpone the adoption of measures that would guarantee solvency. Of course, faced with the emergency of the insolvency of their pension systems, all governments have made reforms - some of them very deep - but without setting restoring forces. The problem with *ad hoc* reforms is that, quoting Turner (2009), "(they) have a high degree of political risk because their timing and magnitude are unknown".

To avoid the future states of the pension system to depend on choices that politicians would not take willingly, two types of strategies are used by governments. First, delegate the management of the pension systems to competent and independent authorities. Second, introduce specific and mandatory rules to allow for automatic adjustment mechanisms (AAMs). These AAMs would guarantee the solvency of the system at any date without requiring political intervention and avoiding the "need for large program changes made in crisis mode" (Turner, 2009).

Turner (2009) clearly defines the concept of automatic adjustments. He shows how in practice many parameters (pension, eligibility age, etc) are indexed on changes in life expectancy, consumer price index or wage growth, etc. In general, AAMs allow to reduce the gap between receipts and expenditures, but cannot guarantee a perfectly balanced budget. Turner reviews some of their applications to twelve high-income countries, categorized in five groups. First, countries with traditional pay-as-you-go (PAYG) systems with life expectancy indexing (LEI) of pension benefits: Portugal, Finland and Norway. Second, countries with pension systems relying both on NDC and LEI of benefits: Italy and Poland. Third, countries using LEI of the earliest age at which social security benefits can be received: United Kingdom and Denmark. Fourth, countries with AAMs tied to solvency: Sweden, Germany, Japan, Canada. Fifth, countries that automatically adjust other parameters of their social security systems, such as the years of contributions required for a full benefit: France.

The implementation of AAMs requires not only straightforward and clear choices about transfers between generations, but also strong social acceptance. Sweden is considered as a major pioneer of AAMs since it adopted Notional Defined Contributions (NDC) plans in 1994. This led the Swedish government to introduce actuarial rules to compute individual pensions, relying on regular and fair revisions of the conversion coefficients for annuities. Later, to reinforce the robustness of the system, an Automatic Balance Mechanism (ABM) was launched that relies on the key rule that the solvency of the pension system must be checked every year, thanks to the flexibility of the present and future pension benefits (Settergren, 2001). The return of the "savings" invested in the NDC crucially depends on this indexation (Settergren and Buguslaw, 2005).

As to the U.S. government, it launched as early as 1983 a radical long run reform (mainly by increasing the payroll taxes and raising the full pension age). This reform prevented a pending Social Security crisis and potentially guarantees an intertemporal balanced budget for about half a century. Nethertheless, as stressed by Aaron (2011), the weakness of this reform is that it "virtually guaranteed the return of deficits and a funding gap, and the need for further legislation to close it". Notice that the U.S. Social Security trust funds are not allowed to borrow. This financial and legal constraint is a strong incentive to plan surpluses to compensate anticipated deficits, acting as a credible restoring force.

The purpose of this paper is twofold. First, it characterizes the properties of the Automatic Adjustment Mechanisms. Second, it proposes a general form of Automatic Balance Mechanism based on the intertemporal minimization of a loss function. Our analysis both shows how the "simple" AAMs contribute to a better solvency and details their intrinsic limitations. In contrast, the Automatic Balance Mechanisms appear as more elaborated and efficient devices to guarantee long run solvency. We show this requires to define a measure of the intertemporal budget balance (for example U.S. actuarial balance or Sweden balance ratio), to fix the time horizon and to adopt a criteria to be optimized.

The main advantage of our model of "optimal" adjustment is its ability to analyse various configurations in terms of ABMs. For instance, the Swedish ABM can be interpreted as a particular solution. Our "smooth" ABM (hereafter denoted S-ABM) relies on the use of distortion indices, which makes it easy to be implemented in a realistic and practical perspective. Smooth, gradual adjustments replace immediate and abrupt changes, enhancing their short-term political acceptance.

In the following, we first define the intertemporal pension budget constraint. Second, we address the issue of AAMs: what are their roles in adjusting, stabilizing and balancing? Third, we build a "smooth" ABM, assuming a trade-off between present and future receipts and expenditures. Finally, we apply this ABM to the U.S. Social Security. The last section concludes.

1 The intertemporal pension budget constraint

At the current period ($t = 0$), the forecast expenditures and forecast receipts at time t are respectively denoted EXP_t and REC_t. Assuming negligeable administration costs, EXP_t can be computed as follows:

$$EXP_t = E_0 \left(\sum_{j \in \Omega_t^R} p_{j,t} \right) \tag{1}$$

where Ω_t^R is the set of retirees for period t and $p_{j,t}$ is the pension paid to each individual j. REC_t is given by:

$$REC_t = E_0 \left(\tau_t \times \sum_{k \in \Omega_t^E} w_{k,t} \right) \tag{2}$$

where Ω_t^E is the set of employees at period t, $w_{k,t}$ is the annual sum of monthly taxable wages paid to each worker k and τ_t is the payroll tax rate for period t.
The intertemporal budget balance of the pension system writes:

$$R_t \cdot F_{t-1} + REC_t = EXP_t + F_t \tag{3}$$

where R_t is the riskless interest factor and F_t the forecast value of the financial asset (reserve fund) for period t.

What about solvency? From an accountancy point of view, the implicit liabilities and solvency of unfunded pension systems can be estimated by different methods (Blanchet and Ouvrard, 2007). In practice, two measures of solvency are generally used.

The first is an assessment of the discounted sum of revenues and expenditures. This valuation approach is used in the United States to assess the present value of the underfunding of the system. This value, called "unfunded obligation", gives a financial (absolute) estimation of the tax gap. The US Social Security Administration defines the Unfunded obligations (UO) as: "the excess of the present value of the projected cost of the program through a specified date over the sum of: (1) the value of trust fund reserves at the beginning of the valuation period; and (2) the present value of the projected non-interest income of the program through a specified date, assuming scheduled tax rates and benefit levels". At the current period $t = 0$, the unfunded obligations compute as follows:

$$UO_0 = \sum_{t=1}^{T} \frac{EXP_t - REC_t}{\Pi_{i=1}^{t} R_i} - F_0 \quad (4)$$
$$= -\frac{F_T}{\Pi_{i=1}^{T} R_i}.$$

Sweden has opted for another method: the asset-liability approach (Settergren, 2001). It defines its pension plan as solvent when:

Present value of contributions payable by current workers
+ Value of the reserve fund
=
Value of pension commitments towards current generations.

