Macroeconomic analysis of public pension systems: An application to Ecuador

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Abstract

This paper aims to assess the impacts of some pension reforms on the economic welfare and main macroeconomic variables of Ecuador, a small emerging and dollarized country in Latin America with a high level of pension replacement rates. We consider policies such as the elimination of the government-financed share of the contributory pension benefit expenditures (40%) and reduction of replacement rates, in a three-sector overlapping generations model. Given a benchmark scenario that includes a PAYG pension system, the model calculates economic welfare effects as well as the macroeconomic impact of various reform scenarios aimed at finding an optimal taxation structure. Our findings suggest that the effects of these reform policies are significant, specifically, the elimination of the government financial share of contributory pension expenditures (for keeping the contributory principle of pension entitlements) and the reduction of the replacement rate to 50% of earnings bring about an economic welfare gain of 15.79%, increasing steady state output (GDP) by 13.53% and private consumption by 6.42%.

JEL codes: H55, EG2, D58

Keywords: Public pensions, pension reforms, CGE-OLG models, Ecuador, Latin America.

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1 Introduction

Ecuador, a small and dollarized country in the South America, is one of the countries with the highest pension replacement rate in the world (OECD-IDB-WB, 2014), provided by a contributory pension system characterized by a high level of generosity (but with low coverage), which is superior to the EU average (see OECD (2015), Conde-Ruiz and González (2016)). Moreover, regarding the *gross pension wealth* indicator[1], Ecuador has the highest one in the world[2] followed by far by the Netherlands[3], a developed country with a private pension system. However, since 2015 Ecuador is facing up a negative financial gap of the pension system, which seems to keep growing because of the upwards trend in the pension coverage rate and the downwards trend (from 2013) in the social security coverage rate. In the long run term, with an aging population like developed countries, the current Ecuadorian pension system seems to be even in worse situation than them if no pension reforms are made. Thus, the mandatory government-payment of 40% of the contributory pension expenditures has been defended under the argument that the pension system is currently unbalanced and it is a Constitutional Right of pensioners. On the other hand, recommendations about pension reforms, particularly on reducing the replacement rate or increasing the contribution rate, have been carried out only from an actuarial point of view[4].

Therefore, motivated by these issues, and since it is very known that pension system reforms involve welfare consequences and effects on the economy, two main questions have been arisen: i) What would be the effects on the macroeconomic variables and welfare if eliminating the 40% government-financed share of contributory pension expenditures? and ii) how would the macroeconomic variables and welfare change be impacted if the replacement rate is reduced?

These type of questions that involve decisions about designs or reforms of pension system schemes are in the field of public and economic policy research[5]. One of the instruments of the sustainability assessment of the pension reforms and their effects on the economy, in the long run, is the Computed General Equilibrium (CGE) models (Sánchez-Martín, 2014). In words of Fehr (2016), CGE models "can go beyond theoretical models and ana-

[1] A pension wealth is "relative to individual earnings that measures the total discounted value of the lifetime flow of all retirement incomes in mandatory pension schemes at retirement age", where the discount rate is of 2%. It is "expressed as a multiple of gross annual individual earnings" (OECD, 2017).

[2] Ecuador has a pension wealth of 23.2 (25.6) times annual individual earnings in the case of males (females) (OECD-IDB-WB, 2014).

[3] The Netherlands has a pension wealth of 16.9 (18.3) times annual individual earnings in the case of males (females) (OECD, 2017).

[4] For example, one of them suggested that if eliminating the 40% government-financed share of contributory pension benefits, the contribution rate would have to be risen twice to reach the roughly 21%, see https://www.eluniverso.com/noticias/2018/03/20/nota/6675790/estudios-actuariales-iess-contradicciones-desactualizados, accessed in May 14, 2018.

[5] They are studied within the new branch of economics named as Pension Economics. Blake (2006), Petersen (1998), Fehr and Kindermann (2018a) are good introductions for doing this type of researching.

lyze practical policy issues in very complex institutional settings which require evaluating different economic effects quantitatively". Moreover, Blake (2006) mentioned that "the overlapping generations (OLG) model is the cornerstone of modern macroeconomics". From the late 1980s and throughout the following decades, the Computed General Equilibrium overlapping generation models (CGE-OLG model) have been improved due to the computational advances, and according to Fehr (1999), "the framework of the Auerbach and Kotlikoff (1987) (AK Model) is by now a fairly standard tool in the numerical analysis of public finance issues that deal with intergenerational redistribution" analysis. The purpose of this work is to have a macro-view of the impact of pension reforms on the Ecuadorian macroeconomy as well as the economic welfare effect on their households. As a first glimpse of the situation of the main macroeconomic variables (GDP growth rate, Government Consumption, Private Consumption, Gross Capital Formation, Gross Savings, and inflation) of Ecuador, see Figures 5 to 10 in the Appendix A.3, where it is also presented a comparison with other economies (OECD members, Latin America and the Caribbean (LAC) and Panama-another dollarized economy of the region). Figure 5 displays the evolution of the GDP growth from 2003 to 2017, where we can see that, besides the abruptly fall of the GDP growth in 2009 (linked to the Great Recession), the GDP growth was positive for Ecuador and Panama. Then, it grows up until 2011 (two years) to reach 7.87%, where it started to descend until -1.57% in 2016 (because of an earthquake). Panama, as well as LAC countries, has had a similar trend than the Ecuadorian one, from 2009 to 2014, but with higher percentages (around 2 percentages points above). Overall, the GDP growth of the OECD members, from 2003 to 2013, has been below of the remained analyzed economies. Regarding the *government final consumption expenditure*, as % of GDP, of all the analyzed economies (except Panama), it has kept roughly constant from 2003 to 2007 (see Figure 6), where the OECD members had the highest percentages, followed by LAC countries, Panama and Ecuador. Then, it has grown up to 2009, where in the case of the OECD members, it reached a peak (19.18%). In that year, Panama (11.95%) passed to have a lower percentage than Ecuador (13.73%). In 2016, Ecuador reached a Government final consumption expenditure of 14.37% of GDP; whereas the OECD, LAC and Panama 17.82%, 16.77% and 10.64%, respectively. Across the board, regarding Private Consumption, Figure 7 shows that the trend for the case of Latin America and the OECD have not had great shifts like Ecuador and Panama. The first two have presented values in the range of 60-65%; whereas Ecuador and Panama started in 2003 with 71.74% and 63%, respectively and end with 60.4% and 50.12% in 2016, respectively. Regarding savings the tendency for the case of Ecuador and Panama was upward, whereas for the OECD and LAC it was roughly constant, see Figure 9.

Since there are no previous CGE-OLG models for Ecuador, we must start with the simplest model for a first approximation. The numerical analysis is based on a three-periods CGE-OLG model a la Auerbach and Kotlikoff (1987) as is presented in Fehr and Kindermann (2018b), but with some particularities of the Ecuadorian economy, namely that a fraction of the aggregate pensions is financed with consumption and income taxes instead of only the social security payroll tax (pension). Since we are focused on the impacts of the pension system in the economy, we abstract from corporate taxes and government debt -as in the work of Fehr (2000)-. Additionally, in its line, our model considers consumption taxes; and for simplicity, we assume that the labor and capital income taxes are equal. Therefore, the tax system of our model includes taxes on labor and capital income as well as on consumption taxes. Finally, we calculate the steady state equilibria of the economy, initial and in the long run. Then, we compare the effects on the economic welfare[6] and main macroeconomic variables, of several pension reforms. One of the main features of the AK model is that it assumes rational expectations and calculates the new long run equilibrium for an economy after assuming a policy reform, particularly those related to taxation. It is built upon three sectors: government, household, and production.

Regarding the household sector, taxes, namely, labor, capital and social security payroll taxes will affect the household by altering the absolute resources it has at its own disposal and the relative prices of consumption in every period. The producer side of the economy is represented by a constant-returns to-scale production function, where inputs are labor and capital. While, respect to the government sector, there are two institutions that have the power of levying taxes (income and payroll taxes) for financing their consumption. One institution is the fiscal authority that provides general public services and the second one is the social security system (through a pay-as-you-go (PAYG) pension system) that provides retirement benefits. Since we do not include public debt, the intertemporal government budget is balanced through taxation.

Due to the complexity of CGE-OLG models and particularly because of data available, almost all models have been built for developed economies. Thus, even now, theoretical development of current models have been constructed mostly with data from the United States of America[7]. Thus, across the board, the study of the macroeconomic effects of pension reforms in developing countries is very scarce, and in Ecuador specifically, as far as the author know, this may be the first work to explore the effects of pension reforms on the Ecuadorian macroeconomic variables. Some works carried out for Latin America countries are Glomm et al. (2009) (study the early retirement effects for the case of Brazil) and Schmidt-Hebbel (1997) (builds a two-period model for the case of Chile for studying the effect of informality).

Results suggest that a PAYG pension system has negative effects on the economy, i.e.,

[6] We measure *economic welfare* through the utility function, which also includes the public consumption. Hence, gains or losses are quantified from changes between the results of the new scenarios and the benchmark situation.

