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Contaduría y Administración
Accounting & Management

Contaduría y Administración Contaduría y Administración, 65 (5), Especial COVID-19, 2020, 1-26

# Impact of the economic crisis caused by COVID-19 on the Mexican pension system and prospects for its reform project

## *Impacto de la crisis económica por COVID-19 en el sistema de pensiones mexicano y perspectivas ante el proyecto de su reforma*

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Received October 11, 2020; accepted December 19, 2020
Available online October 17, 2022

**Abstract**

In view of the current economic and financial environment, the aim of this paper is to determine the effects of the economic crisis caused by the COVID-19 pandemic, on the Mexican pension system risk, and its impact on the project that has been proposed for it. To achieve this goal, the risk behavior of the system was analyzed through its conditional volatility estimated by GARCH family models. The relevance of the changes stated in the reform project regarding the amount and length of the contributions made by the workers, in the light of the impact that the crisis will have on their salaries, was evaluated. This was done by simulating with the Monte Carlo method the total savings balance accumulated at the end of the active life of a standard worker, assuming different income levels. It was concluded that persistence of volatility and asymmetry effects were present, and that workers would be better off if the reform includes measures that increase the amount of the contributions but do not decrease the contribution period.

*JEL Code:* C58, G23, J26
*Keywords:* pension systems; SIEFORE; conditional volatility; economic crisis by COVID-19 pandemic

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Peer Review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.22201/fca.24488410e.2020.3101

**Resumen**

Considerando el actual entorno económico y financiero, el objetivo de este trabajo es determinar los efectos de la crisis económica, provocada por la pandemia de COVID-19, en el riesgo del sistema de pensiones mexicano y su impacto ante la propuesta de reforma del sistema. Para alcanzar este objetivo se analizó el comportamiento del riesgo del sistema a través de su volatilidad condicional, la cual se estimó utilizando modelos de la familia GARCH. Por otra parte, se evalúo la pertinencia de los cambios en las aportaciones y el tiempo de cotización propuestos por el proyecto de reforma del sistema de pensiones, ante el impacto de la crisis en los ingresos de los trabajadores. Lo anterior se realizó simulando con el método de Monte Carlo el ahorro total acumulado al final de la vida activa de un trabajador tipo suponiendo diversos niveles de ingreso. Se concluyó que se presentó persistencia de la volatilidad y efectos de asimetría, y que los trabajadores estarán en una mejor posición si la reforma incluye medidas que incrementen sus aportaciones pero sin disminuir el tiempo de cotización.

*Código JEL:* C58, G23, J26
*Palabras clave:* sistemas de pensión; SIEFORE; volatilidad condicional; crisis económica por COVID-19

## Introduction

After 23 years of operation, the time is drawing nearer every day when the defined contribution pension system will have to prove whether it has been sufficient to provide retired workers with a pension above the subsistence minimum. The transition period between the previous defined benefit retirement scheme and the current one is nearing its end due to the approaching retirement date of those who have contributed continuously during their entire working life, 1,250 weeks, under the defined contribution system introduced in Mexico in July 1997.

Under the current retirement scheme, the amount of the pension depends not only on the contributions and the time during which they are made but also on the returns that can be obtained from the resources deposited in the individual accounts of the worker that are channeled to the financial markets. Therefore, it is necessary to have stable economic and financial conditions.

On March 11, 2020, the coronavirus outbreak that began in December in the city of Wuhan, People's Republic of China, was officially declared a pandemic by the World Health Organization (WHO). International organizations such as the Organization for Economic Cooperation and Development (OECD), the International Monetary Fund (IMF) and the World Bank (WB) agreed that the pandemic caused by COVID-19 has provoked a severe economic crisis that will affect all regions of the world. Its effects are predicted to be severe and will have consequences for the health sector, the global economy, and society.

Against this backdrop, Mexico's pension system plays a dual role: on the one hand, it has been affected by the crisis, but on the other, the current pension system could become a hidden cost for the public budget, contributing to the increase in the fiscal deficit.