Solvency issues have been investigated by Vidal-Melia and Boado-Penas (2010). They precise the connection between the contribution asset and the hidden asset (similar to the equivalent concepts of "hidden tax", "implicit tax on pensions" or "PAYG asset" used in the literature) to evaluate whether using either of these to compile the actuarial balance in PAYG pension systems would provide a reliable solvency indicator. The contribution asset can be interpreted as the maximum level of liabilities that can be financed by the existing contribution rate without periodic supplements from the sponsor, *ceteris paribus*. The hidden asset is the present expected value of the hidden - or implicit - taxes that the system will apply to its participants in the future, defined as contributions in excess of those that would be needed by a capitalized system to pay the same benefits. The authors scrutinize the Swedish "actuarial balance" to identify the elements characterizing these two concepts. They find that only the contribution asset is applied. That leads them to qualify the hidden asset as only a theoretical device, mainly because its computation requires projections of economic, demographic and financial variables.

The tax gap ratio (TG) is another interesting concept and a simple measure of the unsolvency of pension scheme. TG can be measured in two ways:

$$TG_A = \frac{\sum_{t=1}^{T} \frac{EXP_t}{\Pi_{i=0}^{t} R_i} - F_0}{\sum_{t=1}^{T} \frac{REC_t}{\Pi_{i=0}^{t} R_i}} \quad (5)$$

or

$$TG_B = \frac{\sum_{t=1}^{T} \frac{EXP_t}{\Pi_{i=0}^{t} R_i}}{\sum_{t=1}^{T} \frac{REC_t}{\Pi_{i=0}^{t} R_i} + F_0} \quad (6)$$

The TG_A measures the excess of the net-of-reserve expenditures with respect to the receipts. The TG_B measures the excess ot expenditures with respect to the net-of-reserve receipts. These ratios can be compared to implicit debt/notional asset ratios.

The general problem of the social planner or the government is how to adjust parameters (payroll tax rate, pension levels, employment and retirees rates) with time. Adopting automatic adjusment rules implies choosing a law of motion for parameters as a function of economic, financial or demographic variables.

2 Automatic rules: adjusting, stabilizing and balancing

2.1 How the Automatic Adjustment Mechanisms (AAMs) contribute to stabilizing pension schemes

With the AAMs, the institutional parameters are adjusted according to the predefined rules. Otherwise, the changes are considered as discretionary decisions and are likely to depend on the hazards of political choices.

Choosing a specific Automatic Adjustment Mechanism requires to specify several elements (see Bosworth and Weaver, 2011):

- Legitimate the rules according to the example "one objective, one tool." That implies identifying objectives and tools (parameters). Main objectives concern equity, social justice and solvency.

- Choose the frequency of review/assessment.

- Define the elements on which the adjustments are made.

- Set adjustments as *ex ante* based on expectations (prediction-based) or *ex post* based on the states of nature.

- Fix the degree of automaticity: up to which level the adjustments are mandatory (no questioning), which guarantees credibility of the process.

There are several adjustment parameters:

(i) Benefit index: The main objective of the latter is to preserve the level of quality of life. In general, the CPI is used and it permits to maintain the purchase power of the pension. Moreover, when the benefit index is equal to the factor of wage growth, the relative purchase power between workers and pensioners is maintained. Indexing on CPI can have a positive effect on the solvency because the gap between current wages and pensions increases with time. However, the economic crisis may imply that nominal wages growth be lower than inflation.

(ii) Contributory period: To obtain a full pension requires to validate a sufficient number of quarters. The duration of the assessment period can be connected to life expectancy.

(iii) Retirement age ("normal" or minimum): The minimum age is the age at which workers can liquidate their pensions. The normal retirement age is the age which serves as a reference to define the full pension. Generally, the adjustment is not automatic but planned by law (US, France). In practice, with a given frequency, these ages could be revised with new informations about changes in life expectancy for each cohort.

For example, Capretta[1] (2006) recalls the suggestion by Steuerle and Penner (2005) to start the process of automatic adjustments in the U.S. social security by setting the normal retirement age administratively, taking into account the increase in life expectancy, hence mimicking the Swedish NDC's annuity divisor device. However, according to Capretta, it may be easier for the U.S. to adopt an adjustment factor similar to Germany's "sustainability factor". He insists that Congress would be more likely to adopt a mechanistic provision that would automatically guarantee future generations of retirees the same number of years, on average, in benefits as the current generation - automatically.

(iv) Pension-earnings links: The links between pension and earnings can be defined according to two approaches: defined contribution (DC) or defined benefit (DB). In a defined contribution pension scheme, as in Sweden, the coefficient of conversion of capital into an annuity can depend on the age and birth year and this coefficient can be revised to reflect the evolution of generation mortality tables and life expectancy (Life Expectancy Index). In the case of defined benefit (as in US, France or Germany), a replacement rate is used to convert average life-cycle wage into a pension. To control this replacement rate, the main adjusment parameter is the number of years to validate to obtain a full pension (maximal value of the replacement rate). Additionally, the legislator can reward (bonus) long career or penalize (malus) short career. Generally, the changes are planned and based on ex ante expectations: 1983 law in US, 1993 so-called Balladur reform in France (Blanchet

[1] Capretta (2006) considers the examples of Sweden and Germany to address the issue of automatic solvency of the U.S. Social Security. He stresses that, although correcting for longer life spans helps stabilize costs, it is not sufficient to assure solvency at a fixed contribution rate, as fertility and population growth, labor force participation patterns, and productivity growth all play important roles in long term pay-as-you-go financing. As a result, Sweden adopted an ABM, whereas Germany links annual pension indexing to changes in the ratio of pensioners to workers supporting the system, the so-called "sustainability factor".

and Legros, 2002).

2.2 Towards stronger AAMs: Automatic Balance Mechanisms (ABMs)

2.2.1 Definition

What happens if AAMs are not stabilizing enough? A solution consists in adopting a clear obligation of financial sustainability in a finite time: Automatic Balance Mechanisms (ABMs). Bosworth and Weaver (2011) consider the "automatic stabilizing mechanisms" (ASMs) permits the Social Security to be operating on "auto-pilot". In 2001, Sweden is the first country to opt for one type of Automatic Balance Mechanisms (ABMs).

The choice of an ABM raises four major issues:

- How is defined the pension budget balance[2]?

- What are the criteria for choosing changes in current law?

- What room is left for optimization?

- What planning time horizon for full balancing? The difficulty is to define a reference horizon and the frequency of the automatic adjustments.

As the AAMs, the Automatic Balance Mechanisms can be determined:

- Ex ante: demo-economic shocks are anticipated and changes in law are planned.

- Ex post: the law evolves with the knowledge of the states of nature. Changes concern the pension formula parameters and the contribution rate.

