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Funding of a pension plan in a public university in Mexico: a numerical approach

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Abstract

The objective of this work is to show a numerical example of the actuarial liabilities and the annual cash flows that a database of employees of a university represent, calculating also the value of the contributions that targets these actuarial liabilities for different scenarios. The methodology used is actuarial calculations of the funding of a pension plan. The results are that the pension plan is not actuarially viable as with the actual contribution of 5% it does not provide a replacement rate of 100% of the final salary. Also, that in order to obtain the 100% replacement rate, a contribution of as much as 22% of salary is required to target the benefit. The main limitation of this study is that it is a numerical example of a specific university. However, it shows that this one private pension plan struggles to meet its actuarial liabilities, as the literature suggest.

Keywords: pension plans, actuarial liabilities, cash flows, target benefit.
JEL classification: G22.

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Financiamiento de un plan de pensiones en una universidad pública en México: un enfoque numérico

Resumen

El objetivo de este trabajo es mostrar un ejemplo numérico de los pasivos actuariales y los flujos de caja anuales que representa una base de datos de empleados de una universidad, calculando también el valor de las aportaciones que apuntan a estos pasivos actuariales para diferentes escenarios. La metodología utilizada son los cálculos actuariales de la financiación de un plan de pensiones. Los resultados son que el plan de pensiones no es actuarialmente viable ya que con la contribución real del 5% no proporciona una tasa de reemplazo del 100% del salario final. Además, que para obtener la tasa de reemplazo del 100% se requiere un aporte de hasta el 22% del salario para focalizar el beneficio. La principal limitación de este estudio es que es un ejemplo numérico de una universidad específica. Sin embargo, muestra que este plan de pensiones privado tiene dificultades para cumplir con sus obligaciones actuariales, como sugiere la literatura.

Palabras clave: planes de pensiones, pasivos actuariales, flujos de efectivo, beneficio objetivo.
Clasificación JEL: G22.

1. Introduction

Pension systems may be considered as a social contract with the only objective to provide an income to the elderly at the time when it results extremely difficult to generate some kind of income. The design of these contracts is crucial because, for example, for a person it makes all the difference to receive this income or not. However, despite the importance of these pension systems, the characteristics and the consequences of the design of pension plans are unknown specifically in Latin America, where only 53% of the workers are covered by these plans (Altamirano, 2018: 10).

In Mexico, it has been 26 years since the mandatory pension system was reformed from a defined benefit to a defined contribution, through individual accounts managed by private companies. The actual system consists on a multi-pillar model with 4 pillars in total as follows. The first pillar, or

non-contributory pension, provides with a basic pension provided by the government. The second pillar, or mandatory pension, consists on a contributory public pension plan of a defined benefit type. The third pillar, also mandatory, consists in a defined contribution type with individual accounts. The fourth pillar, or voluntary; consists on additional voluntary contributions into individual accounts, social prevision funds, occupational pension plans or private plans (CONSAR, September 2018; Calderón-Colín and Carmona Sánchez, 2023).

The first pillar faces an important financial challenge as it is expected that many workers will not fulfill the requirements to obtain a minimum pension; hence, the government will have to pay these minimum pensions through federal financial resources. The second and third pillars are relatively stable as these consists on individual accounts and private pension plans regulated by the government. However, it is a different scenario for the second pillar, which also faces a financial challenge for the Mexican government. Within the second pillar coexists multiple pension plans where the majority of them are of a defined benefit type and some others have migrated to a defined contribution scheme. The pension plans from local governments and the 55 public universities in Mexico are situated within this second pillar. All of them have their own pension plans, which have no portability and there is not interaction between federal and local schemes (OECD, 2016: 37).

