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Study of the relevance of the early retirement plan for Moroccan civil servants via discrete simulation

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Abstract The supervision of a complex system involves the study and analysis of its operation as well as a continuous search for its improvement and optimization. Simulation in general, and discrete simulation in particular, is an appropriate tool to support different management policies and strategies. In order to carry out a simulation project, special importance must be given to the simulation process, which has led us in this paper to ask the question: is there a standard life cycle of a simulation project? or a repository of the steps to follow? In this paper, we have used the most frequently cited simulation steps in the literature to develop a simulation project life cycle called SPLC (Simulation Project Life Cycle) grouping together the main steps. Then, we were interested in the analysis of the level of use of each of the steps retained by the simulation processes described in the simulation studies considered in the literature review. Secondly, we tried to put the elaborated SPLC cycle into action through a simulation case study, this is the voluntary departure operation launched in Morocco in 2005. Thus, we carried out a simulation allowing to analyze the success rate of this operation, and also its impact on the state of the Moroccan pension fund, and this for the period going from 2005 to 2025. The study was carried out on a set of generated data randomly according to statistical distributions.

Keywords simulation, discrete event simulation, simulation process, simulation steps, life cycle, SPLC, case study, public service, voluntary retirement, pension fund

AMS 2010 subject classifications 68U20, 00A72

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1. Introduction

Since simulation is a decision support technique, it plays an important role in modeling systems when the direct or analytical solution is too complex [1–4] or when the problem is random. The use of simulation can be interesting to study engineering and operational questions without directly involving the real system [5].

Given the risk that a poorly conducted simulation can generate, a simulation methodology is essential to carry out all the steps of such a project. This led us to develop the life cycle of a simulation project called SPLC, from

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the steps most cited in the literature.

The life cycle or development cycle of a simulation project is widely discussed in the literature [6, 7], however, there is no reference or standard cycle in the matter. For greater efficiency and effectiveness, we have carried out an analysis of the simulation processes described in various studies in this area. This analysis was made on the basis of several scientific papers examined, which present different simulation processes followed to conduct studies on the subject. And we were interested in the level of use of the different main steps of a simulation life cycle by the different papers.

Morocco launched a voluntary early retirement program in 2005 for public officials [8] in return for an incentive allowance and a pension calculated on the basis of years of service. This voluntary departure operation was the subject, in this paper, of a simulation case study which will make it possible to analyze, over time, the relevance of this decision of the government at the beginning of the millennium, the rate of its success, as well as its impact on the state of the Moroccan pension fund already in crisis. The simulation study was conducted applying the proposed SPLC. The dataset used in this simulation was generated in accordance with the Moroccan civil service data trends [8, 9].

The same case study was carried out according to another simulation life cycle named Smart SPLC [10] have developed. A comparison between the SPLC and Smart SPLC approaches will be made later in our future work.

This paper is organized into six sections. In the second section, we present the context of this study, namely discrete event simulation and its fields of use, as well as the main steps of a simulation process. The third section presents the SPLC developed from an inventory of the steps most cited in the literature review, as well as an analysis of the use of the different steps retained by the simulation processes presented in the papers considered in our study. In the fourth section, we present the context of a simulation study, focusing on the relevance of the operation voluntary departure from the Moroccan civil service launched in 2005, as well as the detailed development of this simulation according to the proposed SPLC. In the fifth section, the results of the simulation study conducted in the previous section are discussed and analyzed. And to conclude, the sixth and last section retraces the main lines of this paper, both in terms of existing simulation processes and avenues that we intend to explore in our future work, and in terms of the simulation study carried out and potential axes to study.

2. Background

This section is structured in two parts. The first presents the discrete event simulation and its fields of use. The second presents a chronology of the main steps of a simulation process.

2.1. Discrete Event Simulation

Discrete, numerical or discrete event simulation [1] is concerned with systems whose states, namely the attributes of the entities or elements of the system, change at separate times. For example, in a waiting system, if we are interested in the length of the queue, it changes discreetly over time, and if we draw the curve representing this attribute of the system, it would be discrete. Unlike analog or continuous simulation [1], with which the modeling of the system is done by differential equations and the approximation of calculations by digital integration, for example, the variation of the water level in a dam.

In the rest of this paper, we will focus on discrete event simulation.

Discrete simulation consists in building an abstraction of a reality or model, in experimenting on this model [11, 12], and in making it evolve often over time [1]. Generally used models can be logical or mathematical.

They can also be deterministic or most often stochastic [13].

The model used is deterministic when it does not involve chance, and all the data of the simulation have a sure value [14]. It is stochastic when the problem is random, and uses probability laws [6] according to statistical distributions, and in this case, some simulation data can be generated based on random numbers that come from suitable generators.

Discrete event simulation is generally used to better understand the functioning of a complex system in order to modify, improve or make it evolve.

Among the fields of use of discrete event simulation, we can cite:

- Optimization of production systems [15].
- Modeling and simulation of logistics chains [11].
- Patient flow management and improvement of the hospital care chain [16–18].
- Search for configurations or protocols in telecommunication [19, 20].
- Management and optimization of financial and human resources [17].
- Transport and management of road, rail and air traffic [19].
- Ecology, agriculture and livestock [21].
- Town planning, development and prospecting of territories [12], [22].

2.2. Steps of a simulation process

In a simulation project, the system studied generally has 2 types of input, namely, the simulation data and the hypotheses or parameters of the simulated scenarios [1], [23]. At the output, there are the estimated results of the simulation.

The System Engineering approach is generally based on a chronology of steps, called the development cycle or life cycle [24]. According to the literature review, there are many proposals concerning the life cycle of a simulation project, and the most cited steps in the majority of these proposals can be summarized as follows [25]:

1- **Analysis and formulation of the problem**, [1–3], [6, 7], [13], [23], [26–28], consists in defining the limits of the study, as well as the objectives to be achieved.

2- **System definition** [13], [24], consists in defining the entities of the system, their attributes, as well as the activities of the system.

3- **Data collection** [2–4], [6, 7], [23, 24, 26], [28], consists in collecting the data necessary for the simulation, and in specifying the hypotheses and parameters of the simulation for the different scenarios and policies to study.

4- **Modeling** [1–4], [6, 7], [13, 14], [23, 24, 26], [28], consists in building a model or an abstraction of the real system studied.

5- **Model implementation or programming** [1], [3, 4], [13], [24, 26], [28], consists in using either a standard programming language such as Java, python or R, or a language specialized such as SIMAN-ARENA or FlexSim.