Considering the current economic and financial environment, this study aims to determine the effects of the economic crisis caused by the COVID-19 pandemic on the risks to the Mexican pension system and its impact on the proposed system reform. It was assumed that the economic crisis would raise the risk levels of the pension system of the country and that it would provoke an increase in unemployment. The above will affect the income level of workers and therefore impact the total they could accumulate at the end of their active life. The contribution of this work lies in the analysis of the immediate effects of the economic crisis caused by the pandemic on the risk of the pension system and in the determination of the significance of the main points included in the reform, given the impact of the crisis on workers' income. Considering the above, the impact of the crisis due to COVID-19 on the three points that permit workers to accumulate resources in their accounts will be discussed: contributions, duration of the contributions, and the influence of financial markets on pension funds.

This work was divided into six parts, including the introduction, to achieve the objective. The second section is a review of the literature. The third section presents the national and international economic environment. The fourth section presents the methodology used to determine the risk dynamics of the pension system and the significance of the reform proposal considering contributions and contribution time. The next section presents the results of the GARCH models to determine conditional volatility and those of the simulation of the total savings accumulated by workers. The last part presents the conclusions.

## Literature review

International financial markets have increased their relationship with pension systems over the last three decades because their financial systems channel the resources of workers to them. Lachman (2013) makes a study of the different pension schemes. In his work, he describes the performance of the different types of pension systems and finds that they have all been affected during periods of high volatility, especially in the aftermath of the 2008 economic crisis. Defined benefit schemes have been susceptible to fiscal deficits, which, together with demographic problems, have led to a lack of long-term sustainability, and defined contribution schemes have been directly affected by the volatility of financial markets. Both types of pension schemes have experienced low returns and severe losses in crisis periods.

For their part, Ortiz et al. (2019) analyzed international funded pension systems, focusing on those that have returned to a defined benefit pension system after having implemented defined

contribution systems in their countries. Of 30 countries that, between 1981 and 2014, fully or partially privatized their pension systems, 18 partially or fully reversed the privatization of their pensions, as the flaws of the individual accounts system became evident after the 2008 crisis. Among the problems were: high fiscal and administrative costs, transfer of risks from financial markets to workers, stagnation or decrease in coverage rates, deterioration of pension amounts received, and deepening of gender and income inequalities.

The problems of sustainability and maintainability of pay-as-you-go systems have been widely analyzed and debated since the late 1980s. However, Encinas-Goenechea et al. (2020) re-analyzed this type of pension scheme in light of the economic reality experienced in recent years, focusing on the case of pensions in the countries that make up the European Union. The authors study how demographic factors are combined with a decline in financial and economic activity that generates obstacles to maintaining low unemployment rates and promoting growth. The above imposes a great burden on the sustainability of public pension systems. In order to solve this problem, the authors present the measures taken by the countries of the region mentioned above to achieve sustainable systems.

In the case of the Mexican pension system and its performance, the literature is still scarce. A small amount of research analyzes the behavior of the Mexican-funded pension scheme in the face of an economic crisis. Low replacement rates have been a concern since the 2008 crisis. After the 2008 crisis, it became evident that the replacement rate[1] offered by the current pension system would not reach the 60% obtained under the pay-as-you-go system. In a study conducted on the pension situation in Mexico (OECD, 2016), it was emphasized that measures should be implemented to increase the level of contributions to reach at least a 50%[2] replacement rate and, with this same objective, to increase the contribution time to qualify for a pension.

In her research, Ramírez (2019), following the line of analysis of Ortiz et al. and taking as a reference the indicators of the International Labor Organization, analyzes the Mexican pension scheme and the proposal of returning to a public pension system. The author argues that a return to a pay-as-you-go system would be justified because the defined contribution system has not expanded its coverage, and the replacement rate is lower than that offered by the pay-as-you-go system. She also argues that income inequality between genders has widened and that high transition costs have been generated between one system and another, increasing tax revenues.