Therefore, the Mexican pension system is fragmented, as the pillars are not integrated, which generates deficiencies and poor or null benefits to workers. This is because the characteristics and requirements to have access to a pension, within the many plans that coexist, are quite heterogeneous. In Mexico there are more than 1 000 different pension systems and schemes, each of them with different contribution rates, replacement rates, rules, conditions and benefits. This dispersion within pension plans makes impossible to know the total cost that these represent. This is because many of these plans belong to universities or municipalities that do not have the obligation to report their pension costs. Also, the lack of transparency on these kind of plans, makes really difficult to know the responsible of these agreements. Then, the total pension cost that is reported refers to only 5 institutions that do report it. As of 2017, this cost represented 3.12% of the GDP; of which 95% refers to contributory pension plans and 5% to non-contributory pension plans. However, only 7.3% of the total cost is covered by contributions, the other 92.7% is covered by the government (Villarreal and Macías, 2020).

The objective of this work is to expose the relevance to perform an actuarial analysis of the plans belonging to universities, in order to determine

the viability of these plans. To perform this analysis, the numerical data for two institutions that belong to public universities in Mexico are obtained and the actuarial analysis is performed. The layout of this paper is as follows. Section 2 shows an overview of the characteristics of the pension plans for public universities in Mexico. Section 3 shows the specific characteristics of two pension plans from two universities. Section 4 shows the actuarial methods to perform the analysis. Section 5 shows the results and section 6 shows the conclusions.

2. Pension plans in public universities in Mexico

The main feature of the higher education system in Mexico is the diversity and heterogeneity. As of 2016, this system was integrated by 7 095 scholar institutions with 385 777 full-time academics and 3 703 786 students. The majority of these institutions do not have a pension plan that provides a decent monetary payment. However, there are some institutions that do have a pension plan which consists on dynamic retirement (i.e. once the employee meet the requirements to obtain a pension from the university, this retires while the university pays the contributions to the Mexican mandatory system to meet the requirements of age and years of service, in order to receive either a second pension or a complementary pension to reach a certain level of replacement rate) and that such plans have provoke the financial crisis of these institutions (CONAGO, 2016: 4).

The main three factors that have the public universities in Mexico immerse in a financial crisis are:

- Almost 65% of them register an actuarial deficit that represents, in some cases, as much as 536% of the total income. This situation is reported to be sustained only for another 5 years.
- The poor monitoring and control that the universities give to the use of the financial resources, as there were cases where it was found that some academics were receiving a stratospheric amount per month as retirement.
- Each year the Mexican Government pays to the universities an amount equivalent to 3.8% of the GDP, to cover this actuarial deficit. The federal and state government contribute with 85% of the university total income and will have to contribute more, in order to face the unfunded pension plans that reaches the 400,000 millions of pesos (21,000 million USD), which represents 31% of the university total income.

Some of the characteristics from these pension plans that increase the financial deficit in public universities in Mexico are as follows (Zárate, 2013).

- Average retirement age is 52, which increases considerably the deficit given that the life expectancy is 75 years old.
- The principal requirement to reach retirement is 25 years of service with no additional requirement such as age.
- The replacement rate is based on the final salary, which in some cases is as much as 193%.
- The pension amount increases in line with salaries of active workers.
- In the majority of the public universities there are no contributions to finance these pensions, instead, the governments pay for them.
- These pension plans are contained within a dynamic system which increases considerably the deficit.

Then, public universities operate under different pension systems. It can be identified 1) a system in which the university assumes the full cost of pensions, 2) the employees are affiliated to the mandatory social security system, 3) the mandatory social security system is complementary to the university pension system and 4) the employees have two different pensions (the university pension and the social security system pension). From the 26 public universities analyzed in Zárate (2013), only 5 operate under the modality 2), 16 under the modality 3); 5 under the modality 1), which the author mentions that are the worst case scenario; and the rest under modality 4).

In order to face this financial crisis, the government created the "support fund for financial sanitation and for the attention of structural problems of state public universities (UPE)". In a period from 2002 to 2015 the Treasury of Education in Mexico (SEP) provided USD 772 million and in 2016 the Treasury of Finance and Public Credit (SHCP) provided USD 116 million to the fund. However, the main challenge that these public universities face is to make a deep restructure to their pension plans, in order to guarantee their financial viability. As of 2018, 25 public universities in Mexico made substantial changes to their pension plans for the actual employees and 28 made so for the new generations (ANUIES, 2018: 100).