6- **Program validation** [1], [3], [24], [28], consists of returning to step 5 if, after the development of the program, it still does not meet the objectives set.

7- **Model validation** [1–3], [6, 7], [13], [24], [28], consists of returning to step 4, in the case where the model itself is called into question, because the results of the simulation are still not satisfactory.

8- **Experimentation** [1–3], [6, 7], [13], [24, 26], [28], allows to specify the number of experiments to perform, for each scenario studied or policy examined, as well as the data and parameters of the simulation. This often leads to going back to step 3.

9- **Analysis of results and decision making** [1–3], [6, 7], [13], [23, 24], [28], makes it possible to analyze and interpret the results obtained and to list potential decisions.

10- **Documentation** [3], [13], allows documentation of the model and simulation program, as well as a capitalization of the conclusions and recommendations.

3. Life cycle of a simulation project

In this section, we present our proposed SPLC lifecycle, and then we analyze the level of use of the different simulation steps retained in the SPLC by the papers examined for this purpose [25].

3.1. SPLC

The steps described above, and which are the most cited in the literature review in terms of simulation methodology, led us to the development of a life cycle of a simulation project, which we called SPLC, which is presented in Figure 1.

The SPLC thus defined brings together, in a more or less exhaustive manner, the most well-known steps for carrying out a simulation process. Nevertheless, and according to the literature review, the various simulation studies do not always use, and explicitly, all these steps. The correspondence matrix presented by Table 1 shows the use of the different steps compared to a sample of 13 research papers, which we named A1 to A13, considered in this study.

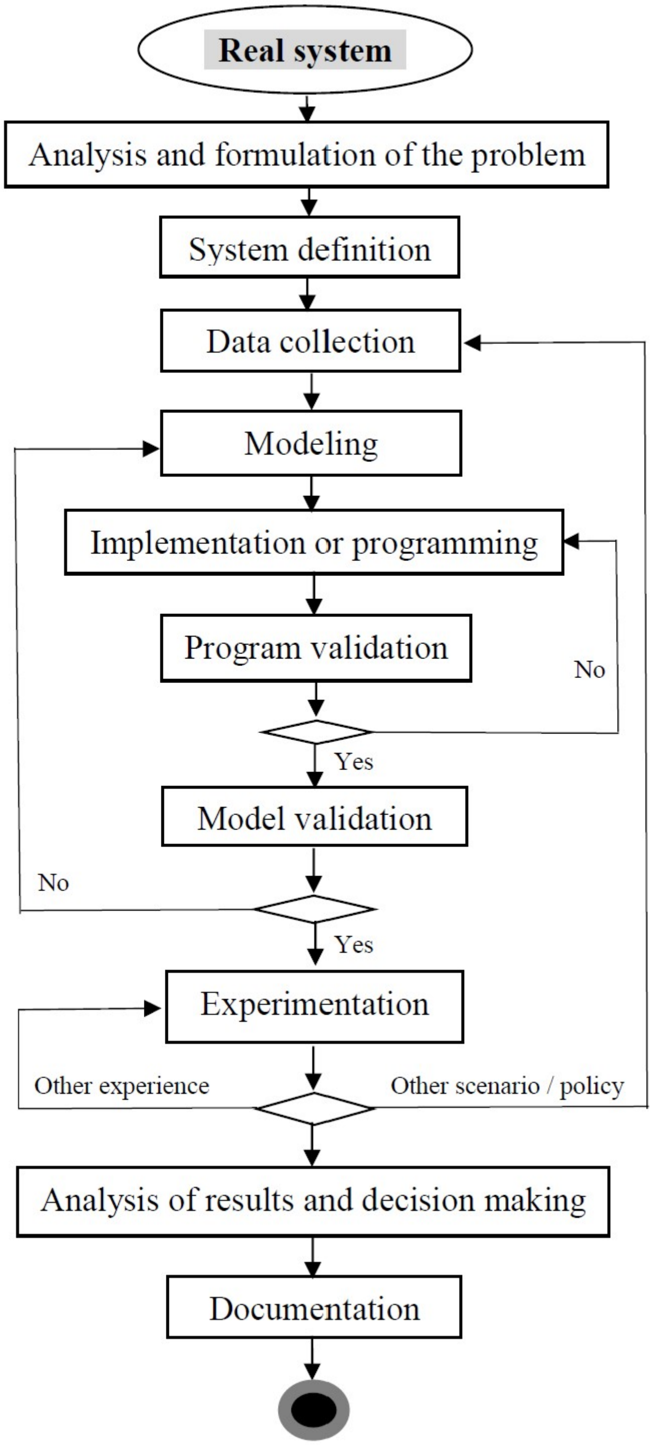

Figure 1. Simulation Project Life Cycle (SPLC) [25]

This correspondence matrix shows that all the steps are not used in the same way by the different papers, and some steps are more present than others in the simulation studies considered.

Table 1. Matrix of Correspondence Between the Steps of the Simulation Process and Their Consideration in the Studied Papers

Papers \ Steps	1	2	3	4	5	6	7	8	9	10
A1 [1]	x			x	x	x	x	x	x	
A2 [2]	x		x	x			x	x	x	
A3 [3]	x		x	x	x	x	x	x	x	x
A4 [4]			x	x	x					
A5 [6]	x		x	x			x	x	x	
A6 [7]	x		x	x			x	x	x	
A7 [13]	x	x		x	x		x	x	x	x
A8 [14]				x						
A9 [23]	x		x	x					x	
A10 [24]	x	x	x	x	x	x	x	x	x	
A11 [26]	x		x	x	x			x		
A12 [27]	x									
A13 [28]	x		x	x	x	x	x	x	x	
TOTAL PAPERS	**11**	**2**	**9**	**12**	**7**	**4**	**8**	**9**	**9**	**2**

3.2. Analysis

In order to be able to better analyze this correspondence matrix, we have tried to represent graphically the use of the different steps of a simulation process in the papers studied. This representation is given by the histogram in Figure 2.