With ABM, the adjustment should result in incremental changes. Indeed, it is hoped the AAM lead to sufficient adjustments and contribute to a better financial balance. The ABM is an ultimate setting that should be expected to be marginal. At each period, the "ideal" timing ought to be:

- First step: the public planner sets the values of the pension parameters;

- Second step: she checks the solvency of the pension schemes;

- Third step: she uses ABM to recalibrate some parameters.

An interesting illustration of two polar ABMs can be computed from the tax gap ratio (see above): a full adjustment operated by receipts by indexing payroll tax on TG_A or a full adjustment operated by receips by indexing pension amount on TG_B^{-1}. Kotlikoff (2011) notices for the US Social Security: "Since the system's \$16 trillion infinite horizon fiscal gap is 3.3 percent of the \$483 trillion present value of its taxable wage base, the system is 27 percent ($0.27 = 0.033/0.124$) underfunded; that is, we could immediately

[2]For example, in Canada and Sweden, the ABM adoption "was preceded by explicit legislative actions to create an initial reference of financial sustainability" (Bosworth and Weaver, 2011).

and permanently raise the FICA contribution rate by 27 percent and make Social Security solvent" or "Another way is to cut Social Security benefits immediately and permanently by 20 percent".

2.2.2 The Swedish NDC experiment: reinforcing AAMs by introducing an explicit ABM

Sweden is only interested in working generations alive today, in their current acquired rights and their contributions they will perform in the future. The implicit prediction horizon is the maximum life length of the younger generation of workers. Sweden has adopted a full adjustment mechanism where a global index on pension benefits is used to guarantee each year an intertemporal budget balance which is computed as the equality between the discounted sum of current and future payroll taxes and the implicit liabilities net of the reserve fund. The notional accounts give each individual a virtual accumulated capital which is made of the sum of his contributions "virtually" revalued annually by the real growth rate of the national average wage. Note that the virtual capital is discounted at rate i. In fact, i is a forecast of the future average growth rate of the average wage in the economy. This approximation has been set at 1.6% per annum. What mechanisms to balance the pension system, then? Respecting the relative standard of living of retirees is ensured by the indexation of pension capital and the growth rate of average wages. This implies two things:

- On the one hand, the forecast growth rate (discount rate equation given by the board) is accurate. From this point of view, a balancing mechanism is provided which is effective only if the reality deviates from the performance by 1.6% and pensions are adjusted accordingly[3].

- On the second hand, the employment rate is stable. It is clear that any economic crisis will involve a balancing mechanism consistent (all things being equal) with the equation. This will necessarily lead to give up the indexation of pensions on the average wage increase.

This de-indexation is specifically activated when the amount of resources in the system consists in the total assets of the reserve fund and virtual assets is less than the sum of accumulated pension rights. Sunden (2009) shows the evolution of this balance ratio from 2002 to 2008. This unfavorable change led to the downward indexation of pensions. The principle of this de-indexation is to activate the reserve fund. The interesting point is probably wondering what can induce an intertemporal unbalance. In fact, at the steady state, the collected contributions should be equal to the sum of the promises made

[3] In passing, the case of a negative difference was not considered (Sunden, 1998).

by the pension plan.

When adding up the amount of reserves, the amount of resources should exceeds liabilities by far. Therefore, it is necessary to have both a depressed economy and low financial rates of return to achieve a low indexation.

The challenge of the increase in life expectancy is clearly taken into account by inserting an explicit conversion rate in the actuarial formula for calculating pensions. They are actuarially neutral, varying by cohort and age at which the individual retires.

However, since the indexing rate of pensions may vary, several combinations exist between index and life expectancy which give the same conversion rate. As we have said very clearly this questions the strict actuarial neutrality regime.

The challenge of the size of generations is taken into account by the adjustment mechanism as well as the variability of the employment rate. Lassila and Tarmo (2007) show that fertility breaks may be taken into account by the mechanism.

However, the Swedish model has a major flaw. When the 2008 economic and financial crisis inferred both a capital loss in the reserve fund and a reduction in the growth of revenue, the Swedish capital ratio fell below the critical value of 1. The amount of pensions was reduced in order to return to balance. This kind of immediate adjustment generates a permanent effect and may be rough when applied for the first time. Consequently, it could be interesting for the legislator to take into account time preference. To this effect, the Swedish government has proposed to reduce taxes levied on pensions. In addition, the pension plan has decided to spread the adjustment over three years. We can therefore conclude that, in case of difficulty, the adjustment rules are modified in a discretionary manner. Another interpretation is that the pension system is still in control and that the crisis has raised difficulties which had not been anticipated before.

2.2.3 The US Social Security fiscal cliff with an automatic and rough adjustment by pension

From a prospective point of view, the Social Security Act requires that the Board of Trustees of the Federal Old-Age and Survivors Insurance (OASI) and Disability Insurance (DI) Trust Funds publishes to the Congress an annual report on the actuarial and financial state of the PAYG. The U.S. Social Security administration opted for a 75-year time horizon. The 75-year annual forecast of Board of trustees (2013) permits a thorough analysis of the solvency. Notably, this report gives an estimation of the year when the system reaches bankruptcy: 2035 for the OASI trust fund and 2016 for the DI trust fund. After this critical year, in the absence of corrective governmental measures, the adjustment -obligation to reduce pensions to achieve a financial balance between pension payments and social contributions- is automatic and brutal because the U.S. Social Security trust funds do not have the right to borrow. The case of U.S. Social Security budgetary rule is interesting since it must comply with a rule that prohibits debt. Therefore, this means that the system can make it if the deficit has previously achieved surpluses. When the reserve fund is exhausted, the adjustment is immediate and rough because of the bankruptcy of the pension scheme. Social Security can only pay pensions at the height of its revenue, which, *de facto*, means a sharp decline in pensions. In 2013, the prudential objective by the Social Security Trustees is straighforward and it justifies a minimal reserve fund to smooth the adjustements:

(i) "The Trustees consider the trust funds to be fully solvent if the funds can pay scheduled benefits in full on a timely basis. A standard method of assessing solvency is the "trust fund ratio," which is the reserves in a fund at the beginning of a year (which do not include advance tax transfers) expressed as a percentage of the cost during the year. The trust fund ratio represents the proportion of a year's cost which the reserves available at the beginning of that year can cover. The Trustees assume that a trust fund ratio of 100 percent of annual program cost provides a reasonable "contingency reserve.""

(ii) "Maintaining a reasonable contingency reserve is important because the trust funds do not have borrowing authority. After reserves are depleted, the trust funds would be unable to pay benefits in full on a timely basis if annual revenue were less than annual cost. Unexpected events, such as severe economic recessions or large changes in other trends, can quickly deplete reserves. In such cases, a reasonable contingency reserve can maintain the ability to pay scheduled benefits while giving lawmakers time to address possible changes to the program."