Some actions that the government defined to face these challenges were as follows (Aguirre, 2016: 17):

- To create a multidisciplinary group with expertise in social security.
- To create a State Secretary with political and economic authority to regulate, coordinate, monitor and that dictates the national social security policy.

- To modify the Mexican Constitution to create a Framework Law which establishes the minimum and maximum rules under which public pension systems will govern.

Another recommendation was that academics from these public universities get involved in the redesign of the pension plans from their own institutions, as they could define the appropriate age for retirement, identify how additional remunerations affect academic staff and what the replacement rate should be for this sector (Universidad Iberoamericana Ciudad de México, November 2016: 7).

A reform to the design of public universities pension plans is of high priority, as these plans were created as defined benefit schemes, where the demographic dynamic is fundamental to these plans be financially viable. With the prevailing demographic structure at the time when these plans were created, it did not represent a burden for the sponsor of the plan (CONSAR, September 2018: 5).

However, from 2015 to 2021 the funds assigned to universities decreased a total of 3.11 billion of USD (57 billion of Mexican Pesos), which makes even more difficult for these to cover these deficits. Also, that from 2000 to 2019 tuition at public universities increased 123%, meanwhile the total funds assigned to these institutions only increased 75%. The laboral conditions that public universities promise to their employees, including those of pension plans, are not funded accordingly and this is now a mayor problem. Then the reason why the urgency to create the so called "support fund for financial sanitation and for the attention of structural problems of state public universities (UPE)". The worst deficit scenario belongs to the following universities: Morelos, Oaxaca, Zacatecas, Chiapas, Estado de México, Tabasco, Veracruz, Michoacán, Nayarit, Guerrero and Baja California (Wong, 2020).

3. Characteristics of pension plans from two public universities in Mexico

The pension plan characteristics from public universities in Mexico are contained in the collective labor agreement at each institution. Because this document is not always of a public domain, it is extremely difficult to perform a comparison between the characteristics of these plans. Moreover, in order to perform an actuarial analysis, the data related to the employees of such institutions is not available. The relevance of this work, is that the actual database of the characteristics of the employees from two institutions

are used to analyze the financial situation that these face by performing an actuarial analysis.

In a previous study (Gómez Hernández, 2019), the characteristics of pension plans from 16 out of 33 autonomous public universities in Mexico were collected. The study shows that all of them have a defined benefit pension plan, which in the majority of the cases is closed to new members. Also, that all of them offer 100% replacement rate when the requirements are met and that only 15 of them make contributions to some kind of fund or trust. Moreover, that the actuarial liabilities from a specific public university in Mexico were found to be as high as USD 230 million as of 2017 and that these will increase as much as USD 424 million by 2027 (Gómez-Hernández and Almaraz-Rodriguez, 2017: 84).

In this study, the database of the characteristics of the employees from a second public university are obtained. The modelling of the value of the fund, the actuarial liabilities and the annual payments required to the pension payments are shown. The information presented here is presented with the main objective to show how a poor design of a pension plan can affect the actuarial liabilities of the institutions and the public finances. Therefore, derived from these calculations, an efficient design of a pension plan is defined, comparing both results from both institutions.

A brief description of the two pension plans analyzed is shown in table 1. For the sake of simplicity, the two pension plans are named "University A" and "University B". Both of the pension plans offer a defined benefit scheme that complements the Mexican mandatory DB system, in order to receive a total of 100% replacement rate. The retirement age is not a compulsory requirement for one of the universities. Both of them have 30 years of service as a minimum requirement to retire. The total contribution for university A is much higher than in university B. The 24% contribution is a total of 8% from the employee and 16% from the university, while the 5% is a total of 3% and 2% from the employee and university, respectively.

Table 1
Main characteristics of two pension plans at universities

	University A	University B
Pension plan type	Funded defined benefit scheme (coexisting with IMSS), closed to new members in 2007	Funded defined benefit scheme (coexisting with ISSSTE), closed to new members in 1991
Retirement age	60 years old	None
Years of service	30	30
Total contributions	24%	5%

Source: own elaboration from collective labor agreement from each institution.