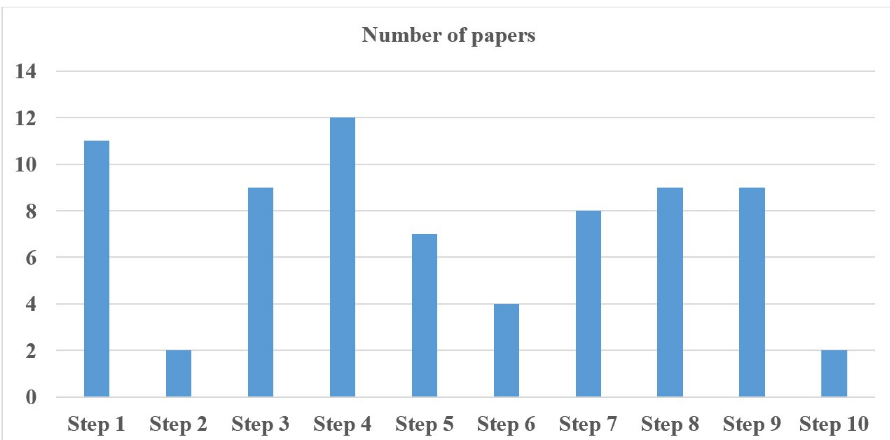

Figure 2. Number of papers using each considered simulation step

Analysis of this graphic representation led us to make the following observations:

- Steps 1 and 4, corresponding respectively to “problem analysis and formulation” and “modeling”, are used by practically all of the papers.

- Steps 3, 8 and 9, on the other hand, are considered by the majority of papers. Indeed, most simulation studies work on data, hence the need for step 3 on "data collection". The data collected is then used in experimentation, hence step 8 "experimentation", and the results of this step are generally the subject of analyzes leading to decision-making, hence step 9 "analysis results and decision making".
- Steps 5 on "programming and implementing the model" and step 6 on "validating the program" are used a little less. Indeed, in a lot of simulation studies, the authors do not always go as far as programming the models, and rather proceed by a fundamental, mathematical or physical resolution. In some other studies, the resolution may also be limited to the use of descriptive statistics.
- Some other steps, in particular, step 2 on "defining the system" and step 10 on "documentation", which, despite their importance in a simulation process, are considered by very few papers.

Regarding the number of steps used, it is more or less important from one paper to another. Considering the 13 research papers of the correspondence matrix, Figure 3 illustrates this disparity. In this figure, each element is represented by two parameters, in the form: Ai - n, where i denotes the number of the paper (i = 1 to 13) and n the number of steps used by this paper (n = 1 to 10).

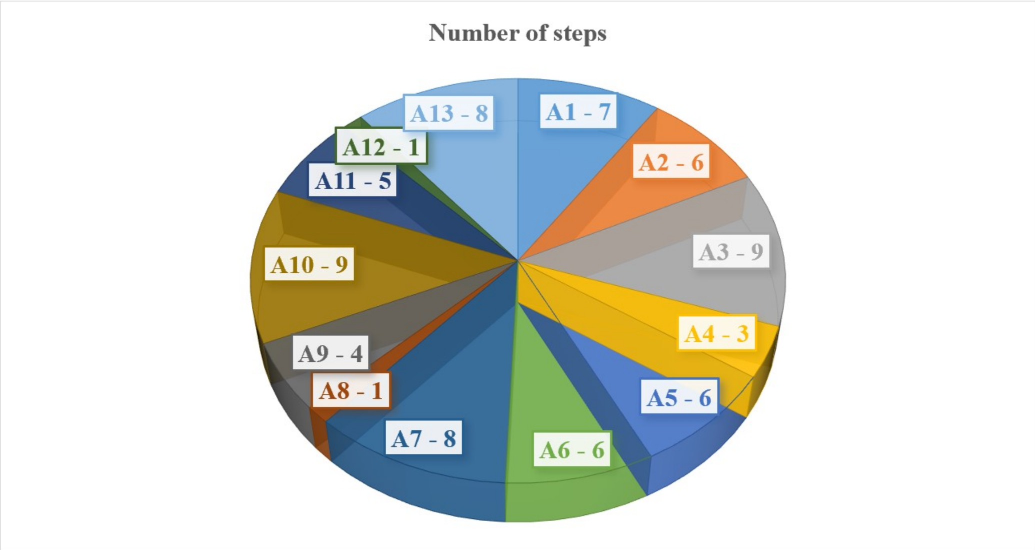

Figure 3. Number of steps used by each paper considered

This disparate use of the different steps of the life cycle of a simulation project by the various papers dealing with the subject of simulation processes is due to the following facts:

- Some papers proceed by a fundamental resolution of the problem and therefore do not consider all the steps concerning "programming" and "experimentation".
- In some papers, fewer steps are considered because, quite simply, some of these steps are sometimes grouped together. For example, "program validation" with "programming", and "model validation" with "modeling".
- Some steps are not always expressed explicitly in the various papers, even sometimes neglected, such as the "system definition" or even the "documentation".

Thus, and after this analysis, we note that the number of papers using each of the stages of the simulation process is not the same from one stage to another. In addition, the number of steps used by each paper studied also varies from one to another.

4. Case study

In this section, we propose to use the life cycle of a simulation project SPLC, proposed in the previous section 3, in a simulation study on the voluntary departure program of the Moroccan civil service. Thus, we ran this simulation according to the SPLC by indicating the tasks carried out at each SPLC stage.

4.1. Study context

Morocco launched a voluntary early retirement program in 2005 for public officials [8] against incentive bonus and a retirement pension calculated on the basis of service years. The objectives of the voluntary departure operation are to encourage departing civil servants to start a business, as well as to keep the payroll at a manageable level.

At that time, the Ministry for the Modernization of the Public Sectors made available to civil servants a site dedicated to this operation, allowing a simulation of the calculation of voluntary severance payments and retirement pensions. But, in this study, we propose to use discrete event simulation to study the relevance and efficiency of this operation over time.

Indeed, the Moroccan Court of Auditors has shown in [9] that if the voluntary departure operation had initially allowed the reduction of the workforce and the weight of the wage bill, its results were not consolidated. It was limited to a one-off staff reduction measure, thus losing its ambition to be sustainable through the establishment of the foundations of modern human resources management. In addition, this operation helped to precipitate the collapse of the pension system, which in 2014 gave rise to new parametric reforms of the pension system, sometimes painful for its members, and whose main orientation, namely extending the retirement age to 63 instead of 60, is opposed to the very idea of voluntary early retirement, defended a few years before.

We tried, in the rest of this study, to prove this financially through a simulation study showing the impact of this operation on the pension fund, this by applying the proposed life cycle SPLC. The dataset used in this study was generated drawing inspiration from the Moroccan civil service system.