[7] Good surveys about CGE models dealing with pension systems are Fehr (2016) and Fehr (2009).

decreasing of savings, income, and welfare of future generations, as a consequence of the transfer mechanism of this pension system type, where young generations pay pensions of elderly generation. A pension reform that includes a reduction of the actual government-financed share of the contributory pension expenditures, but keeps a roughly 0.8 of replacement rate, would not bring about a very significant change on economic welfare (increase of at most 3.66%), but it would carry out a very significant reduction of the income taxes (at most 10.11 percentage points). Nevertheless, this reduction, along with a lower replacement rate is likely to lead a significant economic welfare gain (e.g. 15.79% when the replacement rate is reduced in 0.3). Although the model was calibrated to the Ecuadorian economy, this message also applies to other countries with a PAYG pension system scheme, where government finances part of the contributory pension benefit with other types of taxes. An example could be Spain, where from 2017 the government through public debt had made a "loan" to the social security for pension payments to retirees.

The paper is organized as follows. In the next section, we detail the basic structure of the model. Section 3 explains the calibration for the Ecuadorian economy and its initial equilibrium. Section 4 reports and discusses the simulation results for some reform scenarios. Finally, Section 5 offers discussion and concluding remarks.

2 The model economy

The economy is a 3-period overlapping generation model a la Auerbach and Kotlikoff (1987) that takes into account the model framework of Fehr and Kindermann (2018b) and many features of Fehr (1999) and Fehr (2000) extended for studying pension reforms in the Ecuadorian economy. It includes demography and consists of consumption choices (agents belonging to the same generation are identical) given the preferences and budget constraint of the households, a production sector and the government. In the first period people work and save for the second period of life, in the second one they work and save for the third period, and finally, in the third one, they retire and consume all their savings. The government taxes consumption and income from labor and capital, and pays retirement benefits. An amount of public good that the government supply enters the individual utility function in an additively separable manner. There is a constant returns to scale Cobb-Douglas aggregate production function, where inputs are labor and capital.

2.1 Demographics

The model economy is populated by overlapping generations of individuals which can live up to a maximum possible lifespan of 3 periods, N_t, N_{t-1}, N_{t-2} and abstracts from life span uncertainty. N_t is the number of the cohort in period t, which enters the labor force. The population grows at rate $n_{p,t}$, i.e.,

$$N_t = (1 + n_{p,t})N_{t-1} \tag{1}$$

Time is discrete and each period represents 20 years. Clearly, in period t the total population TP_t size is:

$$TP_t = N_t + N_{t-1} + N_{t-2},$$

where $N_t + N_{t-1}$ is the workforce in period t and N_{t-2} is the retiree population.

2.2 Households

The model assumes that all agents have identical preferences and rational behavior. Agents decide how much to consume (c_t), and consequently save (a_t), in the different periods of their life. They have to pay taxes on income (labor and capital) and consumption. They have to pay a payroll tax to the pension system in period t, in reward for which they receive pension benefits in the third period of life pen_{t+2}.
The model also abstracts from leisure[8] and considers that agents are only concerned with their own welfare, i.e., there is no bequest motive. It is assumed that the utility function is time-separable, it means that lifetime utility can be expressed as a function of individual functions of consumption in each period. Moreover, it is assumed that the utility function has the form of the nested, constant elasticity of substitution (CES). Thus, the lifetime utility (U_t) of a representative agent born in period t is formulated as:

$$U_t = u(c_{1,t}) + \beta u(c_{2,t+1}) + \beta^2 u(c_{3,t+2}) \tag{2}$$

where $c_{s,t}$ is the consumption of the period $s = \{1, 2, 3\}$ at the respective time $t = \{t, t+1, t+2\}$, and the parameter β is the household's discount factor. The periodic utility function, $u(c_{s,t})$ is given by:

$$u(c_{s,t}) = \frac{c_{s,t}^{1-\frac{1}{\gamma}}}{1 - \frac{1}{\gamma}} \tag{3}$$

where $\gamma \geq 0$ is the intertemporal elasticity of substitution between consumption of different years.
The dynamic budget constraints in the three different periods are defined as

$$p_t c_{1,t} = w_t^n - a_{2,t+1}$$

[8] When leisure is included, households have to decide how many hours to work in each period and when to withdraw from the workforce. We let it for further research.

$$p_{t+1}c_{2,t+1} = w^n_{t+1} + R^n_{t+1}a_{2,t+1} - a_{3,t+2}$$

$$p_{t+2}c_{3,t+2} = R^n_{t+2}a_{3,t+2} + pen_{t+2}$$

where p_t is the consumer price at each period of life, which includes the consumption tax rate τ^c_t, and $a_{2,t+1}$ and $a_{3,t+2}$ denote saving for the next periods of life. The net wage and interest rates are defined as

$$w^n_t = w_t(1 - \tau^w_t - \tau^p_t)$$
$$R^n_t = 1 + r_t(1 - \tau^r_t)$$

where τ^r_t is the capital income tax, and τ^w_t and τ^p_t are the labor income and payroll taxes at time t.

Therefore, the intertemporal budget constraint of the household is given by:

$$p_t c_{1,t} + \frac{p_{t+1}c_{2,t+1}}{R^n_{t+1}} + \frac{p_{t+2}c_{3,t+2}}{R^n_{t+1}R^n_{t+2}} = w^n_t + \frac{w^n_{t+1}}{R^n_{t+1}} + \frac{pen_{t+2}}{R^n_{t+1}R^n_{t+2}} = W_{1,t} \quad (4)$$

where $W_{1,t}$ represents the lifetime resources at period t, i.e., the present discounted value of future resources net of taxes (income and consumption) and pension contribution plus future pension benefit.

From the first order conditions for consumption in each period it is derived the next expressions

$$c_{1,t}^{\frac{-1}{\gamma}} = \frac{\beta R^n_{t+1} p_t c_{2,t+1}^{\frac{-1}{\gamma}}}{p_{t+1}} \quad (5)$$

$$c_{2,t+1}^{\frac{-1}{\gamma}} = \frac{\beta R^n_{t+2} p_{t+1} c_{3,t+2}^{\frac{-1}{\gamma}}}{p_{t+2}} \quad (6)$$

Thus, given the consumption at period one[9], the optimal consumption, and consequently savings, are derived from equations (5) and (6). Note that consumption at each period, as well as savings for two- and three-life period, depend on the net wage and interest rates, consumer prices, and pension. Before solving the optimization problem, all aggregate variables are normalized to the size of the newborn size. Thus, it is assumed that each working household at period t (cohorts born at period t, and $t-1$) supplies one unit of labor inelastically. The aggregate labor supply in period t is given by

$$L_t = \frac{1}{N_t}(N_t + N_{t-1}) = 1 + \frac{N_{t-1}}{N_t} = \frac{2 + n_{p,t}}{1 + n_{p,t}} \quad (7)$$

[9]See the appendix A.1 for the solution of the steady state.

The aggregate per capita assets becomes

$$A_t = \frac{a_{2,t}}{1+n_{p,t}} + \frac{a_{3,t}}{(1+n_{p,t})(1+n_{p,t-1})} \tag{8}$$

Note that $a_{2,t}$ and $a_{3,t}$ denote savings of the two older cohorts built in the previous year. The aggregate per capita consumption is given by

$$C_t = c_{1,t} + \frac{c_{2,t}}{1+n_{p,t}} + \frac{c_{3,t}}{(1+n_{p,t})(1+n_{p,t-1})} \tag{9}$$

2.3 The production side

The economy has a large number of identical firms and the sum of which is normalized to unity. They are competitive and produce a single good from aggregate capital and labor. The production function is represented by the Cobb-Douglas type, i.e.,

$$Y_t = F(K_t, L_t) = K^{\alpha} L^{1-\alpha} \quad or \quad y_t = Y_t/L_t = k^{\alpha} \tag{10}$$

where Y_t is the aggregate output, K_t is the aggregate capital stock, L_t is the aggregate labor input and α is the capital share in production. Profits of firms are maximized by renting capital from the capital market, which depreciates at rate δ, and hiring labor from households. The interest and wage rate at time t, derived from the first-order and zero profit condition, are of the form:

$$r_t = \alpha(k_t)^{\alpha-1} - \delta \tag{11}$$

$$w_t = (1-\alpha)(k_t)^{\alpha} \tag{12}$$

Output, Y_t, can be used for consumption in the same period as production takes place or it can be used for increasing next period's capital stock, i.e., for inversion (I_t),

$$I_t = (1+n_{p,t+1})K_{t+1} - (1-\delta)K_t \tag{13}$$

2.4 Government sector

The government collects taxes and contributions from households for financing the public consumption (G_t) and the aggregate pension benefits (PB_t), where, $PB_t = pen_t N_{t-2}$. Thus, the government has two budget constraints. Since we are focused on impacts of pension system in economy -as in the work of Fehr (2000), we abstract from corporate taxes and government debt, thus, the government budget is expressed as

$$T_t = \underbrace{G_t + \theta PB_t}_{T_t^1} + \underbrace{(1-\theta)PB_t}_{T_t^2} \tag{14}$$

where

$$T_t^1 = \tau_t^c C_t + \tau_t^w w_t L_t + \tau_t^r r_t A_t$$

is the aggregate tax revenues from consumption and (labor, capital) income taxation, and

$$T_t^2 = \tau_t^p w_t (N_t + N_{t-1})$$

is the aggregate payroll taxes. θ is the government-financed share of the aggregate pension benefits PB_t, i.e., it could be ranging between 0 and 1.