2.2.4 The canadian second pillar: an automatic adjustment by contribution scattered by the absence of political choice

In Canada, the second pillar is made of two mandatory partially funded plans: Canadian Pension Plan (CPP) and Quebec Pension Plan.

Statutory periodic reviews of the CPP are made from once every 5 years to once every 3 years, where financial status of the CPP is analyzed. Recommendations are given as to whether benefits or contribution rates, or both, should be changed. One of the main sources of information for the reviews is the actuarial report on the CPP by the chief actuary. Best-estimate assumptions are made without any provisions for adverse deviations, to avoid bias w.r.t. either current or future generations. CPP reports are reviewed by an independent panel of Canadian actuaries.

The financial sustainability and intergenerational equity of the pension plan are closely monitored. Recent changes to the CPP aim at a better intergenerational fairness. One of these changes consisted in restoring CPP pension adjustment factors to their actuarially fair value, which implied both subsidiarizing early benefit uptake and penalization of late benefit uptake (after age 65).

Canada's "self-adjustment mechanism" previews the simultaneous increase in contribution rate and the temporary freezing of the indexation for retirees.

The ABM applying to the CPP is such that, if in the current actuarial valuation, legal contribution rate is lower than the minimum contribution rate and no agreement can be reached between federal and provincial finance ministers to increase or maintain the legislated rate, then, for a 3-year period, the contribution rate is increased by half of the difference between the two rates, and the pension benefits are frozen until the next actuarial review. This procedure is called "insufficient rates provisions" which, in the case of CPP, plays as an ABM. Sakamoto (2013) stresses that one of the advantages of this ABM specific to CPP is to "make policymakers conscious of intergenerational fairness". But, on the other hand, since it is activated only when the federal and province finance ministers do not reach an agreement, "it is unlikely that (it) will be activated" in practice.

2.2.5 Two similar national experiences

In Germany, the 2004 reform has adopted a "partial" ABM to control the first pillar pension scheme. Normally, pensions are indexed on the average wage net of the payroll tax. The new formula introduces a "sustainability factor" which is computed as following:

$$SF_t = 1 + \alpha \cdot \left(\frac{\Delta DR_{t-1}}{DR_{t-2}} \right) \tag{7}$$

where $DR_t = \frac{\text{Number of retirees at date } t}{\text{Number of workers at date } t}$ is the dependency ratio. α "represents the degree to which the increase of maturity rate is reflected in reducing the indexation" (Sakamoto, 2013). The current value of α is 0.25. Sakamoto (2013) considers that this "partial" ABM presents three major advantages : high efficiency to restore the financial equilibrium; simplicity to use without changing crucially the benefit formula; guarantee on the stability of contribution rate for workers. On the contrary, he notes that the perspective of a perennial reducing of the pension benefit could be source of "anxieties".

Japan makes predictions every 5 years on a 95-year horizon and computes the intertemporal solvency with respect to this horizon (Sakamoto, 2005 and 2008 ; Fujisawa and Siu-Hang Li, 2012).

In Japan, the 2004 reform adopts an automatic balancing mechanism which modifies the normal indexation by introducing a "modifier". The normal indexation is based on the the per-capita net earnings. The modifier index is the sum of two components (Sakamoto, 2005) : the "rate of decline of active participants to the social security pension schemes" and the "yearly increase rate in life expectancy at age 65". The modified indexation is obtained by subtracting the modifier from the normal indexation.

The modifier is activated if two conditions are checked (Sakamoto, 2013):

- the 95 years financial projections of the social security are unbalanced;
- the inflation and real wage growth rates are positive.

Since the 2004 reform, the Japanese economy has been deflationary, which means the modified indexation procedure has not been activated.

Sakomoto (2013) remarks that the modifier indexation is similar to the German sustainability, which implies identical advantages. The main flaw of this partial ABM is the inflationary nature of the activation criteria: the longer the period of deflation, the longer before the rule is activated.

3 In search of a smooth ABM (S-ABM)

For sake of simplicity, we present a non stochastic approach of ABMs. The computations are based upon given forecast values of receipts (REC_t) and expenditures (EXP_t). Also, the estimated adjustment variables should be considered as forecast values for the current period. In practice, these variables would have to be revised as the forecasts will adjust with time.

We build a simple model[4] based on intertemporal optimization called “smooth automatic balance mechanism” (S-ABM). The objective function is defined as a quadratic loss function. Quadratic cost functions are commonly used in the analysis of monetary policy (Svensson, 2003). A similar approach applied to retirement has been developed by Berger and Lavigne (2007). Though interesting, their approach is limited. In effect, the adjustment they propose relates solely to the contribution rate, and the social cost is measured by the square of the change in each period. Moreover, they do not introduce intertemporal discount, which discards the possibility of procrastination. The dynamic optimization problem we tackle contemplates two possible adjustment modes, respectively by costs and/or by revenues,

[4] An application of our model to the French PAYG system is presented in Gannon et al. (2014).

and time preference is accounted for. With an ABM, the adjustment should result in incremental changes. Indeed, the AAM is expected to command adjustments which are sufficient and which contribute to a better financial balance. The ABM is an ultimate setting that should ideally be thought to be marginal. Of course, it would be very naive to think that minimizing a quadratic loss function could be sufficient to capture all the problems related to the adjustment of the pension system. However, this analytical approach expresses in a straightforward and simple way the idea of smoothing the changes in the current legislation.

The value of the loss associated to each period is measured by:

$$LF_t = \alpha \cdot (A_t - 1)^2 + (1 - \alpha) \cdot (B_t - 1)^2 , \tag{8}$$

where A_t and B_t are two deformation coefficients which modify respectively the present and future payroll tax rates (receipts) and pension benefits (expenses) relatively to those established by the current law. α (resp. $1 - \alpha$) is the social weight given to the revenue (resp. expenses) adjustment[5]. $(A_t - 1)$ and $(B_t - 1)$ measure the relative gap with respect to the current legislation. This loss function captures the fact that changing parameters is costly (both socially and politically) and that, by minimizing it, the social planner seeks to limit changes. The social planner sets a time horizon T to balance the sum of discounted receipts and the sum of discounted expenditures:

$$\sum_{t=1}^{T} \frac{A_t \cdot REC_t}{\Pi_{i=1}^{t} R_i} + F_0 = \sum_{t=1}^{T} \frac{B_t \cdot EXP_t}{\Pi_{i=1}^{t} R_i}. \tag{9}$$

The optimizing program is based on a sum of discounted losses:

$$\begin{cases} \min\limits_{\{A_t, B_t\}} \sum_{t=1}^{T} \left(\frac{1}{1+\delta}\right)^{t-1} \cdot LF_t \\ s.t.\ (9) \end{cases} . \tag{10}$$

where δ, assumed constant, is the public rate of time preference.