4. Modelling of a pension fund: a numerical example

As mentioned before, the objective of this work is to expose the relevance to perform an actuarial analysis of two public universities pension plans, in order to determine the financial and actuarial viability of these plans. The methodology proposed involves mathematical methods divided in four stages:

- First, an overview of the main characteristics of the database of employees from University *B* is given.
- Second, in order to determine the cost of this plan, the total actuarial liabilities are calculated representing the financial cost for the pension plan.
- Third, the annual payments made to cover the pension costs are also calculated, represented by the annual cash flows.
- Fourth, a comparison of the results for both universities is performed, in order to determine an efficient design of a pension plan that is financially self-sustainable and actuarially viable.

These stages of the methodology are described in the next section. The numerical methods are defined mainly from Blake (2006), Booth *et al*. (2005), Bowers *et al*. (1997), Gómez-Hernández & Stewart (2008), Kellison S. (2009) and OECD (2017).

Description of the modelling stages

In the first stage a descriptive statistics of the data is performed. The main objective here is to give an overview of the current situation of the employees at University B. This analysis will be useful to determine a possible justification of the results in other stages.

The second stage consists on calculating the total actuarial liabilities using mathematical methods. According to Blake (2006), the majority of the defined benefit actuarial liabilities are calculated using the so called projected unit method. Equation (1) shows the value of the total actuarial liability for active members of the plan, derived from Blake (2006). AL_a is calculated each year until the plan is extinguished. Recall that the pension plan is closed to new members, according to table 1.

$$AL_a = \sum_{i=1}^{N_a} S_i \, {}_{n_i}|\ddot{a}_{x_i}^{(12)}$$

Where:

AL_a = Total actuarial liabilities for active members
S_i = Salary of employee *i* at time of retirement
${}_{n_i}|\ddot{a}_{x_i}^{(12)} = n_i$ year deferred whole life annuity due with monthly payments at age x_i
n_i = number of years to reach retirement for employee *i*
x_i = retirement age of employee *i*
N_a = total number of active employees

The value of the n_i year deferred whole life annuity due with monthly payments at age x_i is calculated as (Bowers *et al*., 1984) ${}_{n_i}|\ddot{a}_{x_i}^{(12)} = \alpha(12)\,{}_{n_i}|\ddot{a}_{x_i} - \beta(12)$ where ${}_{n|}\ddot{a}_x = \sum_{k=n}^{\infty} v^k \, {}_k p_x$ and ${}_k p_x$ the surviving probability from age x to age $x+k$, $\alpha(12) = \frac{id}{i^{(12)}d^{(12)}}$ and $\beta(12) = \frac{i - i^{(12)}}{i^{(12)}d^{(12)}}$ The value of the monthly rate of return and discount rate are calculated as $d^{(12)} = 12\left(1 - d^{1/12}\right)$ and $i^{(12)} = 12\left[(1+i)^{1/12} - 1\right]$ (Kellison G., 2009).

In a similar fashion than equation (1), equation (2) is derived to show the value of the total actuarial liabilities for pensions in payment. AL_p is also calculated each year until all retired employees died.

$$AL_p = \sum_{i=1}^{N_p} S_i \ddot{a}_{x_i}^{(12)} \qquad (2)$$

Where:

AL_p = total actuarial liabilities for retired employees

$\ddot{a}_{x_i}^{(12)}$ = whole life annuity due with monthly payments at age *x* for employee *i*

N_p = total number of pensioners

The value of the whole life annuity due with monthly payments at age x is calculated as follows (Bowers *et al*., 1984) $\ddot{a}_x^{(12)} = \alpha(12)\ddot{a}_x - \beta(12)$ and $\ddot{a}_x = \sum_{k=0}^{\infty} v^k \, {}_k p_x$ The calculation for each annuity value is performed for each employee *i*. Moreover, the projected salary for employee *i* is calculated as $S_i = S_{x_i}(1+r)^{n_i}$ where S_{xi} is the salary of employee *i* at age *x* (which is known) and *r* is the rate to project the salary *n* years for employee *i*.