In contrast to the model of Fehr and Kindermann (2018b), we separate PB_t (in equation (14)) by two ways of financing, one from a direct payroll tax and another from consumption, and labor and capital income taxes. This structure seems similar to the work of Fehr (1999) and Fehr (2000), where it is considered as a fraction of the aggregate pension benefits for financing non-contributory pensions. However, we are taking into account this feature for financing contributory pensions because it is the reality of the current Ecuadorian pension system. This feature allows the analysis of an additional tax that is needed for paying contributory pensions in PAYG unbalanced pension systems, where contribution rate is not increased because of political reasons. Thus, it appears to be a kind of subsidy to contributory pensions.

The amount of public good G_t that corresponds to the first government budget (T_t^1) is given in per capita, i.e.,

$$G_t = \frac{1}{N_t}(N_t g_1 + N_{t-1} g_2 + N_{t-2} g_3) = g_1 + \frac{g_2}{1+n_{p,t}} + \frac{g_3}{(1+n_{p,t})(1+n_{p,t-1})}$$

where g_j make up per capita coefficients of every cohort-young, middle, and old- for public good provision. However, it does not interfere with household decisions on consumption due to assumption that public goods increase utility in additive separable manner to the household.

2.4.1 The pension system

Here we detail the government budget for pension payments to retirees (T_t^2). Equation (14) shows that a PAYG pension system, which captures some important characteristics of the Ecuadorian institutional setting, particularly that it finances $(1-\theta)$ aggregate pension benefits PB_t, is included in the model. Therefore, the government budget of the pension system (T_t^2) is financed, partly by θ (through income and consumption taxes as shown above) and partly by $(1-\theta)$ through contributions from workers

$$\tau_t^p w_t(N_t + N_{t-1}) = (1-\theta)pen_t N_{t-2} \tag{15}$$

Note that the left part of equation (15) represents the aggregate compulsory earnings base. The budget of the pension system must be balanced in each period, therefore, the national contribution rate, τ_t^p, has to be adjusted to fulfill the period budget constraint:

$$\tau_t^p = \frac{(1-\theta)pen_t}{w_t(2+n_{p,t})(1+n_{p,t-1})} \tag{16}$$

where the pension benefit pen_t is

$$pen_t = \kappa_t w_{t-1},$$

where κ_t is the replacement rate. When θ is zero the whole pension payments has to be financed only by contributions.
Overall, of course, this system consists of a payment by a payroll tax (τ_t^p) and transfers (pen_t) between the young and old generations.

2.5 Equilibrium

A general equilibrium solution of this economy, for a given policy, has to satisfy the following conditions for balancing of the goods and two factor markets:

- The household decisions $c_{1,t}, c_{2,t+1}, c_{3,t+2}$ (5 and 6) solve the household decision problem (2) subject to the respective budget constraint (4).
- Factor prices equal the marginal product of capital and labor, i.e., equations (11) and (12).
- Factor markets clear:

$$A_t = K_t \tag{17}$$

  The labor market is always balanced, since the labor supply of household L_t was substitute into the production function (10).

- The government budget (15) and, of course, (14) have to be balanced in each period.
- The goods market clears, so that:

$$Y_t = C_t + G_t + I_t \tag{18}$$

Despite we will find the long-run equilibria or steady state, where per capita variables are constant over time and consequently the time index t in all equations defined above could be omitted, here we kept it because it allows having a better understanding of the model.

3 Calibration and Initial equilibrium

This section discusses the approach for parameterizing the model and also presents the results of the initial equilibria. Every parameter was chosen to match the Ecuadorian economy in 2014. In order that some stylized macroeconomic facts of the latter is reflected by our resulting benchmark equilibrium, we take into account the standard procedure, i.e., ad-hoc assumptions, short-cuts, and some observed empirical facts.

3.1 Parameterization of the Model

Our variables are of the two kinds: exogenous and endogenous. The *endogenous* ones are the household decisions $(c_1, c_2, c_3, a_2, a_3)$, factor prices (r, w), the pension payroll tax rate (τ^p), aggregate quantities and a tax rate which can be the rate of consumption (τ^c), labor income (τ^w) or capital income (τ^r). In our case, since the value-added tax (VAT) is unique and 'not categorized'[10] like in European countries, it is very sensitive and has not be changed since 2000 (when Ecuador's monetary model changed to dollarization). Thus, we decided to leave it as an exogenous variable. Income taxes (capital and labor) are left for adjusting the government's budget, i.e., they are the endogenous tax rates in our model. In Ecuador, the government levies a uniform income tax on income from both labor and capital, thus $\tau^w = \tau^r$. In 2014, the revenue from taxation of goods and services was 7.04 percent of GDP and aggregate consumption amounts to roughly 60.48 percent of GDP, resulting in a consumption tax rate of 12.09 percent, which is almost exactly the VAT in Ecuador (12%).

On the other side, the *exogenous* parameters, which are presented in this section are: the population grow rate n_p, the household preference parameters (γ, β), technology parameters (α, δ), the government parameters (g_j, τ^c) and the replacement rate of the pension system (κ).

The model's life cycle has to cover 3 periods: young, middle and old ages. Thus, each model period covers 20 years, and agents are born into adulthood at age 25 and can live up to age 85, after which death is certain. Households supply labor until retirement age, which is imposed at age 65. The last demographic parameter is the population growth rate, where we set an annual growth of 1.85%, which was the average annual growth during

[10] There are some exceptions where the VAT is zero, particularly to non-added value food.

the last 25 years[11], i.e., a periodic growth rate of 44,28% ($n_p = 1.0185^{20} - 1$). With respect to the household preference parameters, the intertemporal elasticity of substitution (γ) is set to 0.5, which implies an individual relative risk aversion of 2. This value is within the range of commonly used values, see Auerbach and Kotlikoff (1987), Glomm et al. (2009), İmrohoroğlu and Kitao (2009), Fehr and Uhde (2013). For calibrating an annual capital-output ratio of 1.44[12], it is set the annual time discount factor β to 0.9756.
Regarding technology parameters we set the capital share in production to $\alpha = 0.3303$[13]. Thus, this implies that the wage share is equal to 0.6697. The parameter δ, the annual depreciation rate of capital, is set as 15 percent. It is derived by assuming that the capital output ratio is 1.44, and considering an investment to GDP ratio of 24.71%[14] and a population growth rate of 1.85 percent (set earlier).
Finally, the total government expenditure as a fraction of GDP was calibrated to be around of 14% (BCE, 2017), thus we assumed a fixed $g = 0.08$, where expenditures for the young population are higher than for the old one, i.e., $g_1 = 0.05$, $g_2 = 0.02$, $g_3 = 0.01$. The resulting values for the model period are reported together with all other exogenous parameters in Table 1.

3.2 The Benchmark Equilibrium

We begin with an economy in its steady state using parameters reported in Table 1, which will be our benchmark model (BM). Table 2 summarizes the macroeconomic data at initial equilibrium generated by our calibrated OLG model. It is compared it with some stylized facts of the Ecuadorian economy in 2014.
The model captures the central interaction between the pension system and the remaining tax system, which is most important in the present context. The PAYG pension takes into account the 40% government-financed share of pension expenditures, i.e., $\theta = 0.4$ and a replacement rate that represents the roughly 80% of the last wage, $\kappa = 0.8$. We let the labor and capital income taxes, τ^w and τ^r, adjust to clear the government budget constraint from computing the initial steady state, and the replacement rate determines the payroll tax rate.

[11] Authors' own calculations from United-Nations (2017).

[12] Since there is no empirical information about the capital-output of Ecuador, we computed it from the model, where we assume a depreciation rate of 15% and an interest rate of 8%.

[13] This value is according to Cabezas-Gottschalk (2016).

[14] This value corresponds to the year 2015, see (BCE, 2017). We decided to use this lower value, since the value in 2014 was a peak one (27.24%) and it has been going down and in order to have a better calibration.

Parameter	Symbol	Value	Target
Demographics			
Population growth	$n_{p,t}$	1.85%	United-Nations (2017)
Preference			
Inter-temporal elasticity of substitution	γ	0.50	commonly used values
Time discount factor	β	0.97	capital output ratio of 1.44
Production technology			
Capital share in production	α	0.3303	Cabezas-Gottschalk (2016)
Depreciation of capital (annual)	δ	0.15	capital output ratio of 1.44
Policy variables			
Consumption tax rate	τ^c	0.1209	BCE (2017)
Government expenditure per capita:			$G(\%GDP) = 14\%$, BCE (2017)
	g_1	0.05	
	g_2	0.02	
	g_3	0.01	
Replacement rate	κ	0.8	
Share of pension expenditures financed by government	θ	0.4	Social Security Law of Ecuador

Table 1: Calibrated parameters in the OLG model

Table 2: The Benchmark model (BM): The initial equilibrium of the OLG model

	Initial Equilibrium	Ecuador 2014*
Expenditures on GDP (in % of GDP)		
Private Consumption	67.70	60.48
Government Consumption	14.85	14.62
Investment	10.10	24.71
Tax revenue (in % of GDP)		
Consumption tax	8.18	7.04
Labor earnings tax	11.15	4.50
Capital income tax	4.35	1.00**
Tax rates (in %)		
Consumption	12.09	12.09
Labor Earnings	16.64	12.46
Capital Income	16.64	3.16***
Contribution rate	13.62	10.46
Interest rate (in % p.a.)	7.96	
Capital-output ratio (annual)	1.44	

*Source: (BCE, 2017; OPF, 2015). Authors' calculations.