4.2. Application of the SPLC

The objective of this project being, as already mentioned, to study the relevance of the voluntary departure operation, with a little more than ten years of hindsight after its adoption. We tried to carry out the simulation project relating to the voluntary departure program of the Moroccan civil service according to the proposed cycle SPLC [25] by describing the tasks that were carried out in each of the ten stages of this life cycle.

1- **Analysis and formulation of the problem** allows to define:

- The outline of the study, namely:
  - The start year of the study, or the year of voluntary departure, is 2005.
  - The system to be simulated, namely a sample generated by drawing inspiration from the real Moroccan civil service system, is a pension fund with 10 000 adherent employees.
  - Retirement being at 60, at this time.
  - The number of retirees, from the fund in question, in 2005 is already 1 000 retirees.
  - The initial reserve of the fund at this start date of the simulation is 250 Mdh (Millions de dirhams).
  - The study will span the period from 2005 to 2025.
- The indicators to be measured, for each simulated year, in our case, we were interested in the following seven indicators:
  - The Total Number of Adherent Employees **(TNAE)**.

- The Total Number of Retirees **(TNR)**.
- The Total Employee Contribution Amount **(TECA)**.
- The Total Amount of Retiree Pensions **(TARP)**.
- The Amount of the Fund's Reserve **(AFR)**.
- The Number of New Retirees **(NNRet)** for each simulated year, which will be counted in the total number of retirees for the year after.
- The Number of New Recruits **(NNRec)** for each simulated year, which will be counted in the total number of employees for the year after.

• The definition of the different scenarios or policies to be studied. In the present case, and in order to study the relevance of this voluntary departure operation, we propose to consider the following two scenarios:

- Scenario 1: Apply voluntary departure from December 2005, with incentive bonuses to the employees in question.
- Scenario 2: Do not apply voluntary departure. And in this case, inject a subsidy, equivalent to the amount of the departure bonuses of the employees who could have been affected by this operation, in the reserve of the pension fund, and this in December 2005.

2- **System definition** consists in defining the entities of the studied system, as well as their attributes. In our case, these are entities such as "employees" and "retirees", as well as attributes such as current employee age, current employee salary, age at hire, salary at hiring, the contribution rate to the pension fund according to salary or the amount of the retirement pension.

3- **Data collection** allows to :

• Collect the data necessary for the simulation. In our case, we tried to locate all the data that we deemed useful for the progress of the project. For this, and not having a real database, we drew inspiration, to generate the data for the study, from trends of data relating to public service employees, in particular those of local communities and public bodies [8, 9]. These data are partly of stochastic or random type, such as the age at the time of recruitment of an employee. Hence, the need to resort to the use of a suitable generator of pseudo-random numbers in order to be able to generate the data of the simulation.

• Specify the assumptions and parameters of the simulation for the different scenarios studied. In our case, this involves studying over a period of 20 years, from 2005 to 2025, the following two scenarios:

- Scenario 1: Apply voluntary departure from December 2005 in favor of employees aged between 40 and 55 years, with a minimum of 18 years of service, and wishing to benefit from early retirement. Up to 1 in 5 employees are interested and selected for voluntary departure. An employee who wishes to leave and who has obtained the agreement will benefit from [8]:
  - ✓ A Departure Incentive Bonus (DIB), in an amount equal to:

$$DIB = LSBR * 2 * NYW \tag{1}$$

✓ A Retirement Pension (RP) calculated as follows:

$$RP = ((NYW * 2)/100) * LSBR \quad (2)$$

With:

· NYW: Number of Years Worked, capped at 18 years in the formula (1)

· LSBR: Last Salary Before Retirement

– Scenario 2: Do not apply voluntary departure. And in this case, inject a subsidy, equivalent to the amount of the departure bonuses of the employees who could have been interested and retained for this operation, in the reserve of the pension fund, and this in December 2005. In this case, the Pension at Retirement (PR), a normal retirement at age 60, would be calculated as follows [8]:

$$PR = ((NAT * 2.5)/100) * DSAR \quad (3)$$

4- **Modeling** consists in building a model of the studied system. In our case, this is a mathematical formulation of the problem. Indeed, simulation data is generated according to stochastic processes and statistical laws [29] defined by drawing inspiration from trends in existing data in the Moroccan civil service [8, 9].

Modeling the system makes it possible to construct a representation of the various data of the study, and to design the mathematical model to be manipulated. In our case study, this involves defining the different models to generate the inputs for the simulation. Most of these data have been modeled as tabulated distributions, and in each interval the function is uniform.

Hereinafter, the mathematical models representing each of the parameters used:

- Current net salary: The distribution of the current net salary for the 10 000 employees considered in the study is given by Table 2.

Table 2. Distribution of current net salary

Current salary (dh)	**Frequency (%)**
[30 000 – 40 000]	5
[20 000 – 30 000]	10
[15 000 – 20 000]	10
[10 000 – 15 000]	15
[7 500 – 10 000]	20
[5 000 – 7 500]	20
[3 000 – 5 000]	20

- Current age of employees: The distribution of the current age of the employees considered is given by Table 3.

Table 3. Distribution of the current age of employees

Current age (year)	**Frequency (%)**
[51 – 60]	40
[41 – 50]	30
[31 – 40]	15
[20 – 30]	15

- New recruitments: In this study, while considering an initial sample of 10 000 employees, we assume that the number of new recruits per year varies between 250 and 400 new employees according to a uniform law.
- Age at hire: The age distribution for new hires, throughout the simulation, is given in Table 4.

Table 4. Age distribution at hiring

Age at hire (year)	Frequency (%)
[20 – 22]	5
[23 – 24]	20
[25 – 28]	25
[29 – 32]	25
[33 – 35]	20
[36 – 40]	5

- Net salary on hiring: The net salary of employees on hiring is distributed according to Table 5 below:

Table 5. Distribution of net wages upon hiring

Salary at hire (dh)	Frequency (%)
[24 000 – 32 000]	5
[16 000 – 24 000]	5
[12 000 – 16 000]	10
[8 000 – 12 000]	20
[6 000 – 8 000]	20
[4 000 – 6 000]	20
[2 400 – 4 000]	20

- Promotion: In this simulation, we assume that for employee advancement, salaries are increased by 5% every 5 years.
- Contribution compared to salary: The distribution of the contribution rate to the pension fund by salary bracket is given in Table 6.