The third stage of the analysis consists on calculating the total annual cash flows, see equations (3) and (4). CF_t^a and CF_t^p are also calculated each year *t* until the plan is extinguished (Gomez-Hernandez & Almaraz-Rodriguez, 2017).

$$CF_t^a = \sum_{i=1}^{N_a} S_{t,i} \; {}_{n_i}p_{x_i} \tag{3}$$

$$CF_t^p = \sum_{i=1}^{N_p} P_{t,i} \; {}_t p_{x_i} \tag{4}$$

Where:

$S_{t,i}$ = projected salary for employee *i* at time *t*

$P_{t,i}$ = value of the pension in payment for employee *i* at time *t*

The fourth stage consists in comparing both results from University A (taken from previous work) and B and to propose an efficient design of a pension plan that is financially self-sustainable and actuarially viable. The purpose is to calculate a value of the fund by assuming equation (5) (Booth, *et al*., 2005).

$$f_T = f_0(1+j)^T + (1-e_1)\sum_{t=1}^{T} c_t(1+j)^{T-t} \tag{5}$$

Where:

f_T = the value of the projected fund at time *T*

T = number of periods up to retirement age

j = the value of the rate of return for the fund

e_1 = expense fraction on the value of contributions

c_t = the value of the contribution at time *t*

Note that a constant value of the contribution and the rate of return is assumed in equation (4). After the value of the fund is calculated, the replacement rate is obtained in order to show the level of pensions in retirement relative to earnings when working (OECD, 2011; Institute of actuaries, 1980), see equation (6).

$$RR_T = \frac{f_T}{\ddot{a}_x^{(12)} S_T} \tag{6}$$

The value of the replacement rate is calculated a hypothetic employee with different scenarios of the value of the contribution and the value of the rate of return on the fund.

4.1 Actuarial assumptions

The assumptions to perform the calculations are taken from the pension plan characteristics and from the best practices in private pension plans. These are taken from an official publication from the Mexican Government (CONSAR, 2021). These assumptions are described as follows:

- All employees retire immediately after 30 years of service
- An annual increase on salary of 4.5%, i.e. r =0.045 (CONSAR, 2021: 34)
- A real discount rate of 3.5%, i.e. i=0.035 to calculate the value of the annuities (CONSAR, 2021: 33)
- Mexican mortality rates according to the National Commission on Insurance (CNSF) in Mexico, which assumes ω=100 (CNSF, May 2000: 14)
- No ancillary benefits for the sake of simplicity
- The value of the initial fund is zero, i.e. f_0=0
- No charge on the value of the contributions, i.e. e_1 =0

According to the previous assumptions, when calculating the value of the fund a simplified form of equation (5) is defined as equation (7). This value is shown annually; the process is performed as many years as is necessary according to the employees' data base of University B.

$$f_{t+1} = (f_t + c)(1 + j) \tag{7}$$

Next section shows the results derived from these four stages defined in this sections and according to the assumptions.

5. Results

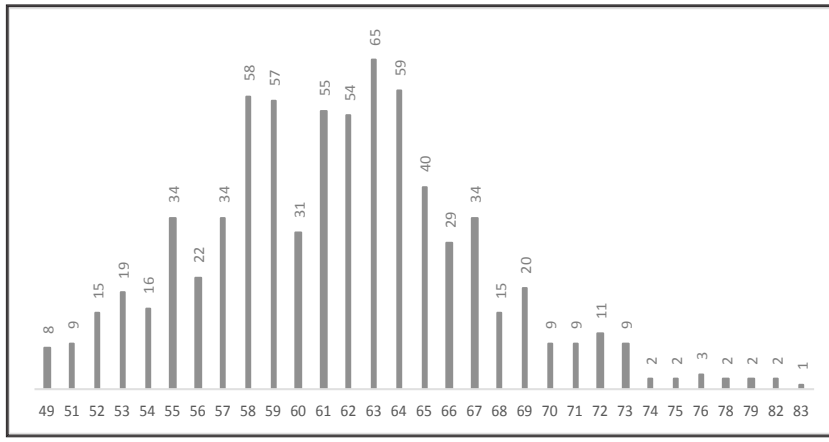
The results for the first stage of the modelling are given in table 2. A total of 727 employees were included in the study. The average age and the average years of service are both quite high; however, considering both results, the average age of entry at this plan is 26 years old. The minimum salary found is USD 14, this is because this particular type of employee only registers two hours per week; whereas the maximum salary refers to an employee that works 40 hours a week, hence, the heterogeneity of the database.