Assumed value. * This value is computed assuming 1% of capital income tax revenues.

All in all, the model match up the basic economic and fiscal structure of Ecuador quite well. Since it is assumed a closed economy, the interest rate is defined endogenously by private savings, which is high and consequently, investment is not represented very well[15]. The government sector is not represented very well because it is neglected some important features such as government debt and corporate taxes. The high consumption tax revenue is because of the high consumption expenditures. Consumption was lower in 2014 and investment was considerably higher. Because of income tax revenues in Ecuador are collected taking into account the total income (labor and capital) and there is not available information separately, we assume that the capital income tax revenue is 1% in order to compute the corresponding taxes. Thus, the labor and capital income taxes result in 12.46% and 3.16%, respectively. The labor income tax revenue in 2014 is quite low, which needs to be viewed taking into account that Ecuador has a high degree of shadow economy[16].

Now, what are the behavioral reactions of the households when a pension reform is introduced? Resulting reactions are of crucial importance for the welfare and macroeconomic effects generated by the model. Next section describes our policy reform scenarios and reports the simulation results.

4 Simulation Results

Based on the benchmark equilibrium model (BM) with a PAYG pension system (very generous) in period $t = 0$, we introduce a pension reform in period $t = 1$ and compute the macroeconomic and welfare[17] changes in a new long run equilibrium. The assumed pension reforms, whose effects will be compared with the benchmark model, are of three types and are based on a sensitivity analysis of one of the elements of the system for highlighting its properties. Results will be presented for the case of the variables such as income taxes, contribution-, wage- and interest rate, private and public consumption, annual capital-output ratio and GDP. Moreover, at the final row, it is presented the changes in economic welfare or utility consequences, which includes the public consumption instead of only the private one.

1. Scenario (1): Reforms that affect the generosity of the pension benefit (pen_{t-2}), i.e., alternative replacement rates (κ), but keeping the 40% government-financed share of pension expenditures ($\theta = 0.4$).

[15] We could say that investment in 2014 is high because most of it was carried out by the government through debt, which is not considered in our model

[16] According to Medina and Schneider (2017), Ecuador has an average shadow economy of 33.6% of GDP from 1991 to 2015. This percentage is close to the average percentage of 32.3%, measured for 158 countries.

[17] Welfare is measured as a change in the utility

2. Scenario (2): Reforms that affect the government-financed share of pension expenditures, i.e., alternative θs, but keeping the actual replacement rate ($\kappa = 0.8$).

3. Scenario (3): Reforms that affect the generosity of the pension benefit (pen_{t-2}), i.e., alternative replacement rates (κ), but with no government-financed share of pension payments ($\theta = 0$).

4.1 Reform Scenarios: sensitivity analysis

- **Scenario (1)**: Reforms that affect the generosity of pension benefits with $\theta = 0.4$

Pension reforms that affect the generosity of the pension, would affect the pensioner, in the sense that they would receive lower amounts of benefits. This fact would let to increase the savings of workers in order to keep a similar consumption in their retired like in their working life. On the other hand, it would benefit to the active population, in the sense that their contribution rates would decrease and could consume more, which would increase their economic welfare.

Table 3 summarizes the effects of alternative replacement rates κ on the economy, from $\kappa = 0$ (without a PAYG) until $\kappa = 1$ (pension equal to the last salary), but keeping the 40% government-financed share of pension expenditures ($\theta = 0.4$).

In order to reach the long-run steady state, the labor and capital income tax rates would be increased up to 2.42 percentage points when $\kappa = 1$, or be reduced until 9.84 percentage points when $\kappa = 0.2$.

On the other hand, simulation results evidence, as expected, that a more generous PAYG pension system (when $\kappa > 0.8$, e.g. $\kappa = 1$) reduces the long run economic welfare up to 8.85 percent (measured as a reduction of the utility), since it crowds out (18.08%) private savings. Consequently, the capital stock as well as wages are lower than benchmark model and decrease in 18.08% and 6.35%, respectively. Therefore, private consumption also would decrease in 2.47% and the annual interest rates would be risen in the long run 0.71 percentage points. Overall, there would be a fall of GDP of 6.35%. With lower replacement rates (when $\kappa < 0.8$), of course, income taxes and contribution rate drop for balancing the government budget (14) and the pension budget (15), respectively. In these cases, the transmission of such reforms would be contrary, i.e., the long run welfare would be increased since savings would increase. Consequently, the capital stock increase and wages, too. Therefore, the private consumption would increase. For example, if $\kappa = 0.5$, the economic welfare is likely to be risen in 12.68% as well as GDP and private consumption in 11.88% and 2.81% respectively.

By looking at Figure 1, it is clearly evident the reduction of economic welfare, as well as GDP and annual capital-output ratio, when a generous pension benefit (higher κ) takes place and the opposite happens when κ is lower than 0.8.

Table 3: Effects of alternative replacement rates in %[a], with $\theta = 0.4$

	$\kappa = 0$	$\kappa = 0.2$	$\kappa = 0.3$	$\kappa = 0.4$	$\kappa = 0.5$	$\kappa = 0.6$	$\kappa = 0.7$	$\kappa = 0.9$	$\kappa = 1$
Income taxes ($\tau^w = \tau^r$) (p.p.)	-14.09	-9.84	-7.93	-6.13	-4.45	-2.88	-1.39	1.31	2.42
Contribution rate (p.p.)	-13.62	-10.21	-8.51	-6.81	-5.11	-3.40	-1.70	1.70	3.23
Wage rate	40.30	27.12	21.56	16.50	11.88	7.62	3.67	-3.44	-6.35
Interest rate (p.a.) (p.p.)	-3.60	-2.57	-2.09	-1.64	-1.21	-0.79	-0.39	0.38	0.71
Private Consumption	2.43	3.66	3.66	3.36	2.81	2.05	1.10	-1.24	-2.47
Government Consumption	-28.72	-21.34	-17.73	-14.17	-10.62	-7.08	-3.54	3.56	6.78
Capital-output ratio (annual)	98.68	62.68	48.56	36.30	25.56	16.06	7.59	-6.85	-12.46
GDP	40.30	27.12	21.56	16.50	11.88	7.62	3.67	-3.44	-6.35
Economic welfare	30.13	23.76	20.25	16.56	12.68	8.63	4.40	-4.58	-8.85

Note: [a]All changes are reported as percentage differences to the benchmark model (BM), except for income taxes, contribution rate, and interest rate, which are already reported in percentage points. p.p: percentage points

Table 4: Effects of alternative government-financed shares of pension expenditures[a], with $\kappa = 0.8$.

	$\theta = 0$	$\theta = 0.05$	$\theta = 0.10$	$\theta = 0.15$	$\theta = 0.20$	$\theta = 0.25$	$\theta = 0.30$	$\theta = 0.35$
Income taxes ($\tau^w = \tau^r$) (p.p.)	-10.11	-8.82	-7.55	-6.28	-5.01	-3.75	-2.50	-1.25
Contribution rate (p.p.)	9.08	7.94	6.81	5.67	4.54	3.40	2.27	1.13
Wage rate	1.78	1.55	1.33	1.10	0.88	0.66	0.44	0.22
Interest rate (p.a.) (p.p.)	-0.19	-0.17	-0.14	-0.12	-0.10	-0.07	-0.05	-0.02
Private Consumption	4.13	3.59	3.06	2.53	2.01	1.50	1.00	0.50
Government Consumption	-1.74	-1.53	-1.31	-1.09	-0.88	-0.66	-0.44	-0.22
Capital-output ratio (annual)	3.63	3.17	2.71	2.25	1.80	1.35	0.90	0.45
GDP	1.78	1.55	1.33	1.10	0.88	0.66	0.44	0.22
Economic welfare	3.66	3.19	2.73	2.28	1.82	1.36	0.91	0.45

Note: [a]All changes are reported as percentage differences to the benchmark model (BM), except for income taxes, contribution rate, and interest rate, which are already reported in percentage points. p.p: percentage points

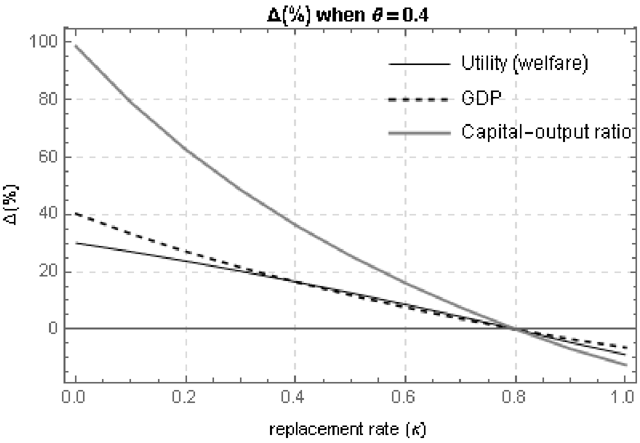


Figure 1: Percentage changes on main variables: sensitivity analysis by alternative replacement rates with respect to the benchmark model

- **Scenario (2)**: Reforms that affect the government-financed share of pension expenditures with $\kappa = 0.8$

As we mentioned earlier and from (14) the effects of alternative fractions of pension expenditures PB (when it is lower than 0.4) would be mainly on income taxes (reduction), and on national contribution rates (increase). Table 4 displays the corresponding results of changes on the economy. The effects on the remaining variables are almost null (under 1%) when θ goings down to 0.30. Therefore, since the effects on taxation are offset, a Ricardian equivalence appears to be held in those cases, i.e., the behavior of all agents of this economy would remain after the reform takes place.