De la Torre-Torres et al. (2020a) find that the net return index provided by the National Commission of the Retirement Savings System, CONSAR, is not a good indicator in times of crisis and

[1]The replacement rate refers to the percentage of salary received by a retired worker with respect to the salary earned prior to retirement.
[2]It was calculated that a replacement rate of 50% is achieved, with a probability of 75-90%, with an average contribution of 13-18% over 40 years.

propose a Markovian model of regime switching that provides more information for decision making on pension fund investment policy.

Within the literature dedicated to creating indicators for the Mexican case, some of the research deals with the creation of indices that go beyond just showing the behavior of pension funds by measuring their performance. Núñez and León (2019) propose a benchmark portfolio to optimize the Mexican pension fund investment policy, intending to achieve the maximum possible replacement rate. As a result, they obtain a more conservative portfolio than those currently managed by the Basic SIEFOREs, comprised of a low percentage of risk assets and short-term assets with maturities between three and five years.

De la Torre-Torres et al. (2015a) and De la Torre-Torres et al. (2015b) designed two benchmark indicators. In their first paper, they use a minimum variance portfolio, and in the second, they present a benchmark called Actual Position Benchmark (APB) based on the life cycle of the worker. In practice, taking the latter index as a reference, S&P Dow Jones/BMV Mexico launched benchmarks for the Mexican pension system.

The volatility of pension fund returns in Mexico is studied under two different scenarios with regime change in the papers by Martínez-Preece, Sosa, and Zubieta (2019) and López-Herrera, Martínez-Preece. and Santillán-Salgado (2020).

## National and international economic environment

Given the international economic crisis, several international organizations have made forecasts on the effects of the pandemic on the world economy. The IMF (2020) forecasts that this crisis is the most severe after the Great Depression, with a drop in world GDP to -4.5% for 2020, after having recorded growth of 2.9% in 2019 and a recovery forecast for 2021 that will reach 5.3%[3]. Figure 1 shows how Mexico, the United States, the Eurozone countries, and the world will have a fall in output this year. The exception will be China, which in September 2020 began its recovery and is expected to reach 1% GDP growth this year and 8.2% in 2021.

[3]Data as of September 2020

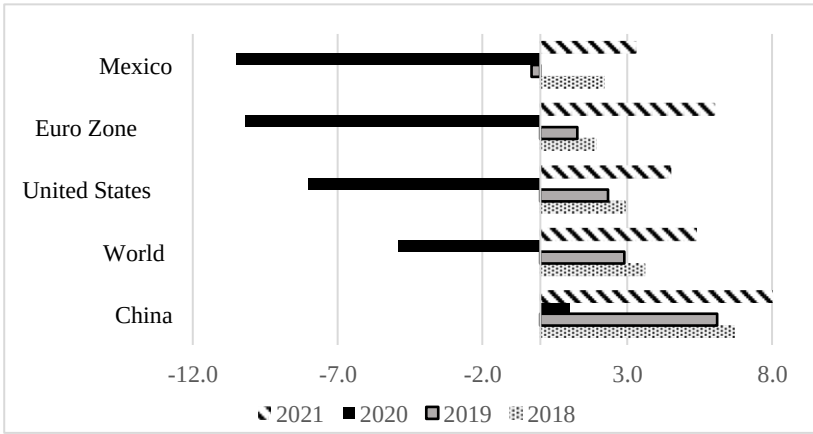


Figure 1. Percentage drop in GDP
Source: created by the author with IMF data (2020)

The projections for international trade also foresee a significant drop during 2020, mainly due to the disruption of supply chains (IMF, 2020). In 2020, international trade is projected to have negative growth of -11.9%, with a recovery in 2021 of 8.0%. Oil demand fell by 55% during the first half of this year due to the pandemic, which will negatively affect the income of oil-exporting countries. Another sector that has suffered the effects of the economic crisis from the outset is tourism. Mitigation and isolation measures during 2020 have led to temporary closures of 100% of tourist destinations. In a moderate scenario (UNCTAD, 2020), one-third of tourism revenues are expected to be lost in 2020.