Table 6. Distribution of the contribution to the pension fund

Salary bracket (dh)	Contribution rate (%)
<5 000	5
5 000 to 7 000	6
7 000 to 10 000	7
10 000 to 40 000	10

Thus, the monthly contribution of an employee to the pension fund will be calculated as follows:

$$Contribution = (ContributionRate * Salary)/100 \tag{4}$$

5- **Implementation or programming** consists in implementing the model developed in the form of a program, in a standard or specialized language. For this we used:

- A simulation approach by fixed period driven by a clock [29, 30], for time management during simulation, in the sense that we were interested in the system, to measure the different indicators, only periodically, of a year-end at The Other. The period used thus being one year.
- The Java object-oriented programming language to implement our model. This choice was made to master all the parts of the code and also to take advantage of the benefits of the object-oriented approach, in particular the principle of maintenance and scalability, such as being able to add functionalities without great effort at the programming level.
- A pseudo-random number generator, in the form of a congruential multiplicative mathematical function, allowing to generate random numbers or probabilities, according to a uniform law in the interval [0, 1]. This function, each time it is called, returns a random number, named alea. The numbers thus generated were used to calculate the simulation data according to the distributions of the statistical laws used in step 4 [29], [31, 32]. Thus, to calculate a value of a random variable of the simulation, the calculation procedure differs according to the statistical law used. For a tabulated distribution, the distribution function is used. For a uniform distribution in an interval [a , b] for example, the formula used is:

$$(b - a) * alea + a \tag{5}$$

With this formula (5), the values obtained will always be between a and b, alea always being between 0 and 1. So for example, each year of the simulated period, to generate the Number of New Employees Recruited for a given year of the simulated period ($NNER$) according to a uniform law in [250 - 400], the procedure to follow would be to generate an alea in the interval [0 - 1], then to calculate this number as being:

$$NNER = (400–250) * alea + 250$$
$$NNER = 250 \text{ to } 400 \text{ as long as } alea \text{ is between } 0 \text{ and } 1$$

6- **Program validation** allows us to check and refine the simulation program developed, which has led us to return iteratively to step 5, until we achieve satisfactory results and achieve the set objectives.

7- **Model validation** makes it possible to ensure that the model conforms to the system studied, which led us to return iteratively to steps 4, 5, 6 and 7.

8- **Experimentation** makes it possible to generate the data and simulation parameters necessary to perform the experiments for the different scenarios studied, and subsequently to estimate the different indicators for the simulated period. Thus, during this step, the work done consisted of:

- Initialize the simulation using the data common to the two scenarios studied, namely:
  - Generate the 10 000 employees, adherents to the pension fund considered in this study, with their attributes (salary, age, age at recruitment, rate of contribution to the pension fund, etc.) generated compared to the models developed in the step 4.
  - Generate the 1 000 retirees, boarders of the same fund, with their attributes (amount of the pension) generated compared to the models developed in step 4.
  - Feed the reserve of the pension fund with the initial amount considered, which amounts to 250 Mdh.
- Add the following initializations according to the studied scenario, namely:
  - Scenarios 1: by applying voluntary departure in 2005, generate the number of employees who have resorted to and obtained said voluntary departure among the 10 000 employees who are members of the pension fund in question, according to the process indicated in scenario 1 at step 3.

– Scenarios 2: not having applied voluntary departure in 2005, inject a subsidy into the reserve of the pension fund in question, for a total amount equivalent to that of the incentive premiums, due if voluntary departure had been applied, and calculated according to formula (1) of step 3.

- After the initialization of the simulation, the simulation program will allow:
  – Perform all necessary updates on pension fund data.
  – Calculate the values of the various indicators measured, according to the parameters and assumptions presented in step 3, as well as the models developed in step 4.

  And this, with a frequency or period of one year, December of each year, over a period of 20 years, ranging from 2005 to 2025.

9- **Analysis of results and decision making** allows the presentation, analysis and interpretation of the results obtained, as well as the list of recommendations and potential decisions. In our case, we measured the seven indicators defined at step 1, for each year, during a forecast simulation experiment over the period from 2005 to 2025. The various values were calculated, according to the calculation procedures used in accordance to the distributions or statistical laws defined in step 4, and from pseudo-random numbers of a suitable generator as indicated in step 5 [29], [33, 34].

Tables 7 and 8, below, respectively summarize the results of the simulation, over a period of 20 years, for scenarios 1 and 2. These results will be interpreted and discussed in section 5. The proposals and recommendations formulated in the section 6.

- **Scenario 1:** Apply voluntary departure in 2005. Table 7 below shows the various parameters measured annually, namely, the total number of employees, the total amount of their contributions, the total number of retirees, the total amount of their pensions, as well as the final amount of the fund reserve at the end of each simulated year. The number of new retirees, as well as the number of new recruits are counted, respectively, with the total number of retirees and the total number of new recruits for the following year.
  In 2005, in the first row of the results table, we specify that:
  – The Total Number of Adherent Employees **(TNAE)**, participating in the pension fund has been set at 10 000, in accordance with the considerations of step 1.
  – The Total Number of Retirees **(TNR)** from the same fund has been set at 1 000, in accordance with the considerations of step 1.
  – The Total Employee Contribution Amount **(TECA)** has been calculated as:

$$TECA = \sum_{i=1}^{10\ 000} ECA_i \tag{6}$$

  In formula (6), the ECA_i or Employee Contribution Amount, for each employee i of the 10 000 employees, is calculated according to formula (4) given in step 4.
  – The Total Amount of Retiree Pensions **(TARP)** has been calculated as:

$$TARP = \sum_{j=1}^{1\ 000} ARP_j \tag{7}$$

  In formula (7), the ARP_j or Amount of Retiree Pension, for each retiree j of the 1 000 retirees, is calculated according to formula (3) given in step 3.
  – The Amount of the Fund's Reserve **(AFR)** has been calculated as:

$$AFR = Initial\ reserve + TECA - TARP \tag{8}$$

  Where "$Initial\ reserve$" in formula (8) corresponds to the amount initially considered in the reserve of the pension fund, at the start of the simulation, namely 250 Mdh according to step 1.

– The Number of New Retirees **(NNRet)** was calculated as:

$$NNRet = Normal\ retirees + Voluntary\ departures \quad (9)$$

Where "$Normal\ retirees$" of formula (9) corresponds to the total number of new retirees for the year 2005 according to a normal retirement, as indicated in step 3, and "$Voluntary\ departures$" represents the number of employees having benefited from the voluntary early retirement operation launched in 2005. It should be noted that with this scenario, the number of voluntary departures is calculated only once, at the start of the simulation in 2005.