On the other hand, in the case of eliminating the pension support by the government ($\theta = 0$), results evidence an increase of private consumption, annual capital-output ratio and economic welfare up to 4.13%, 3.63% and 3.66%, respectively. While, income taxes are likely to lead a reduction of 10.11 percentage points. Of course, in this case, total pension expenditures would have to be financed by 100% of the contribution rate, thus, it would need to increase 9.08 percentage points to reach 22.7% for keeping the generous pension of 80% of the last wage. Since the percentage point change gap between these two taxes is very low, public consumption would fall an insignificant 1.74%, but the private one would increase in higher percentage than it. Overall, there is a welfare gain.

Similarly as in scenario (1), Figure 2 shows the variations in welfare (welfare gains), GDP and annual capital-output ratio, when θ is reduced. Note that percentage variations of welfare and capital-output ratio are equals.

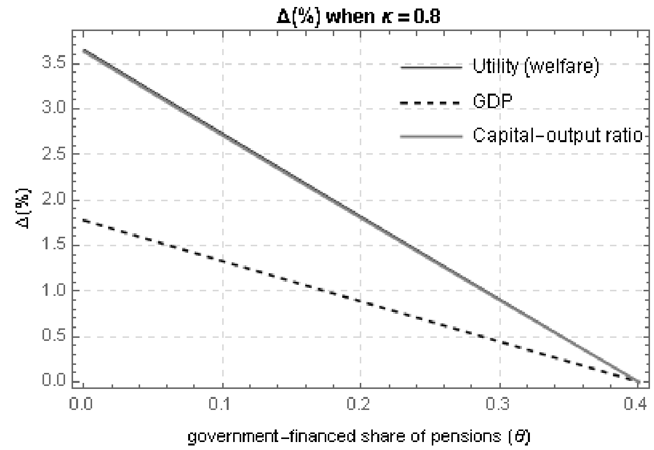


Figure 2: Percentage changes on main variables: sensitivity analysis by government-financed shares of pension expenditures with respect to the benchmark model

- **Scenario (3)**: Reforms that affect generosity of pension benefits with $\theta = 0$

Once we have carried out the sensitivity analysis of alternative replacement rates (κ) when $\theta = 0.4$ and alternative θs when $\kappa = 0.8$, we run the last simulation assuming a null government-financed share of pension expenditures ($\theta = 0$) for alternative replacement rates. This sensitivity analysis helps, on one hand, to have a macro view of the taxation structure but keeping the principle of contributivity (pensions have to be financed only by contribution rates)[18], and on the other hand, to simulate a recommendation of Conde-Ruiz (2014) related to reductions in income taxes instead of contribution rates when the policy makers are looking for reducing the fiscal taxation pressure upon the households labor income. Table 5 reports the effects on the economy of this new scenario with respect to the benchmark scenario (initial equilibrium). Comparing they with results of the last two scenarios presented above, it is revealed sharply changes, particularly in tax rates. The welfare gain is very significant when the pension is under 80% of the last wage ($\kappa \leqslant 0.7$), whose changes are from 8.04% until 27.83% (the highest percentage of all options analyzed within the three scenarios), when $\kappa = 0.7$ and $\kappa = 0.1$, respectively.

[18]See Conde-Ruiz (2014) for a detailed analysis about this issue.

Table 5: Effects of alternative replacement rates but with no government-financed share of pension expenditures[a], with $\theta = 0$.

	$\kappa = 0.1$	$\kappa = 0.2$	$\kappa = 0.3$	$\kappa = 0.4$	$\kappa = 0.5$	$\kappa = 0.6$	$\kappa = 0.7$	$\kappa = 0.8$	$\kappa = 0.9$	$\kappa = 0.99$
Income taxes ($\tau^w = \tau^r$) (p.p.)	-13.71	-13.29	-12.84	-12.36	-11.84	-11.30	-10.72	-10.11	-9.45	-8.83
Contribution rate (p.p.)	-10.78	-7.94	-5.11	-2.27	0.57	3.40	6.24	9.08	11.92	14.47
Wage rate	33.82	28.03	22.78	17.97	13.53	9.38	5.48	1.78	-1.77	-4.84
Interest rate (p.a.) (p.p.)	-3.11	-2.64	-2.20	-1.78	-1.37	-0.97	-0.58	-0.19	0.19	0.54
Private Consumption	4.22	5.45	6.19	6.50	6.42	5.99	5.22	4.13	2.72	1.19
Government Consumption	-25.27	-21.89	-18.55	-15.23	-11.92	-8.58	-5.19	-1.74	1.80	5.09
Capital-output ratio (annual)	80.52	65.03	51.60	39.81	29.34	19.94	11.42	3.63	-3.55	-9.57
GDP	33.82	28.03	22.78	17.97	13.53	9.38	5.48	1.78	-1.77	-4.84
Economic welfare	27.83	25.24	22.36	19.22	15.79	12.08	8.04	3.66	-1.12	-5.80

Note: [a]All changes are reported as percentage differences to the benchmark model (BM), except for income taxes, contribution rate, and interest rate, which are already reported in percentage points. p.p: percentage points.

Figure 3 shows the percentage changes of economic welfare, GDP and annual capital-output rate when $\theta = 0$ for a range of replacement rates (0 to 1).

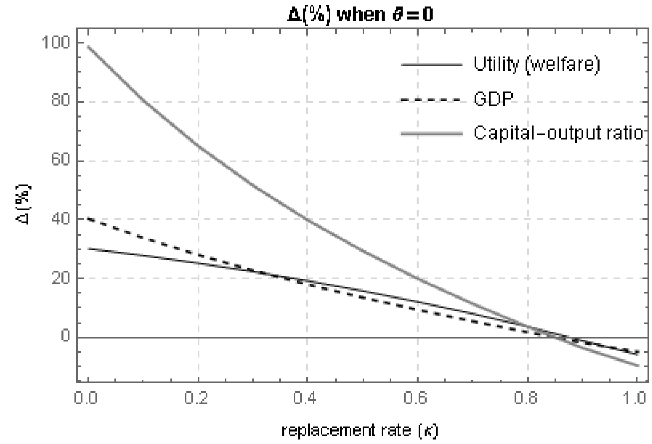


Figure 3: Percentage changes on main variables: sensitivity analysis by replacement rate with respect to the benchmark model when $\theta = 0$.

In order to find an optimal scenario that smooths the fiscal taxation pressure of income (focusing on the economic welfare of households), the contribution rate is pinning down[19]. Therefore, it could be said that it corresponds to the case when the replacement rate (κ) is roughly 0.5. Consequently, the equilibrium in the long run is satisfied with a roughly contribution rate of 14%[20]. Income taxes are likely to lead a reduction of 11.84 percentage points to reach a roughly 5%.

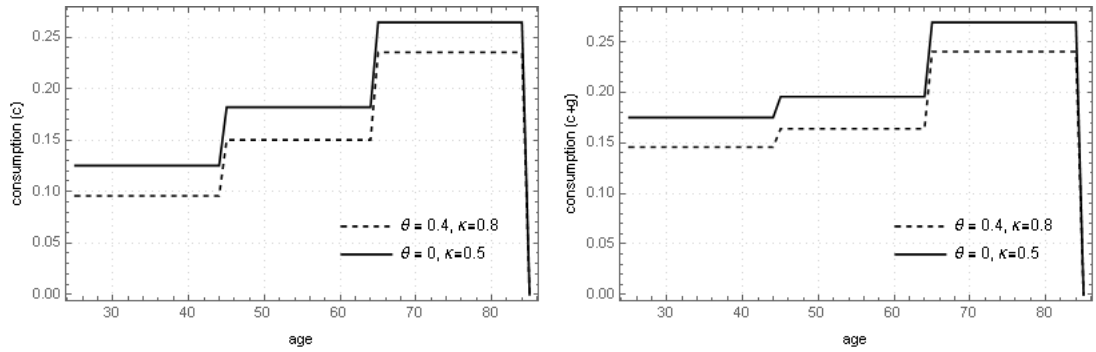
Note that the this income tax percentage points gap has been hiding an additional pension tax, i.e., if the pension benefit would be financed only with contributions of workers (θ= 0), the income tax would be lower and the pension payroll tax would be higher. Of course, since the model is not able to make up the actual Ecuadorian labor supply structure, the informality is not considered here, and consequently, the latter effect (all workers would have to pay a higher tax to the social security) on the household wealth would be the same. However, in terms of analyzing the impact of a pension system (that also includes the non-contributors), it is of crucial importance, because it reveals that there exists a kind of subsidy for the contributory pension benefits in a very generosity PAYG pension system.