Table 2
Main characteristics of the employees at University B

Total number of employees	726
Average age	62
Average years of service	36
Monthly average salary	USD 274
Minimum monthly salary	USD 14
Maximum monthly salary	USD 569

Source: database of actual employees University B.

Figure 1 shows the distribution of the ages for these employees. The results show that the maximum number of employees are at age 41 years old, with a minimum age of 26 and a maximum age of 83; which is quite heterogeneous. Another results from this figure is that the plan will be extinguished when the 26 years old employee die.

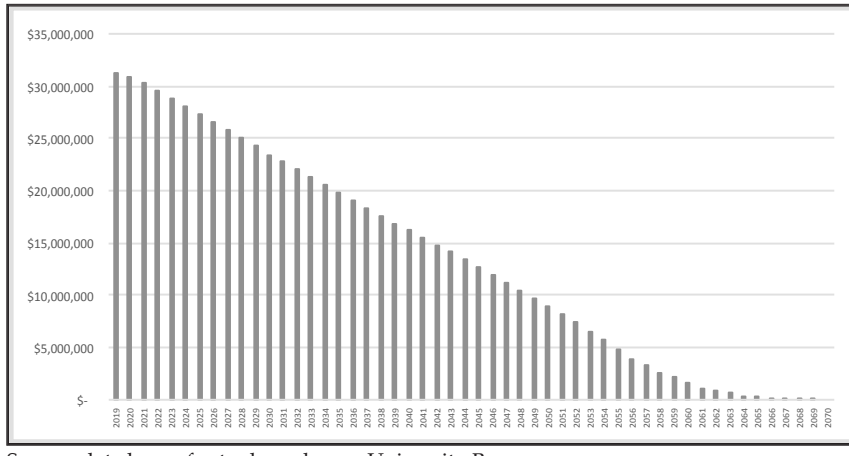


Source: data base of actual employees University B.

Figure 1
Number of employees distributed by age

Another important characteristic from this database of employees is that only the active members of the pension plan and the pensioners are taken into account. Other employees, who started working at this university after 1991, were not included in the analysis due to the plan being closed to new members after that date. Therefore, according to this analysis, there are a considerable number of employees who already meet the requirements to retire but are still active members. Hence, for the subsequent calculations it is assumed that all employees who have 30 years of service or more retire immediately. Under this hypothesis, 631 employees retire.

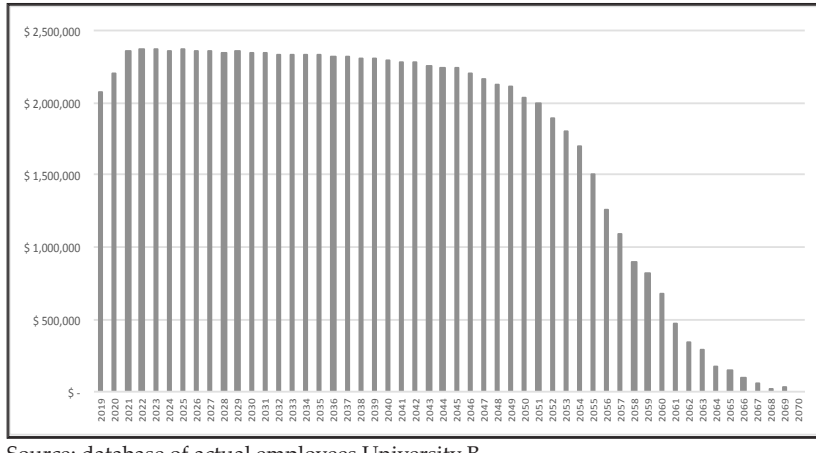
The results for the total actuarial liabilities (equation 1 and 2) are shown in figure 2. The results from this second stage of the methodology show that the plan will be extinguished by 2070 and that the maximum value is found at 2019; with a total of USD 31 158 907. The reason for this is because from the database of employees from University B, 87% of the total employees are retired in 2019. The original database consists of 726 employees and 631 already meet the requirements to retire, but for some reason these employees are still active. Then, for calculation purposes, it is assumed that all the employees with 30 years of service retire immediately, starting 2019.