The first order conditions are:

$$\begin{cases} A_t : \left(\frac{1}{1+\delta}\right)^{t-1} \cdot 2 \cdot \alpha \cdot (A_t - 1) = \psi \cdot \frac{REC_t}{\Pi_{i=1}^{t} R_i} \\ B_t : \left(\frac{1}{1+\delta}\right)^{t-1} \cdot 2 \cdot (1 - \alpha) \cdot (B_t - 1) = -\psi \cdot \frac{EXP_t}{\Pi_{i=1}^{t} R_i} \end{cases} . \tag{11}$$

[5] For reason of simplification of our analysis, this parameter is denoted identically as the adjustement degree by pension.

where the Lagrange multiplier ψ measures the social value of the marginal slacking of the budget constraint. The problem is well behaved and the second order conditions are checked by strict quasi-concavity.

Proposition: *A smooth-ABM can be implemented by applying the two following rules:*

(i) *Estimation of the final adjustment target at time* $t = 0$:

$$\left\{ \begin{array}{l} A_T = 1 + UO_0 / \sum_{t=1}^{T} \left(\frac{REC_t^2 + \frac{\alpha}{1-\alpha} \cdot EXP_t^2}{\Pi_{i=1}^{t} R_i \cdot REC_T} \cdot \left(\frac{\Pi_{i=t+1}^{T} R_i}{(1+\delta)^{T-t}} \right) \right) \\ B_T = 1 - \frac{1-\alpha}{\alpha} \cdot (1 - A_T) \end{array} \right. , \tag{12}$$

(ii) *Convergence rule to the final adjustment target*:

$$\left\{ \begin{array}{l} (A_t - 1) = \frac{REC_t}{REC_T} \cdot \frac{\Pi_{i=t+1}^{T} R_i}{(1+\delta)^{T-t}} \cdot (A_T - 1) \\ (B_t - 1) = \frac{EXP_t}{EXP_T} \cdot \frac{\Pi_{i=t+1}^{T} R_i}{(1+\delta)^{T-t}} \cdot (B_T - 1) \end{array} \right. . \tag{13}$$

Proof: see appendix.

From these adjustment processes, we deduce the forecast dynamics of the reserve funds:

$$F_t = A_t \cdot REC_t - B_t \cdot EXP_t - R_t \cdot F_{t-1} \tag{14}$$

In other words, the revision of the current levels of receipts and expenditures evolves approximately as follows:

$$\left\{ \begin{array}{l} A_t \simeq 1 + \left(1 + \left(r_{t+1} - \delta - g_{t+1}^{REC}\right)\right) \cdot (A_{t+1} - 1) \\ B_t \simeq 1 + \left(1 + \left(r_{t+1} - \delta - g_{t+1}^{EXP}\right)\right) \cdot (B_{t+1} - 1) \end{array} \right. \tag{15}$$

where g_t^{REC} and g_t^{EXP} are respectively the receipts and expenditures growth rates.

This adjustment rule is characterized by the following propriety: when $A_{t-1} > 1$ (i.e. receipts increasing) and $B_{t-1} < 1$ (i.e. expenditures decreasing), then $A_t > A_{t-1}$ and $B_t < B_{t-1}$ iff the growth rates of the receipts and of the expenditures are greater than the interest rate net of the present preference. That means that the absolute adjusments increase with time.

This maximizing problem may be completed by adding constraints on the level of the reserve fund ($F_T > 0$, for a terminal constraint or $F_t \geq 0$ $\forall t$ if no debt constraint) or the adjustment parameters ($\tau_t \leq \tau_{\max}$ as for example in Germany).

Our results can be interpreted in three ways:

(i) A_t and B_t can induce practical implications in terms of pension reforms. They define distances to a fixed target in terms of payroll taxes (receipts) and pension benefits (expenditures);

(ii) Measuring A_t and B_t would allow to show how much the pension schemes are unbalanced in the long run;

(iii) Revealed preferences: reforms imply changes in legislation. The levels of expenditures and receipts are modified with respect to a previous scenario without reform. Assuming A_t and B_t to be measured with accuracy would associate public decisions with an implicit function of public preferences.

For example, supposing a full equivalence in the measures of the financial sustainability, the Swedish case can be interpreted as the result of the following parameter choices:

$$\left\{ \begin{array}{l} \alpha \rightarrow 1 \text{ (no adjustment by receipts)} \\ \delta_t = r_t - g_t^{EXP} \text{ (flat adjustment)} \end{array} \right. . \tag{16}$$

These values of parameters imply:

$$\left\{ \begin{array}{l} A_T = ... = A_t = ... = A_1 = 1 \\ B_T = ... = B_t = ... = B_1 < 1 \end{array} \right. . \tag{17}$$

4 Applying the S-ABM to the U.S. Social Security

4.1 Sensitivity analysis

As mentioned earlier, the Board of trustees of the U.S. federal OASDI trust funds (2013) publishes annual forecasts with a 75-year horizon. This forecast of the US Social Security comprises three scenarios: pessimistic (high-cost), optimistic (low-cost) and middle (intermediate). This publication plays an important part, because it gives a clear idea of the likely survival duration of the pension system. In this section, we look at what the use of ABM requires in terms of increased revenues and spending cuts. In our computations, we use the forecast obtained with the intermediate scenario.

We consider several parametric variants in the forecast horizon, the time preference, the weight of social adjustment by revenues (versus expenses).

Figures 1, 2 and 3 respectively show parametric variants.

Figure 1 shows the profile of A and B for variants in the social weight (given respectively to revenue and expenditure) with $\delta = 0.025$ and $T = 75$.

Choosing α is a crucial political decision because it determines the share of the fiscal burden between workers ("young") and pensioners ("old"). Not surprisingly, the adjustment of expenses is more demanding for high values of α and conversely, the adjustment of revenues is more demanding for low values of α. For example, if $\alpha \to 0$, $B_1 \to 1$ and $B_T \to 1$ and $A_1 \to 1.1$ and $A_T \to 1.32$. That means an increasing of tax rate of 10% in the short run $(t = 1)$ and 32% in the long run $(t = T = 75)$. If $\alpha \to 1$, $A_1 \to 1$ and $A_T \to 1$ and $B_1 \to 0.933$ and $B_T \to 0.734$. That means a decrease in pensions of 6.7% in the short run $(t = 1)$ and 26.6% in the long run $(t = T = 75)$.