– The Number of New Recruits **(NNRec)** was calculated according to the model in step 4.

After 2005, the various indicators are calculated and updated, year after year. The number of new retirees, for each simulated year, is counted in the total number of retirees for the following year. Likewise, the number of new recruits for each simulated year is counted in the total number of employees for the following year.

Table 7. Simulation results for scenario 1

Simulated year	TNAE	TECA (Mdh)	TNR	TARP (Mdh)	AFR (Mdh)	NNRet	NNRec
2005	10 000	127.35	1 000	111.73	265.61	1 197	257
2006	9 060	112.15	2 197	215.09	162.68	430	385
2007	9 015	111.68	2 627	260.41	13.95	423	380
2008	8 972	110.31	3 050	305.84	-181.59	436	292
2009	8 828	109.33	3 486	350.33	-422.58	436	357
2010	8 749	115.27	3 921	399.40	-706.72	405	372
2011	8 716	113.57	4 370	449.33	-1 042.48	409	274
2012	8 581	112.20	4 784	495.86	-1 426.13	414	335
2013	8 502	109.76	5 200	543.73	-1 860.10	416	293
2014	8 379	107.60	5 631	594.35	-2 346.86	431	301
2015	8 249	114.77	6 092	645.99	-2 878.08	411	366
2016	8 204	113.92	6 399	683.73	-3 448.79	307	255
2017	8 152	113.13	6 750	726.72	-4 062.38	351	395
2018	8 196	113.15	7 061	765.78	-4 714.30	311	324
2019	8 209	113.96	7 349	798.36	-5 398.90	298	375
2020	8 286	119.97	7 687	838.16	-6 117.49	338	268
2021	8 216	119.61	8 034	891.61	-6 879.49	327	313
2022	8 202	119.01	8 312	933.05	-7 673.53	328	352
2023	8 226	118.26	8 614	984.66	-8 509.93	302	356
2024	8 280	118.97	8 955	1 041.47	-9 390.22	301	376
2025	8 355	126.38	9 290	1 087.62	-10 301.46	335	296

• **Scenario 2:** Do not apply voluntary departure in 2005. The results of this scenario are presented in table 8. And in this case, all the calculations were made in the same way as in scenario 1, with two differences:

– In 2005, there were no voluntary departures for early retirement, but only normal departures. Thus, the number of new retirees in 2005 was calculated as:

$$New\ retirees = Normal\ retirees \quad (10)$$

– In 2005, a subsidy of an amount equivalent to the total incentive bonuses granted to employees, following voluntary departure in the case of scenario 1, was injected into the pension fund reserve with scenario 2. Thus in 2005, the reserve of the fund was calculated as:

$$Reserve = Initial\ reserve + Grant + TECA - TARP \tag{11}$$

Grant value is calculated as:

$$Grant = \sum_{k=1} IB_k \tag{12}$$

IB_k in formula (12) corresponds to the Incentive Bonus granted to each employee k who benefited from voluntary departure, and it is calculated according to formula (1) in step 3.

Table 8. Results of the simulation according to scenario 2

Simulated year	TNAE	TECA (Mdh)	TNR	TARP (Mdh)	AFR (Mdh)	NNRet	NNRec
2005	10 000	127.35	1 000	111.73	584.20	477	257
2006	9 780	120.68	1 477	165.54	539.34	458	385
2007	9 707	119.87	1 935	214.11	445.10	451	380
2008	9 636	118.07	2 386	262.42	300.75	467	292
2009	9 461	116.61	2 853	310.41	106.95	467	357
2010	9 351	122.44	3 332	363.90	-134.50	479	372
2011	9 244	120.35	3 815	418.39	-432.54	483	274
2012	9 035	118.57	4 259	468.39	-782.35	444	335
2013	8 926	115.65	4 698	519.77	-1 186.47	439	293
2014	8 780	113.09	5 164	574.57	-1 647.95	466	301
2015	8 615	120.37	5 653	629.55	-2 157.14	489	366
2016	8 492	118.19	5 981	669.34	-2 708.29	328	255
2017	8 419	117.82	6 362	715.86	-3 306.33	381	395
2018	8 433	118.16	6 702	759.16	-3 947.34	340	324
2019	8 417	117.59	7 024	795.16	-4 624.91	322	375
2020	8 470	123.37	7 391	838.98	-5 340.51	367	268
2021	8 371	122.94	7 757	885.04	-6 102.61	366	313
2022	8 318	122.10	8 063	920.33	-6 900.84	306	352
2023	8 364	120.93	8 383	964.10	-7 744.01	320	356
2024	8 400	120.35	8 751	1 011.47	-8 635.14	368	376
2025	8 408	128.69	9 114	1 054.08	-9 560.52	363	296

10- **Documentation** allows to document the model, program and results of the simulation, as well as a capitalization of the conclusions and recommendations. This paper responds, in part and among others, to this step.

5. Analysis & Discussion

The results obtained during this simulation experiment led to the following observations:

- The voluntary departure program certainly enabled a reduction in the number of employees, at least during the first period of the simulation. Nevertheless, and over the years, the number of employees with voluntary departure has practically caught up with that in the case of non-application of the voluntary departure operation. This is clearly illustrated by Figure 4.

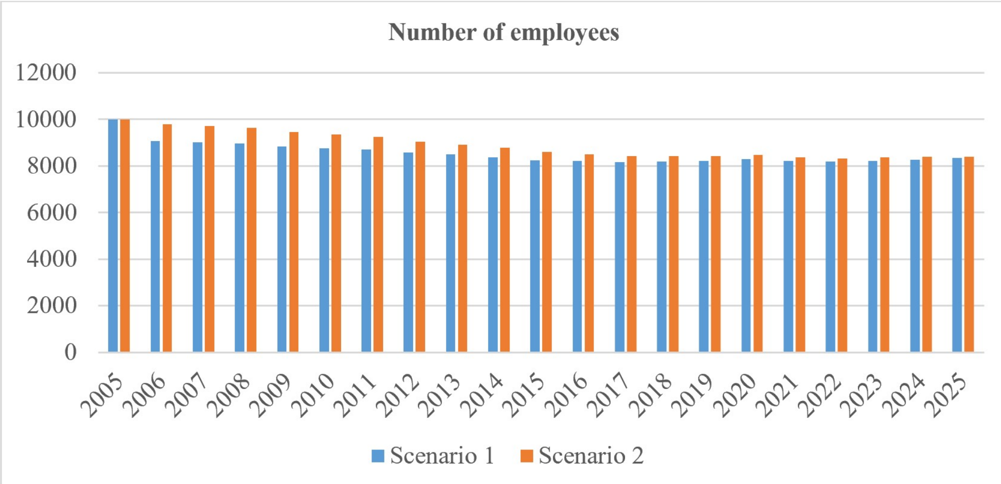

Figure 4. Comparison of the number of employees according to the two studied scenarios