Source: data base of actual employees University B.

Figure 2
Total value of the actuarial liabilities for University B (USD)

The results for the total annual cash flows (equation 3 and 4) are shown in figure 3. The results show that by 2022, the maximum value is found as USD 2 372 496 and the reason for this is because all the employees are already retired, by that date. Figure 3 shows also that by 2070 the plan is extinguished.



Source: database of actual employees University B.

Figure 3
Total annual cash flows for University B (USD)

The results in figures 2 and 3 can be compared with the results from University A. Table 2 shows the results for both universities in terms of monetary cost. The results from University A correspond to a total of 2 204 employees (Gómez-Hernández and Almaraz-Rodríguez, 2017: 84).

Table 3
Summary of the results found as of 2019

	University A	**University B**
Average annual salary	USD 8.940	USD 3.288
Average age	47	62
Minimum/Maximum annual salary	USD 202/66,829	USD 168/6,828
Total actuarial liabilities	USD 286 millions	USD 31 millions
Total cash flow	USD 21 millions	USD 2 millions
Maximum total actuarial liabilities	USD 427 millions (by 2027)	USD 31 millions (by 2019)
Maximum total annual cash flow	USD 46 millions (by 2035)	USD 2.3 millions (by 2022)
Year for the plan to be extinguished	2087	2070

Source: data base of actual employees University A and B.

When comparing both pension plans, the results are that on average employees in University B are older than in University A. As a consequence, the pension plan in University B is extinguished 17 years before. Also, that on average the salary is much higher in University A and that there is a higher dispersion on the salaries, measured by the minimum and maximum values. As a consequence, the total actuarial liabilities are much higher in University A, which figure is almost 14 times higher.

Therefore, an efficient design of a pension plan that is financially self-sustainable and actuarially viable is needed. In order to achieve this objective, equation (7) is used to model the value of the fund for each university under analysis and under the following assumptions:

- The value of the contribution c is determined to target a pension of 100% of final salary
- Three different scenarios for the salary: low income, median income and high income
- The rate of return for the fund is 2.2%, i.e. j=0.022 (CONSAR, 2021: 60).

The results for this final stage are shown in table 3. It can be seen that the contribution rate required to reach a pension with a replacement rate of 100% final salary (equation 6), increases as the salary increases. Also, that the required contribution rate is quite higher than the defined by the plan (i.e. 5%). Then, for the plan to be financially sustainable the plan needs to contribute as much as 17.3 percentage points more than the actual rate.

Table 4
Sensibility analysis for *c* to reach 100% of final salary
as a replacement rate by income scenario.

	USD	***AL***	***c***
Low Income	14	USD 1.989	16%
Median Income	183	USD 34.103	21.7%
High Income	569	USD 112.171	22.3%

Also, a required contribution of 35% for University A is needed to reach 100% replacement rate of final salary. This also is higher than the 24% contribution rate defined in the pension plan rules. However, the difference for this university is only 11 percentage points.

Another important result is shown in table 4 that refers to the calculations for the required annual real rate of return in order to reach 100% replacement rate. Last column in table 4 shows the required annual real rate of return for each scenario for the salary. The results are that for all three scenarios the value of i is much higher than the 1.8% average rate of return on the funds in Mexico. That is, if the university sets its contribution rate as 5%, the target rate of return on the pension fund needs to be 9%, 11% and 11.16%; respectively for all three scenarios on the salary.

Table 5
Sensibility analysis for *j* to reach 100% of final salary
as a replacement rate by income scenario

	USD	***AL***	***j***
Low Income	14	USD 1.989	9%
Median Income	183	USD 34.103	11%
High Income	569	USD 112.171	11.16%

From results in tables 2, 3 and 4, the following characteristics for a pension plan financially and actuarially sustainable for university B can be defined:

- A total of 30 years of service
- No retirement age
- 100% final salary replacement rate
- No ancillary benefits
- Levels of contribution within the range 9% to 11.16% of salary
- A minimum annual real rate of return of 1.8% and a maximum increase on salary of 4.25% guarantee.