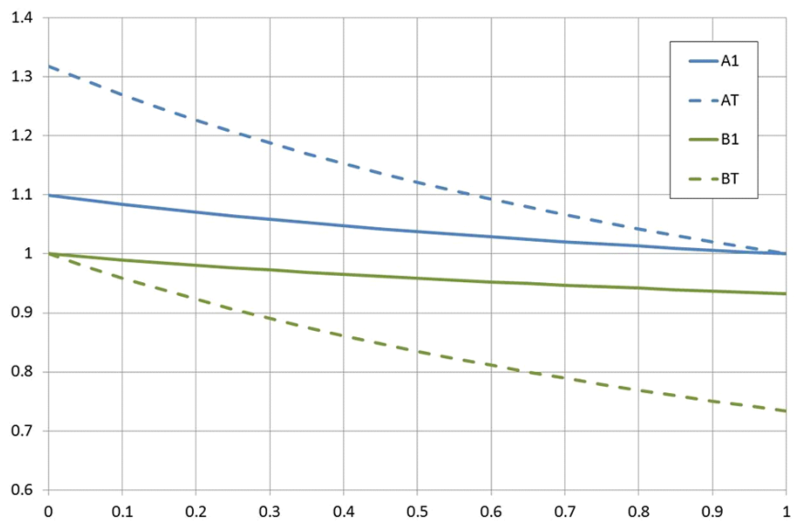

Fig. 1. Sensitivity to the social weighting (α)

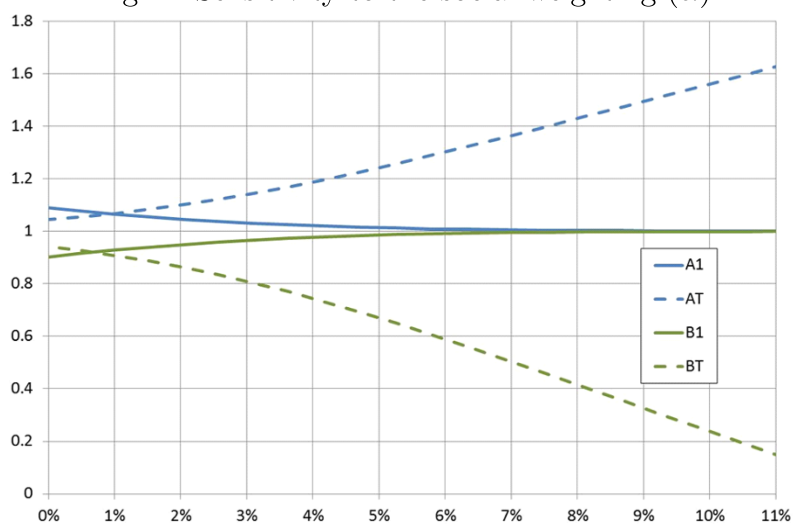

Fig. 2a. Sensitivity to the time preference (δ)

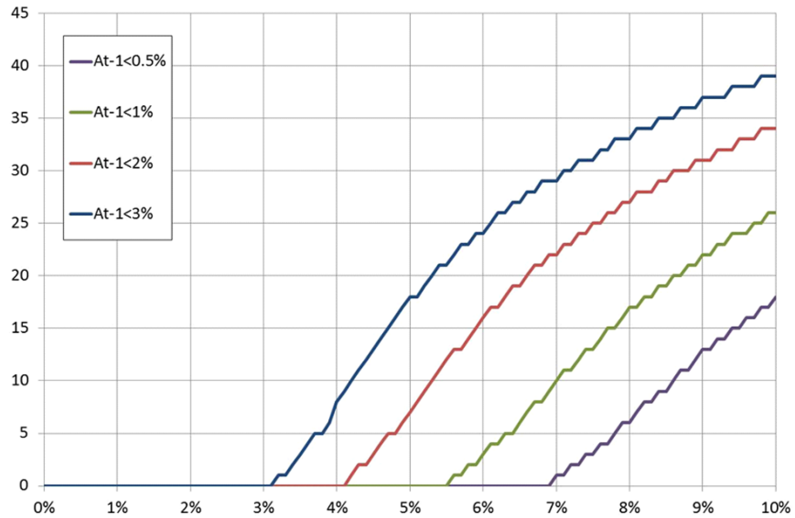

Fig. 2b. Sensitivity to the time preference:
Time lag - or procrastination duration - before a significant adjustment (A_t)

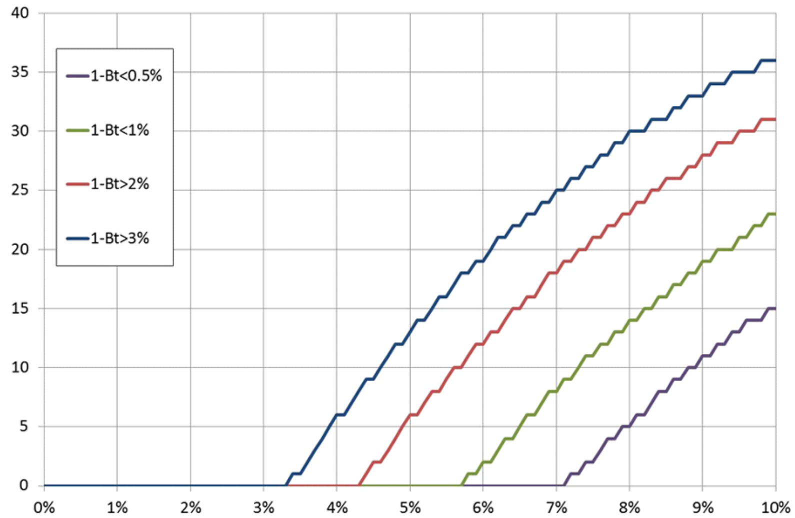

Fig. 2c. Sensitivity to the time preference:
Time lag - or procrastination duration - before a significant adjustment (B_t)

Variations in time preference (δ) clearly show the consequences of postponing adjustment mechanisms. Delaying adjusment induces very high adjustment costs in the future. The gap between short run and long run adjustment ($A_T - A_1$ or $B_T - B_1$) increases exponentially with δ. For example, if $\delta > 10\%$, the gap exceeds 70% for B and 50% for A. Conversely, if $\delta < 2\%$, the gap is less than 5% for B and 8% for A.

Values of δ greater than 9% require more than ten years for adjustments of A and B above 0.5%. Values of δ greater than 7.5% require more than ten years for adjustments of A and B greater than 1%. Values of δ greater than 5.5% require more than ten years for adjustments of A and B greater than 2%. Values of δ greater than 4.5% require more than ten years for adjustments of A and B greater than 3%. Note that if δ is weak ($< 0.75\%$), the adjustment is stronger in the short run than in the long run.