Regarding unemployment rates, OECD countries (2020a) reported significant increases in this item during the first months of 2020, reporting 42.59% in July 2020.

Given the current situation caused by the COVID-19 pandemic, the total volume of assets managed by pension funds in OECD member countries (2020b) reached USD 29.757,335[4] trillion, which represents a 6% contraction when comparing the first quarter of 2020 with the same date in 2019, due to the decline in stock markets in the face of the pandemic declaration.

The outlook in Mexico is similar to the international one. GDP growth in the second quarter of 2020 had an unprecedented drop, even compared to previous crises, as can be seen when reviewing the same period in 1995 and 2009, the latter as a consequence of the 2008 crisis. Figure 2 demonstrates that the GDP variation reached -18.68% in the second quarter of this year, compared to -9.68% in the second quarter of 1995 and -8.93% in the same period in 2009. This decline in GDP resulted from the decrease in domestic consumption, which led to a drop in industrial activity and increased unemployment.

[4]Projected figure for 2020

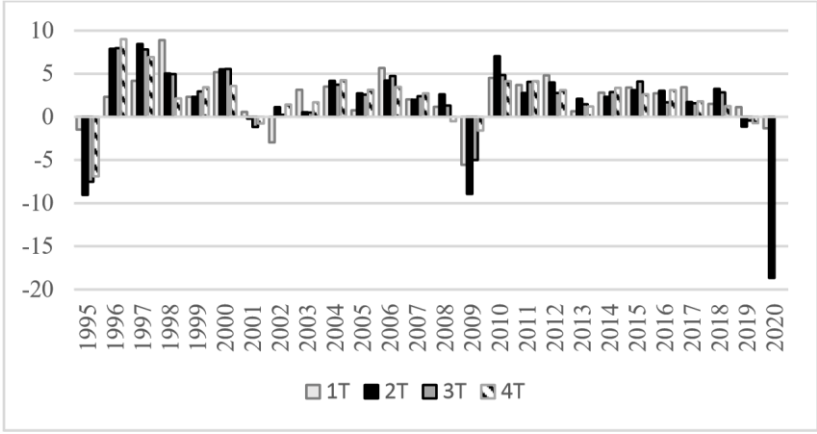


Figure 2. Variation in Gross Domestic Product (Constant values in millions of pesos at 2013 prices)
Source: created by the author. INEGI

The private consumption and industrial production indices displayed sharp declines in the first half of 2020, with negative variations of 23.52% and 30.08%, respectively, as a result of the lockdown measures that began to be implemented at the end of March 2020.

The unemployment rate, underemployment, and critical employment conditions reflected the lack of growth in consumption and industrial production. The unemployment rate increased in the second quarter of 2020 compared to the first quarter, reaching 5.34% in the second quarter compared to 3.26% at the end of the first quarter. The underemployment rate increased significantly in the second quarter, reaching 20.5% compared to 8.65% in the first quarter. The critical employment conditions rate reached 22.6% at the end of the first quarter, see Figures 3. a) and 3. b). informal employment represented 56.2% of the population over 15 years of age, as reported by INEGI at the end of March 2020.