6. Conclusions

Pension plans in public universities in Mexico are immerse in a financial crisis since several years ago. The principal reason is the value of the actuarial liabilities that their pension plans represent. As of 2016, 65% of the public universities register an actuarial deficit which, in some cases, this represents as much as 536% of their total income. Each year the Mexican Government contributes with 3.8% of the GDP to cover this deficit. The actuarial liabilities are so high and increasing rapidly, that many universities have already made changes to the design of their pension plans. The most common of these changes is the increase on the years of service to retire. For example, in some cases the requirement is as low as 25 years and the average retirement age as low as 52 years old.

Other important characteristics that have made that these deficits increase are that 100% of these universities offer a defined benefit scheme with the replacement rate based on final salary and a 100% replacement rate. In some cases, with no contributions to finance this benefit, designed as a PAYG scheme and relying on government contributions.

In order to examine this situation, this paper considers two examples of pension plans in public universities in Mexico. The characteristics of their pension plans were obtained and, together with the actual database of employees from these universities, the actuarial liabilities and the annual cash flows were calculated. Moreover, in a posterior stage, a numerical example of the funding of a notional pension plan is simulated to target the actuarial liability that different scenarios of employees represent. Both universities are named as A and B.

The results are that in both universities a funded defined benefit pension plan with 100% final salary replacement rate is offered to the employees in

both universities. Also, that both pension plans are closed to new members, in 2007 for university A and in 1991 for university B. The requirements for retirement are 60 years old with 30 years of service and no retirement age with 30 years of service, respectively.

From the actual database of employees for university B; the results are that from a total of 726 employees, members of the pension plan, the average age is 62 with a median of 41, which gives a quite heterogeneous age. The average of years of service is 36, which makes that 87% of the employees already meet the requirements to retire and they have not done so; hence, the high averages on age and years of service.

Moreover, assuming that all employees retire immediately after 30 years of service, an annual increase on salary of 4.25%, no ancillary benefits for the sake of simplicity and a discount rate of 3.75%; the results are that the maximum value for the actuarial liabilities is USD 31 million at present year. The annual cash flows increase at a figure as much as USD 2.3 million by 2022 with the extinction of the plan by 2070.

The employee database from university B is considered as an old population with a high average on years of service, much higher than the 30 years require to retire; hence, the high value of the actuarial liabilities as of 2019. This is as expected, as the plan was closed to new members in 1991. Also, considering that the average age at university A is 47 years old and the plan was closed to new members in 2007, the maximum value for the actuarial liabilities is expected to occur in 2027.

In a final stage, the funding of a pension plan was simulated with three different scenarios for the salary of the employees at university B, in order to propose an efficient design of a pension plan that is financially and actuarially viable for this particular university. The results show that a contribution of as high as 22.3% of salary is required to finance a plan with 30 years of service and 100% final salary replacement rate for an employee with high income. This scenario is possible only if this plan guarantees a minimum annual real rate of return of 1.8% and an increase on salary of maximum 4.25%. When assuming an employee with low income the result for the target contribution rate is 16%, which in both cases is much higher than the actual contribution rate at that university of 5%.

On the other hand, when the contribution rate is set at 5% and an annual rate of return is calculated to target the actuarial liabilities for the same three scenarios of income as before, the results are that an annual value as high as 11.16% is required to do so with a high income employee and as low as 9% with a low income employee. In both cases, the annual rate of return

is much higher than the actual average on private pension plans funds in Mexico of 1.8%.

The pension plan design proposed is considered to be viable as a contribution rate as high as 41% of salary is found at actual circumstances in one particular public university in Mexico. Also, that the actual contribution rate at the mandatory pension plan in Mexico of 11.5% is similar than the suggested one in this work.

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Statement

This paper has not already been published, and that, if accepted for publication in the Review, this will not be submitted for publication elsewhere without the agreement of the Editor of the Review.

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