The U.S. pension system performs surpluses until 2032 (intermediate scenario forecasting). Afterward, the U.S. government will be forced to reform (tax increase or decrease in pensions). The longer the horizon, the more the planner integrates imbalance. This means that the adjustments are very sensitive to time horizon. For a 25-year time horizon, the present value of the unfunded fraction of the liabilities is low. It increases with the forecast horizon.

Increasing T has two cumulated effects:

- taking into account a larger period of deficit (A_t and B_t are larger);
- discounting more the value of last period (A_T and B_T are larger).

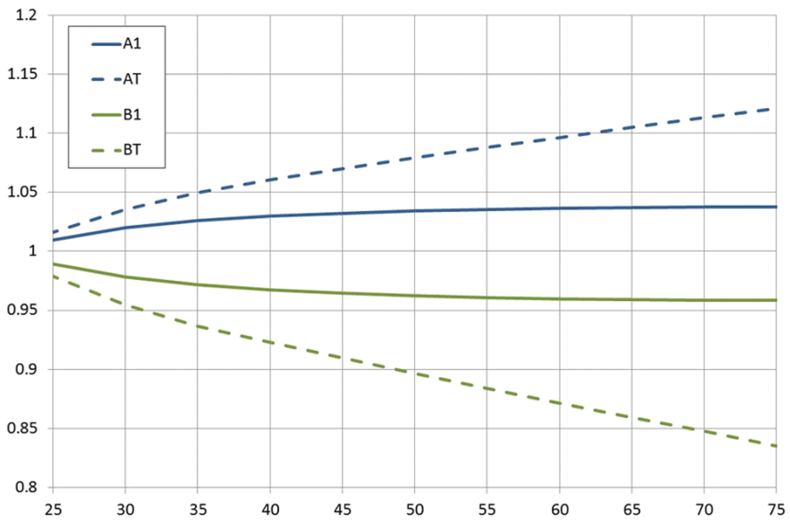

Fig. 3. Sensitivity to the time horizon (T)

4.2 Global analysis of a benchmark set of parameters

For the following set of parameters, $\alpha = 0.5$, $\delta = 2.5\%$ and $T = 75$, we compute the evolution of the adjustment coefficients.

The ABM implies an immediate adjustment consisting in a 4% increase in tax rate and a 4% decrease in pension.

The adjustment settles progressively and in the end, reaches a 10% increase in the tax rate and a 16% decrease in pension.

Figure 4 and figure 5 represent the evolution of taxes (contributions) and pensions in the case where the parameters are the following:

$$\begin{cases} \alpha = 0.5 \\ \delta = 2.5\% \\ T = 75 \end{cases} . \tag{18}$$

A low value of δ induces lesser procrastination. This results in an immediate adjustment of both A and B by 4%: contributions increase by 4% while pensions decrease by 4%.

There is a continuous increase in the tax rate and a continuous decrease in the pensions during the whole 75-year period. At the end of the period, the tax has increased by 10% and the pensions have decreased by 16%.

During the first part of the period, the adjustment creates a surplus. Then, the reserve fund increases and reaches its maximum in 2060 when the pension scheme is unbalanced. From this period, the reserve fund is used in order to finance the pensions and decreases until the end of the period. The total asset of the fund is null in 2085.

Figure 5 provides the corresponding intergenerational analysis. The upper part of the chart represents the increase in the contributions for various generations. Of course, the older the generation, the shorter is the period of contributions rising. In other words, the generation born in 1950 (G1950) "suffers" a short period of increased contributions (after the age of 60) while the youngest one – born in 2000 (G2000) – "suffers" an increase in its contributions during its whole working period.

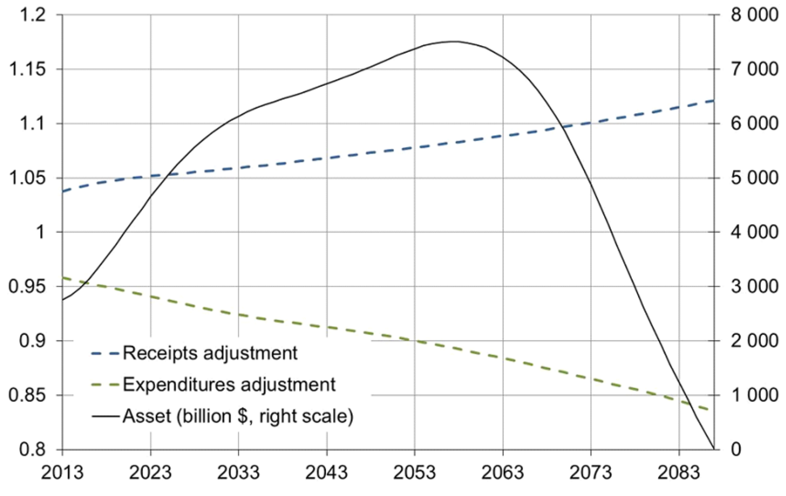

Fig. 4. Adjustments

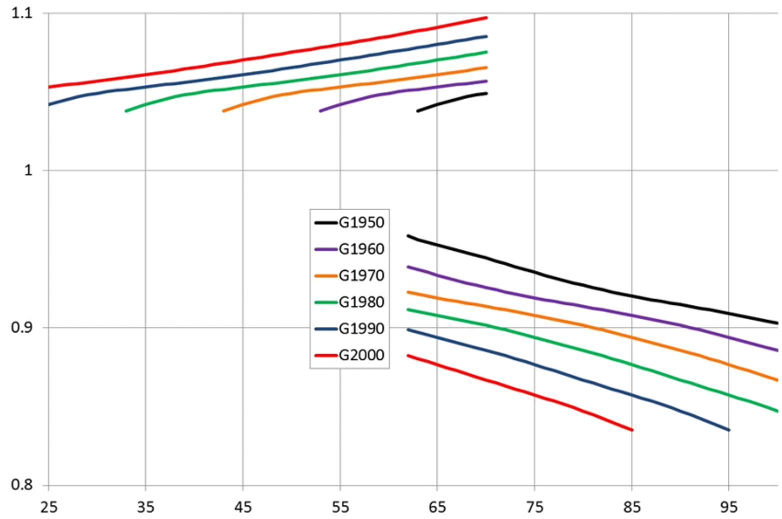

Fig. 5. Generational impact per age

On the other hand, all generations are affected by a decrease in their pensions. In terms of pension yields, this means that the oldest generation will have a higher return from its pension scheme than the youngest one. We also observe that the reserve fund being depleted at the end of the simulation period (figures 6 and 7), other adjustments will have to be done that will undoubtedly decrease the younger generations' pension yields.