On the other hand, of course, income tax revenues and public consumption too go down. Savings and capital would increase (46.84%), so the interest rate falls (1.37 percentage points). Finally, the economic welfare, private consumption, and GDP would increase 15.79%, 6.42%, and 13.53%, respectively.

[19]The gap between the optimal pension payroll tax and the one of the benchmark scenario would be close to zero.

[20]This value is 0.57 percentage points higher than the one of the benchmark scenario.

Figure 4 compares the age profiles for consumption between models with $\theta = 0.4, \kappa = 0.8$ and $\theta = 0, \kappa = 0.5$. It reveals clearly the welfare gain (of course in terms of consumption) when the government-financed share of pension benefit expenditures is eliminated and the generosity of the pension is reduced. Note that consumption (private) increase with age, so the older generation has a higher consumption. When the public consumption is added to the private consumption, the younger- and middle generation consumption is almost equal (since g_1 is much bigger than g_2); nevertheless, the old generation consumption remains higher.



(a) consumption (private) (b) consumption (private+public)

Figure 4: Life-cycle consumption

5 Discussion and Conclusions

Motivated by the current situation of the Ecuadorian pension system, and since reforms in a PAYG pension system causes distortions on decisions of agents, in this paper we have studied the effects of some pension reforms on the long run level of macroeconomic variables and economic welfare for the case of the Ecuadorian economy. Particularly, we worked with the so debatable reform related to the elimination of the 40% government-financed share of contributory pension payments, as well as reduction of replacement rate. For this purpose we have used a three-period CGE-OLG economy a la Auerbach and Kotlikoff (1987) that takes into account the model framework of Fehr and Kindermann (2018b) and many features of Fehr (1999) and Fehr (2000), calibrated to data from Ecuador in year 2014. Main results allow us to arrive at the following conclusions.

First, when $\kappa = 0$, which means that economy does not have a PAYG, results evidence the hypothesis that a PAYG brings about a reduction in the long-run welfare of individuals for the case of Ecuador, since it crowds out private savings and consequently, the capital stock, inversion, and wages decrease. Therefore, economic welfare, measured as the change in utility, would drop, too. However, these results needs to be taken carefully because the transitional path quantification has been abstracted, which generally shows that the welfare losses of future cohorts are mainly owed to welfare gains of transitional cohorts, where usually they are mitigated through compensations by a Fiscal Authority. Without this analysis, as Fehr and Kindermann (2018b) suggest, our results seem to "favor the reduction or privatization of the unfunded pension system", where the redistribution of resources across generations would be lost. We left this issue for a further research.

Second, results of reducing the 40% government-financed share of pension benefits payments, but keeping the generous pension that makes up 80% of past earnings, reported a low impact (up to of 3.66% in economic welfare) with respect to the equilibrium with the actual pension system features. This low impact is due to that fraction has to be paid through taxes, thus, the income tax would have to be reduced almost in the same roughly percentage points that the contribution rate would have to rise. In the case of elimination of that 40%, the former would descent 10.11 percentage points and the latter would ascent 9.08 percentage points. Note that the income taxes at initial equilibrium are *hidden taxes* in the sense that they are not recognized as an additional contribution rate. Therefore, it reveals that younger generations would have to pay a double tax for financing the pension benefits of the old generation, which would be seen as an unfair 'agreement'. Moreover, since the population growth rate is decreasing, the fiscal taxation pressure on the younger population for keeping that generous pension will be higher in the future.

Despite this work does not consider the non-contributory analysis, here it is necessary to highlight that the fact of contributory pensions are financed by income- and consumption taxes, like the Ecuadorian case, the contributivity principle is broken. Thus, non-contributory workers would also have the right of receiving pensions (Conde-Ruiz, 2014). Across the board, though, taxes are used for non-contributory pensions (Conde-Ruiz, 2014), for instance as it is modeled in Fehr (1999, 2000). Otherwise, it could be seen as a subsidy for financing the contributory PAYG pension system.

Third, if the policy reform is about only reducing the generosity of pension, but keeping that 40%, results show higher economic welfare gains (up to 23.76% when $\kappa = 0.2$) and, of course, reductions of income taxes (fall of 9.84 percentage points when $\kappa = 0.2$) and contribution rates (fall of 10.21 percentage points when $\kappa = 0.2$) with respect to the initial equilibrium. Nevertheless, if we want to have a transparent fiscal taxation structure -in the sense of contributivity principle- and combining both policy reforms, i.e., elimination of 40% and reduction of replacement rates, results reported even higher gains (up to 25.24 % when $\kappa = 0.2$). In order to find an optimal scenario that smooths the fiscal taxation pressure on household income and the fall of the economic welfare of households, the contribution rate is pinning down[21]. Therefore, it could be said that it corresponds to

[21] The gap between the optimal pension payroll tax and the one of the benchmark scenario would be close to zero.

the case when the replacement rate (κ) is roughly 0.5. Consequently, the equilibrium in the long run is satisfied with a roughly contribution rate of 14%. Income taxes are likely to lead a reduction of 11.84 percentage points to reach roughly 5%. Of course, their revenues and public consumption too go down. Savings and capital would increase (46.84%), so the interest rate falls (1.37 percentage points). The economic welfare, private consumption, and GDP would increase 15.79%, 6.42%, and 13.53%, respectively.

Finally, on the other hand, since our aim was to get a macro-view of the effects of a PAYG pension system and its reforms on the Ecuadorian economy, we have abstracted from some potentially important issues -as does any model-, such as leisure, heterogeneity, and uncertainties. Moreover, the model assumed a closed economy and did not include informality (low coverage of social security). We leave these issues for future researching. Thus, the quantitative numerical results, have to be interpreted cautiously. Nevertheless, despite its obvious limitations, we think that our first approach is a very useful starting point for future discussions of policies reforms in Ecuador that have impacts on macroeconomic variables, particularly on the design of a pension system scheme. Also, we think it could be used in other economies with unbalanced PAYG pension systems, where income or consumption taxes finance the contributory pensions.

Motivated by the chapter one, and since reforms in a PAYG pension system causes distortions on decisions of agents, in this chapter we have studied the effects of it on the long run level of macroeconomic variables and economic welfare for the case of the Ecuadorian economy. Particularly, we worked with the so debatable reform related to the elimination of the 40% government-financed share of contributory pension expenditures, as well as reduction of replacement rate. For this purpose we have used a three-period CGE-OLG economy a la Auerbach and Kotlikoff (1987) that takes into account the model framework of Fehr and Kindermann (2018a) and many features of Fehr (1999) and Fehr (2000), calibrated to data from Ecuador in year 2014. Main results allow us to arrive at the following conclusions.

First, when $\kappa = 0$, which means that economy does not have a PAYG, results evidence the hypothesis that a PAYG brings about a reduction in the long-run welfare of individuals for the case of Ecuador, since it crowds out private savings and consequently, the capital stock, inversion, and wages decrease. Therefore, economic welfare, measured as the change in utility, would drop, too. However, these results needs to be taken carefully because the transitional path quantification has been abstracted, which generally shows that the welfare losses of future cohorts are mainly owed to welfare gains of transitional cohorts, where usually they are mitigated through compensations by a Fiscal Authority. Without this analysis, as Fehr and Kindermann (2018a) suggest, our results seem to "favor the reduction or privatization of the unfunded pension system", where the redistribution of resources across generations would be lost. We left this issue for a further research. Nevertheless, in the next chapter, we will assess the redistribution of pension

benefits of a cohort of workers (but from a micro-view), which would help, partly to fulfill this gap.
Second, results of reducing the 40% government-financed share of pension benefits payments, but keeping the generous pension that makes up 80% of past earnings, reported a low impact (up to of 3.66% in economic welfare) with respect to the equilibrium with the actual pension system features. This low impact is due to that fraction has to be paid through taxes, thus, the income tax would have to be reduced almost in the same roughly percentage points that the contribution rate would have to rise. In the case of elimination of that 40%, the former would descent 10.11 percentage points and the latter would ascent 9.08 percentage points. Note that the income taxes at initial equilibrium are *hidden taxes* in the sense that they are not recognized as an additional contribution rate. Therefore, it reveals that younger generations would have to pay a double tax for financing the pension benefits of the old generation, which would be seen as an unfair 'agreement'. Moreover, as we reviewed in chapter one since the population growth rate is decreasing, the fiscal taxation pressure on the younger population for keeping that generous pension will be higher in the future.
Despite this work does not consider the non-contributory analysis, here it is necessary to highlight that the fact of contributory pensions are financed by income- and consumption taxes, like the Ecuadorian case, the contributivity principle is broken. Thus, non-contributory workers would also have the right of receiving pensions (Conde-Ruiz, 2014). Across the board, though, taxes are used for non-contributory pensions (Conde-Ruiz, 2014), for instance as it is modeled in Fehr (1999, 2000). Otherwise, it could be seen as a subsidy for financing the contributory PAYG pension system.
Third, if the policy reform is about only reducing the generosity of pension, but keeping that 40%, results show higher economic welfare gains (up to 23.76% when $\kappa = 0.2$) and, of course, reductions of income taxes (fall of 9.84 percentage points when $\kappa = 0.2$) and contribution rates (fall of 10.21 percentage points when $\kappa = 0.2$) with respect to the initial equilibrium. Nevertheless, if we want to have a transparent fiscal taxation structure- in the sense of contributivity principle- and combining both policy reforms, i.e., elimination of 40% and reduction of replacement rates, results reported even higher gains (up to 25.24 % $\kappa = 0.2$). In order to find an optimal scenario that smooths the fiscal taxation pressure on household income and the fall of the economic welfare of households, the contribution rate is pinning down[22]. Therefore, it could be said that it corresponds to the case when the replacement rate (κ) is roughly 0.5. Consequently, the equilibrium in the long run is satisfied with a contribution rate of 14.19% (0.57 percentage points higher than the one of the benchmark model). While income taxes are likely to lead a reduction of 11.84 percentage points to reach roughly 5%. Of course, their revenues and public consumption