- Through figure 5, we can note that:
  - In 2005, and with scenario 1, the number of new retirees ($NNRet$) is particularly high, which is normal following the voluntary departures that took place in that year.
  - During the first period of the simulation, the $NNRet$ with scenario 2 is much higher than that of scenario 1, which is understandable, since in the case of scenario 2, the total number of employees himself is greater, the voluntary departure not having taken place. Also, and with both scenarios this time, the $NNRet$ is generally greater than the number of new recruits ($NNRec$).
  - But, over the years, the gap between the $NNRet$ and the $NNRec$ in each of the two scenarios narrows. The gap between the two scenarios is also increasingly smoothed.

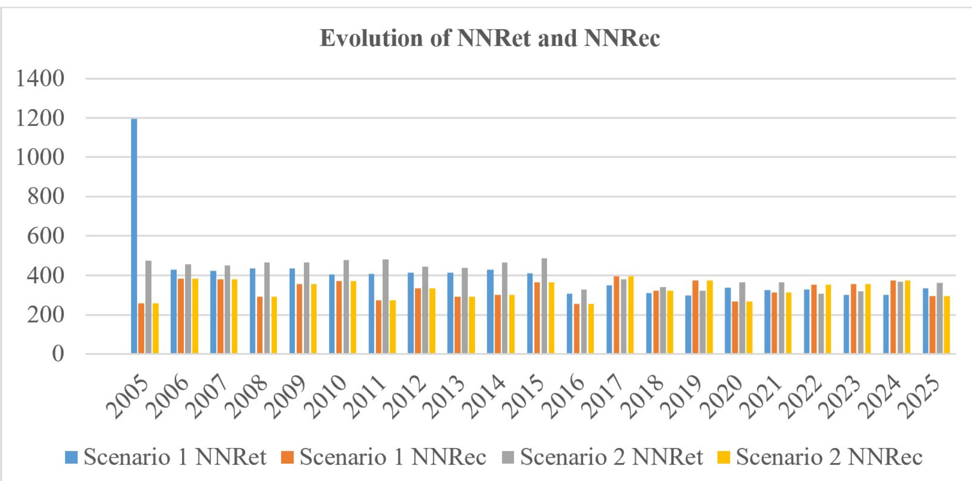

Figure 5. Number of new retirees and new recruits in both scenarios

- Figure 6 shows that:
  - Apart from the very first years of the simulation with scenario 2, the total amount of retirement pensions ($TARP$) is greater than the total amount of employee contributions ($TECA$).
  - This gap between $TARP$ and $TECA$ widens a little more from one year to the next. it is even more pronounced with scenario 1. This will influence the balance of the pension fund, and further widen the deficit, even more in the case of scenario 1.

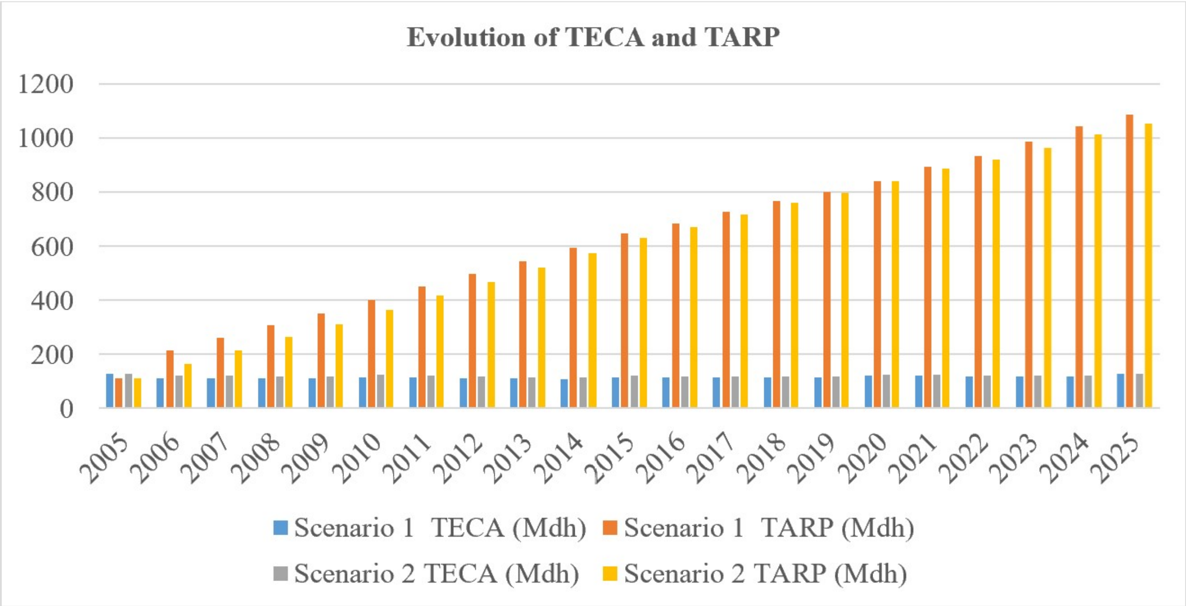

Figure 6. Total amount of employee contributions and total amount of retirement pension in both scenarios

- Figure 7 shows that the deficit of the pension fund reserve is much larger with scenario 1 than with scenario 2. Indeed, the deficit in 2025 would be 10 301 Mdh with scenario 1 instead of 9 560 Mdh with scenario 2, and thus, almost 740 Million Dirhams of difference. This is mainly due to the increase in the number of pensioners in the pension fund at the time of voluntary departure in 2005 with scenario 1, whereas in the second case, that of scenario 2, we assumed that there was no there, were no voluntary departures on retirement in 2005, and that in addition, we injected the amounts of bonuses to encourage voluntary departure [8], as a subsidy in the reserve of the fund.