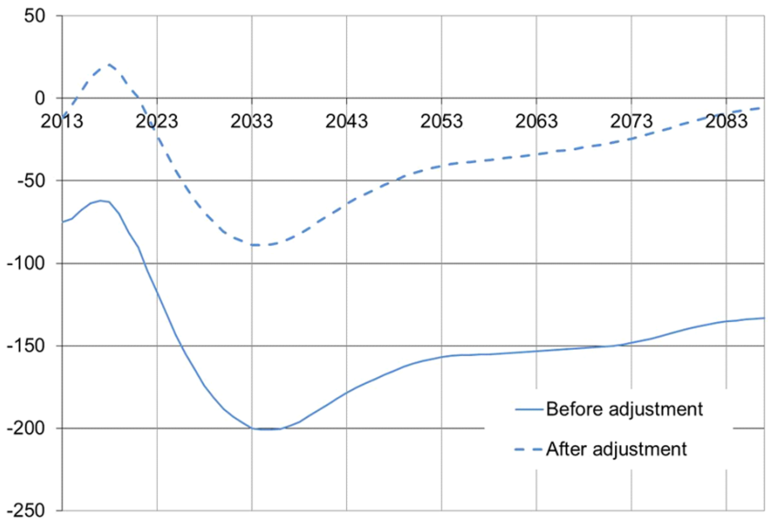

Fig. 6. Adjustment primary balance (billion $, present value)

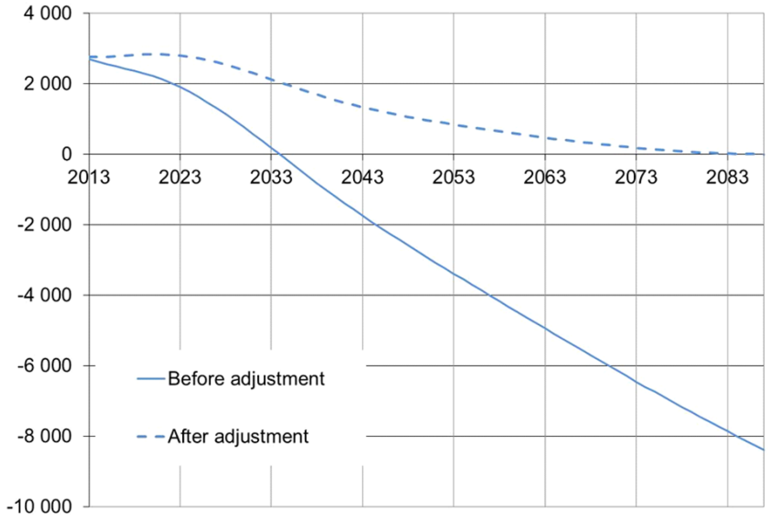

Fig. 7. Reserve fund (billion $, present value)

Conclusion

This article has identified different types of AAM that can be implemented and has shown how they contribute to a better solvency. Sweden is the only country that strengthens its AAMs with an ABM that ensures financial stability. Similarly as in the Swedish pension system, we propose to build an ABM starting from a dynamic optimization setting. For a given planning horizon, we obtain formulas that determine how revenues and expenses must be adjusted at each period. That allows to consider the ABM chosen by Sweden as a special case. Indeed, the Swedish ABM can be obtained by assuming very high adjustment costs on revenue and choosing a particular concept of measure of solvency. We apply these formulas to the financial balances of the US Social Security (OASDI program). Using dynamic optimization avoids brutal adjustments and thus moderates or smooths the marginal adjustments necessary for financial stability.

A possible extension of our approach could consist in building an ABM in a context where economic variables would be assumed as endogenous (Auerbach and Lee, 2011). A study of the relationship between the fitting parameters and the evolution of the economy can be a natural extension of this article. From a macroeconomic point of view, OLG-CGE models have been developed to estimate the impact of Social Security reforms in an intertemporal and intergenerational general equilibrium framework. Such models are used to "optimize" Social Security reforms. Furthermore, dynamic microsimulation models give a lot of details on the microeconomic impacts of Social

Security reforms.

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Appendix

The two F.O.C express a tradeoff between increasing the social cost of adjustment and reducing the deficit. At each period, for a loss level given, the tradeoff between A and B implies to the following Marginal Substitution Rate (MRS):

$$\left(\frac{\Delta A}{\Delta B}\right)_{L \text{ given}} = -\frac{\Delta L/\Delta B}{\Delta L/\Delta A} = -\frac{(1-\alpha)\cdot(B_t-1)}{\alpha\cdot(A_t-1)}. \tag{19}$$

By comparaison, the slide of the budget constraint for F_t and F_{t+1} given is such that:

$$\left(\frac{\Delta A}{\Delta B}\right)_{\text{Budget Constraint}} = \frac{EXP_t}{REC_t}, \tag{20}$$

where $\frac{EXP_t}{REC_t}$ is the balance ratio. In case of problem of global unsolvency, in general this ratio is always lesser than 1. At the optimum, the tangency of the two curves implies:

$$-\frac{(1-\alpha)\cdot(B_t-1)}{\alpha\cdot(A_t-1)} = \frac{EXP_t}{REC_t}. \tag{21}$$

From the FOC, we deduce that:

$$\left\{\begin{array}{l} (A_t-1) = \frac{REC_t}{REC_T}\cdot\left(\frac{1}{1+\delta}\right)^{T-(t+1)}\cdot\Pi_{i=t+1}^{T}R_i\cdot(A_T-1) \\ (B_t-1) = -\frac{EXP_t}{REC_T}\cdot\frac{\alpha}{1-\alpha}\left(\frac{1}{1+\delta}\right)^{T-(t+1)}\cdot\Pi_{i=t+1}^{T}R_i\cdot(A_T-1) \end{array}\right. . \tag{22}$$

By incorporating these two expressions in the intertemporal budget constraint, we find the forecast final adjustment:

$$\left\{\begin{array}{l} (A_T-1) = UO_0/\sum_{t=1}^{T}\left(\frac{REC_t^2+\frac{\alpha}{1-\alpha}\cdot EXP_t^2}{REC_T}\cdot\left(\frac{1}{1+\delta}\right)^{T-(t+1)}\cdot\frac{\Pi_{i=t+1}^{T}R_i}{\Pi_{i=1}^{t}R_i}\right) \\ (B_T-1) = -\frac{\alpha}{1-\alpha}\cdot\frac{EXP_t}{REC_t}\cdot(A_T-1) \end{array}\right. . \tag{23}$$