[22]The gap between the optimal pension payroll tax and the one of the benchmark scenario would be close to zero.

too go down. Savings and capital would increase (46.84%), so the interest rate falls (1.37 percentage points). Finally, the economic welfare, private consumption, and GDP would increase 15.79%, 6.42%, and 13.53%, respectively.
Finally, on the other hand, since our aim was to get a macro-view of the effects of a PAYG on the Ecuadorian economy, we have abstracted from some potentially important issues-as does any model-, such as leisure, heterogeneity, and uncertainties. Moreover, the model assumed a closed economy and did not include informality (low coverage of social security). We leave these issues for future researching. Thus, the quantitative numerical results, have to be interpreted cautiously. Nevertheless, despite its obvious limitations, we think that our first approach is a very useful starting point for future discussions of policies reforms in Ecuador that have impacts on macroeconomic variables, particularly on the design of a pension system scheme. Also, we think it could be used in other economies with unbalanced PAYG pension systems, where income or consumption taxes finance the contributory pensions.

A Appendix

A.1 The steady state

Since everything is constant in time all t indexes are superfluous, therefore they are dropped. We have to maximize the utility given in equation (2) subject to the constraint (4), which now becomes:

$$pc_1 + \frac{pc_2}{R^n} + \frac{pc_3}{(R^n)^2} = w^n + \frac{w^n}{R^n} + \frac{pen}{(R^n)^2} = W_1 \tag{19}$$

Now,

$$c_2 = (\beta R^n)^{\gamma} c_1 \ \ and \ \ c_3 = (\beta R^n)^{\gamma} c_2 = (\beta R^n)^{2\gamma} c_1 \tag{20}$$

Substituting (20) into (19) the consumption for the first period of life is obtained:

$$c_1 = \frac{1}{p}\left\{1 + \beta^{\gamma}(R^n)^{\gamma-1} + \beta^{2\gamma}(R^n)^{2(\gamma-1)}\right\}^{-1} W_1 \tag{21}$$

The savings a_2 and a_3 are given by

$$a_2 = w^n - pc_1 \tag{22}$$

$$a_3 = w^n + R^n a_2 - pc_2 \tag{23}$$

A.2 Computation

In order to find the initial and final steady state equilibria of the model, for some given conditions, we solved a set of non-linear equations that specify the optimization behavior of individual agents, firms and government. The technique used for solving our CGE-OLG model under perfect foresight was the most common, which is related to iterations over guesses of price factors[23]. Having computed factor prices and individual decisions variables, we arrived at the mentioned non-linear system, where the two remaining (the capital stock K_t and income taxes) variables have to be guessed. We used the Newton method for solving numerically the resulting system. This method converges quadratically, which implies a fast convergence, especially when our initial guess is near the actual solution, and therefore it needs fewer iterations.

A.3 Macoeconomic variables: Ecuador vs OECD and Latin America

Figures displayed in this section use data from the World Bank database available at: http://databank.worldbank.org/data/databases[24].

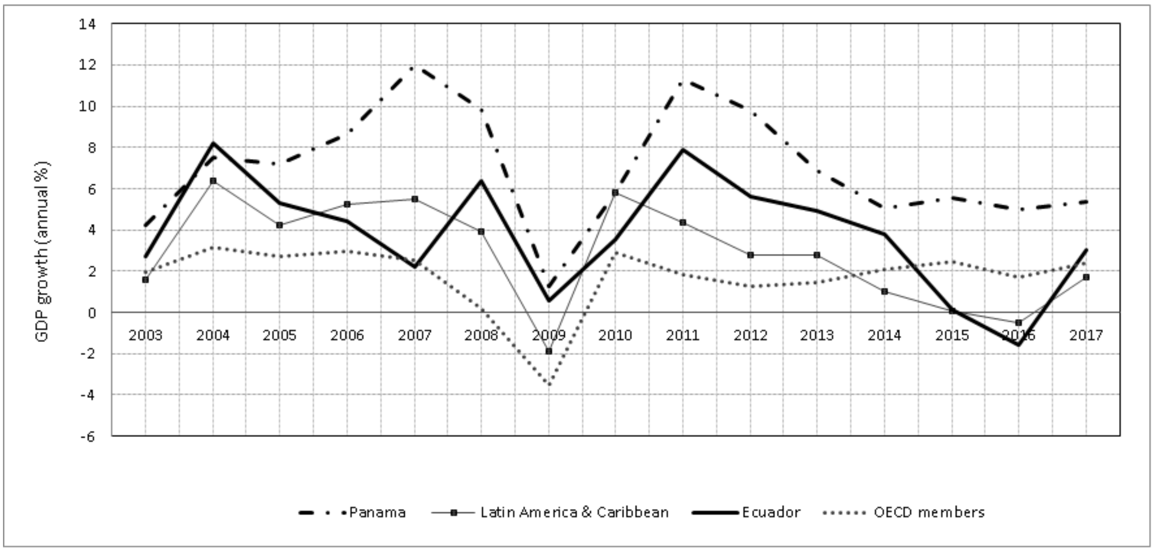


Figure 5: Evolution of GDP growth (annual %) by countries, 2003-2017. Source: databank.worlbank

[23]This technique is often called the *Gauss-Seidel method*. For a more detailed description of this procedure, see Fehr and Kindermann (2018b).

[24]For the sake of simplicity, we will cite it as databank.worldbank.

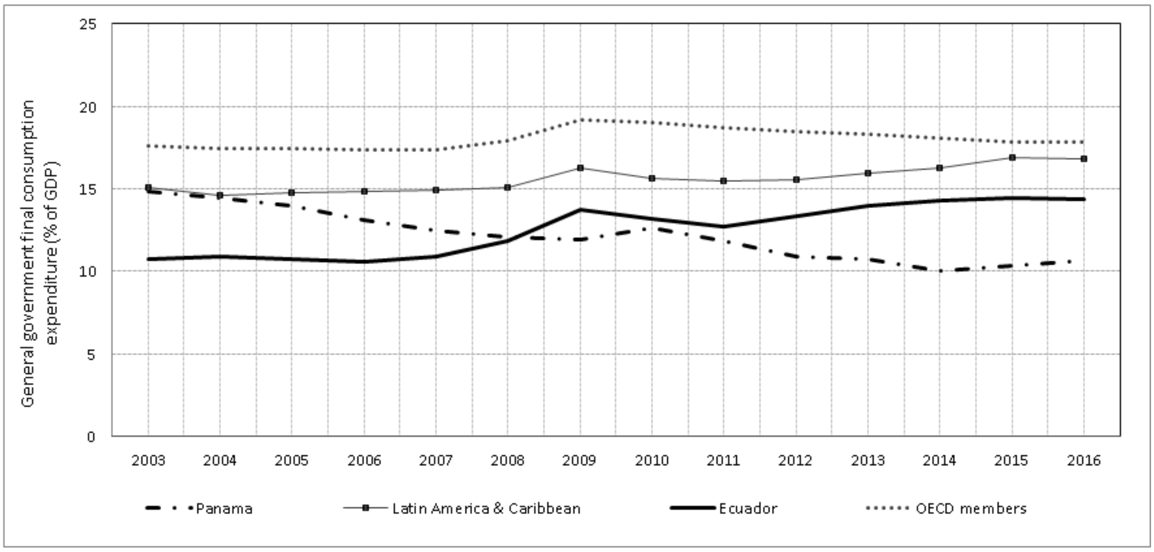


Figure 6: Evolution of General government final consumption expenditure (G), as % of GDP, by countries, 2003-2016. Source: databank.worlbank