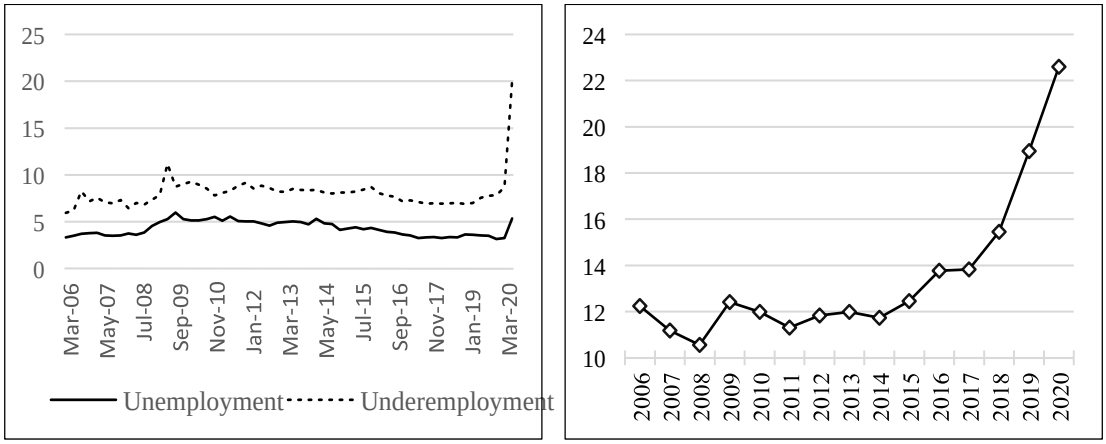


Figure 3.a) unemployment rate[5] and underemployment rate[6] Figure 3.b) rate of critical employment conditions[7]
Figure 3. Labor market
Source: created by the author with INEGI data.

Regarding the financial context of Mexico, the government funding rate decreased from 7.28% on January 1 of this year to 4.51% on August 30, 2020. This funding rate started to decrease at the end of 2019, although this trend became more pronounced as of the pandemic and has followed the same downward trend as the US Federal Reserve funds rate, which presented a level of 0.10% at the close of August 2020.

Stock markets also showed a decline this year. The Prices and Quotations Index (IPyC) reported a sharp decline of 21.56% between January and March of this year. However, this represented less than half of the decline it suffered during the 2008 crisis. On that occasion, from May 2008 to February 2009, the IPyC lost 44.48%. Figure 4. a) presents the behavior of the Prices and Quotations Index, which went from 44,108.31 to 34,554.59 points, with a slight increase to 36,840.73 points in August. The IPyC maintained a downward trend, although with a slight recovery in the second quarter of the year, unlike the MCSI World Index, which showed a decline in April but recovered quickly, reaching its pre-crisis levels at the end of May, see Figure 4. b).

[5]The unemployment rate considers the population not working but looking for work—a seasonally adjusted series as a percentage of the economically active population.
[6]The underemployment rate is the percentage of the employed population with the need and availability to offer more working time than their current occupation allows, as a percentage of the economically active population.
[7]The rate of critical occupation conditions includes people who are working less than 35 hours per week for reasons beyond their control, plus those who work more than 35 hours per week with monthly incomes below the minimum wage and those who work more than 48 hours per week earning up to two minimum wages, as a percentage of the employed population.


Figure 4. a) Prices and Quotations Index


Figure 4. b) MSCI World Index

Figure 4. Stock indices
Source: created by the author

The exchange market depreciated against the US dollar by 28% in response to the declaration of the COVID-19 pandemic. However, although it was a severe drop, its intensity was less than the depreciation suffered between September and October 2008, which reached 36%. In 2020, the recovery was faster than in 2008 (see Figure 5. a).

On the other hand, public debt, which was already showing an upward trend since 2017, increased by 13.01% from January 2020 to July 2020, see Figure 5. b).


Figure 5. a) Exchange rate of the Mexican peso against the US dollar

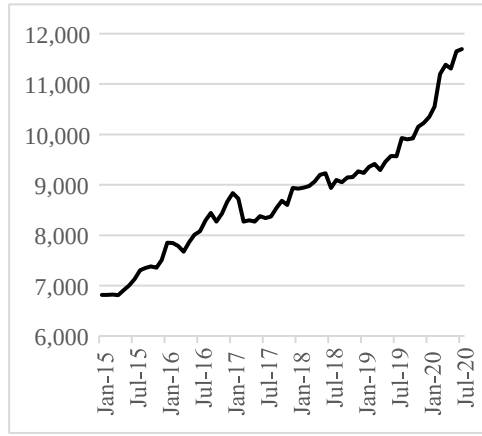


Figure 5. b) Public debt (in millions of pesos)

Figure 5. MXN-USD exchange rate and public debt volume. Source: created by the author with data from BANXICO

One of the impacts of the drop in interest rates and the fall in output, with its consequent negative effect on the Mexican stock market, is that during the first seven months of the year, government fixed income and variable income instruments held by non-residents demonstrated a negative variation, due to the outflow of capital during the first months of the year. The volume of fixed income securities held by non-residents from January to July of this year fell by 26.56%, and non-resident holdings of variable income instruments fell by 28.35% (Banxico, 2020).