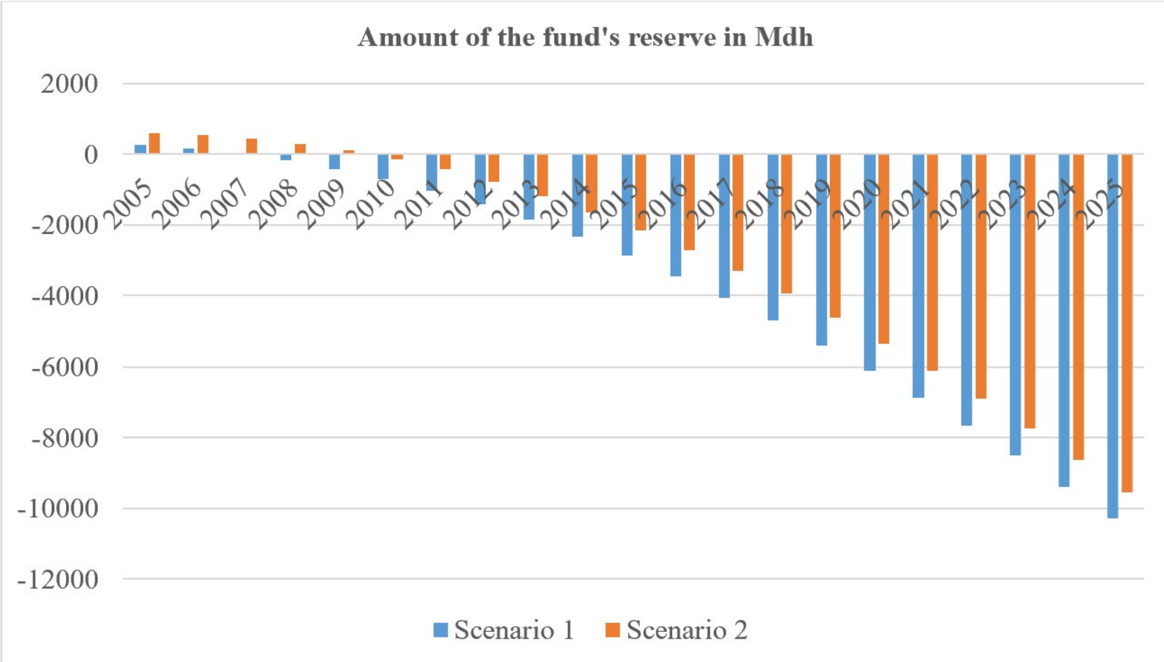

Figure 7. Comparison of the amount of the pension fund reserve with the two scenarios considered

Thus, we can say that the program of voluntary departure from the civil service did not really have an interest in the financial aspect, on the contrary, it contributed to an increase in the charges of the Moroccan pension fund. The pension fund crisis gave rise, from 2014, to a new parametric reform of the pension system which consisted, among other things, in pushing the retirement age to 63 years, and therefore retaining again and more employees. This in contradiction with the thesis defended in 2005 to justify the launch of the voluntary departures' operation, which essentially aimed at reducing the workforce and subsequently the wage bill [9].

6. Conclusion and future work

The methodology followed during the development of a simulation project is based on steps which are not always mentioned in the simulation processes described in the various studies on the subject. In the SPLC, presented in this paper, we tried to group together the steps most cited in the literature review, and which are relevant in the development of a simulation project, but which are not always considered in the studies carried out. In fact, in the different simulation studies, the authors each time consider a specific process, with more or less steps. This led us to note the absence of a standard or a reference cycle for the development of a simulation project, nor of a repository of the steps to follow for this.

Moreover, in the different simulation processes used in the literature, it is generally not specified, and for each step, who does what? And with what means? There is no separation between the managerial, operational and support aspects of the simulation process. In other words, the process is generally not really urbanized. And to respond to this problem, we suggest using a process approach, encouraged both by the ISO 9001: 2015 [35] standard, based on a quality management system, and by the CIGREF [36] standard of the network of large French companies and public administrations. The process modeling approach makes it possible to obtain the expected results while guaranteeing a good level of consistency and compliance with the requirements of the system, insofar as this approach makes it possible to control the interactions and interdependencies between the processes of the system.

A first draft of the future SPLC named Smart SPLC has already been published in the Journal of Software (JSW) [10]. In this paper, the same case study was carried out according to the Smart SPLC. Our goal in the future is to:

- Improve and finalize the Smart SPLC.
- Make further case studies by the SPLC and by the Smart SPLC. In this direction, a case study on the issue of road safety has already been carried out according to the SPLC [37]. This has already made it possible to demonstrate the applicability of the SPLC in different fields of study, namely, that of retirement and voluntary departure in this paper, and that of road safety in [37].
- Carry out a benchmark or a comparative study between the SPLC and the Smart SPLC. A reflection is underway to develop the indicators or metrics that would make it possible to carry out this benchmarking study between the SPLC and the Smart SPLC. For example, we cite the technical aspects used at each stage, the actors involved, etc.
- Highlight strengths of Smart SPLC compared to SPLC. This in the light of the various case studies carried out.

The analysis of the results of the simulation, by applying the SPLC, revealed a doubt about the validity of the voluntary departure applied in 2005 from a financial point of view. Moreover, this doubt was confirmed in a report from the Moroccan Court of Auditors [9], as well as by the last crisis of the pension fund which gave rise in 2014 to a new and recent reform of this fund, which consists to do the opposite of what was done in 2005, namely the postponement of the retirement age to 63 years, but also the increase in the contribution rate of members, as well as a regression in the calculation of retirement pensions.

In the same context, and in relation to the same theme, the simulation and the problem of pensions, we propose to carry out a new simulation study to analyze the relevance of the last parametric reform of the pension fund, initiated in 2014, and which is based on readjustment of three parameters:

- Extension of the retirement age to 63 years, at the rate of 6 months per year from 2018.
- Increase in the contribution rate for members of the fund. For example, for a contribution rate that was at 10%, an increase of 1% each year, reaching 14% of salary in January 2019.
- Regression of the retirement pension calculated no longer on the basis of the last salary, but on the average salary of the last 8 years worked, and with a weighting of 2 points, instead of 2.5 per year worked.

We therefore propose to carry out a simulation study to analyze, over time, the relevance and sustainability of this new reform, knowing that in some reports on the public service, we already talk about the limit of this one, and that the problem would be posed again by 2022. In the same sense, we also propose to carry out other simulation studies considering new variations for the three previous parameters.

Conflict of Interest : *The opinions expressed in the case study discussed in this paper, which is carried out on a purely academic basis, do not commit any organization or institution.*

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