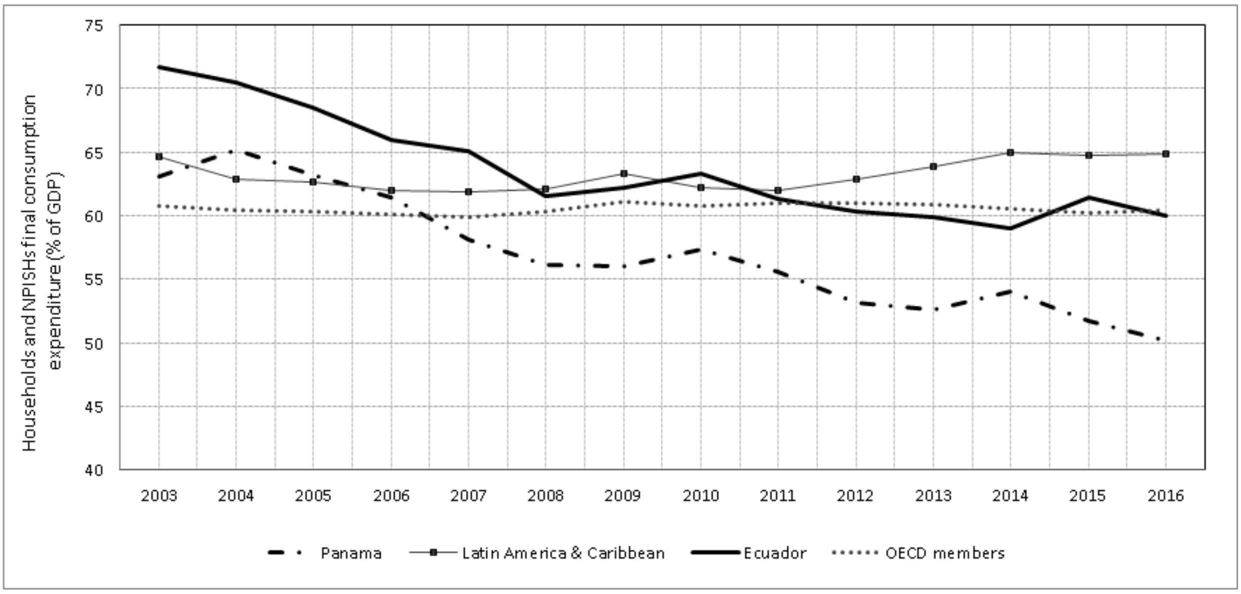


Figure 7: Evolution of Households and nonprofit institutions serving households final consumption expenditure (C), as % of GDP,) by countries, 2003-2016. Source: databank.worlbank

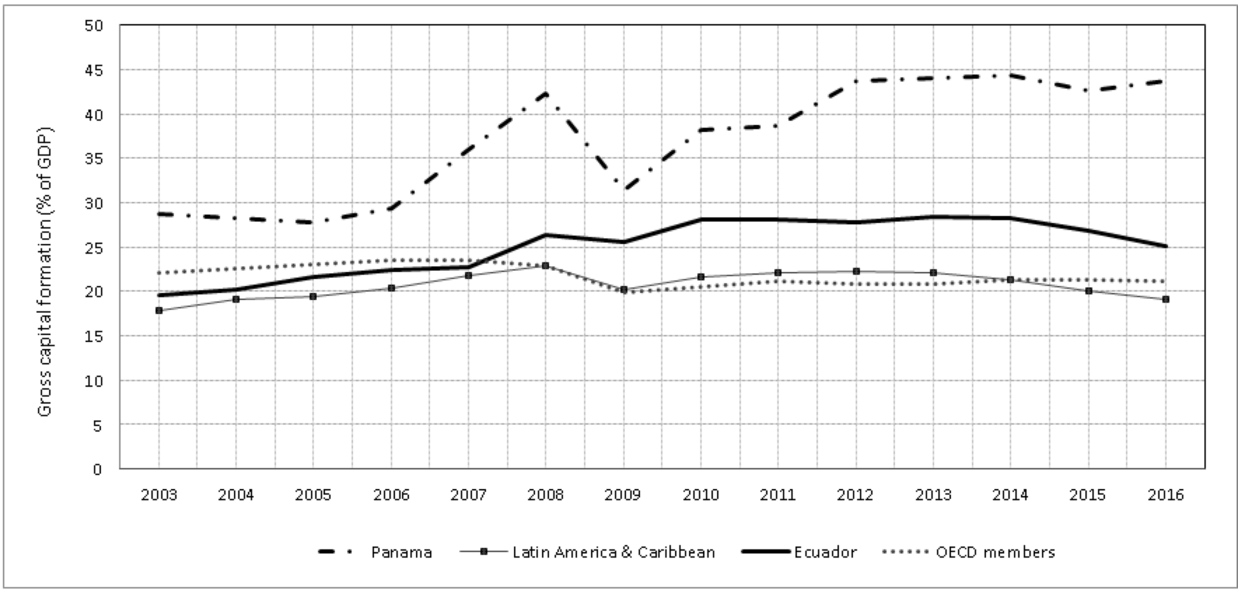


Figure 8: Evolution of Gross capital formation (I), as % of GDP, by countries, 2003-2016. Source: databank.worlbank

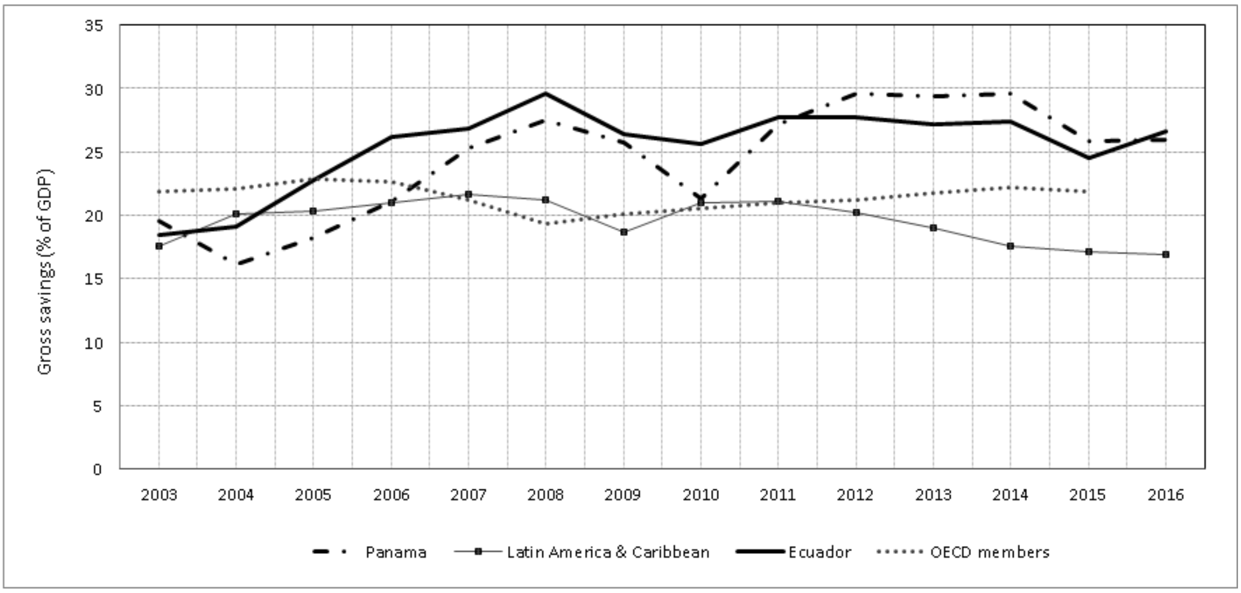


Figure 9: Evolution of gross savings (A), as % of GDP, by countries, 2003-2016. Source: databank.worlbank

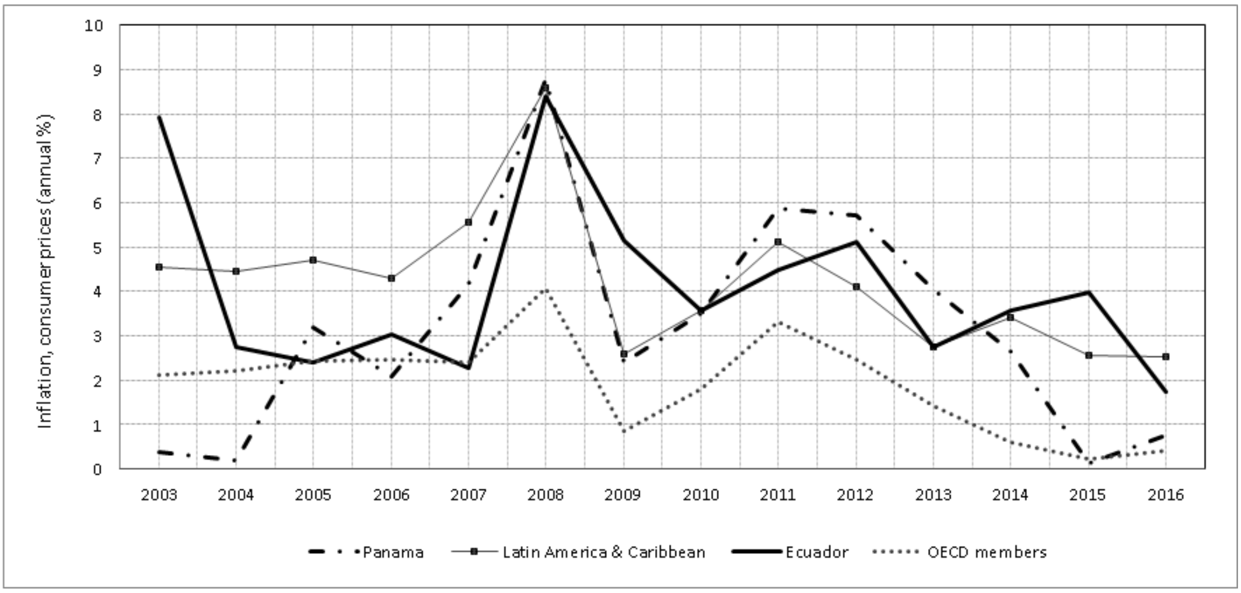


Figure 10: Evolution of Inflation, consumer prices (annual %) by countries, 2003-2016. Source: databank.worlbank

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