## *Overview of the pension system*

To enable workers to receive higher returns and protect their savings from unnecessary risk, the investment policy was restructured by creating new types of SIEFOREs. The basic generational SIEFOREs, SBG, began operating on December 14, 2019, and consist of a fund for workers 25 years of age or younger, 8 funds with 5-year age ranges, starting with workers over 25 years of age, and a pension fund for workers 65 years of age or older. The assets that make up the SIEFORE portfolios vary over time according to the age of the workers. Investment limits in risky assets are higher for funds for younger workers, and fixed-income assets will be incorporated in higher proportions in pension funds for older

workers. Figure 6. a) presents the proportion of assets managed by the types of SIEFOREs before the creation of the SBGs[8], and 6. b) shows the proportion of assets with which the SBGs started operating.

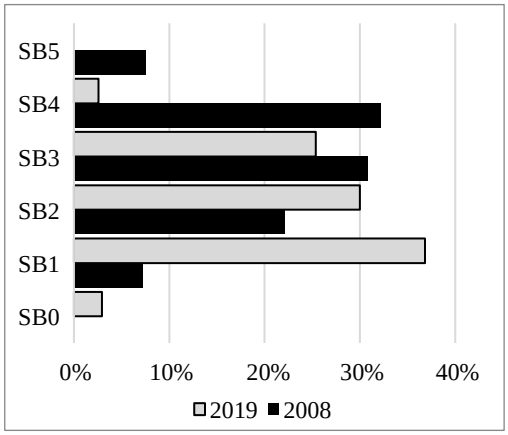


Figure 6. a) Assets managed by the Basic SIEFOREs

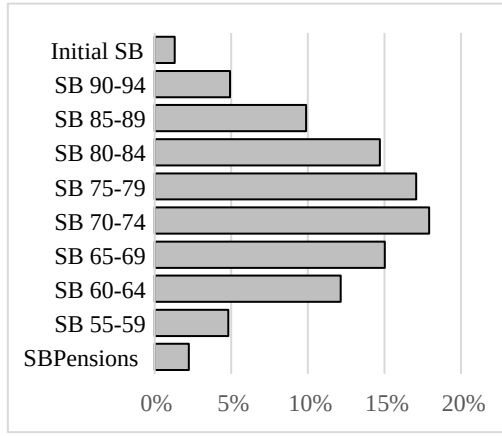


Figure 6. b) Proportion of assets managed by basic generational SIEFOREs

Figure 6. Types of Basic SIEFOREs
Source: created by the author with CONSAR data

With the restructuring of the pension funds, the proportion of debt instruments decreased slightly, from 73.30% to 68.90%, while the proportion of international variable return, and to a lesser extent of structured products and commodities in the pension funds, increased. See Figure 7.

[8]Information as of the end of November 2019

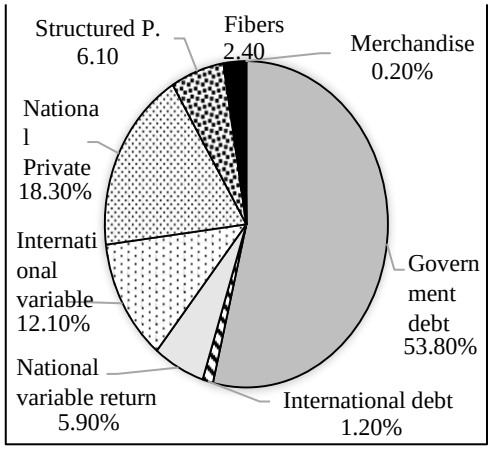


Figure 7. a) Composition of investment funds (June 2019)

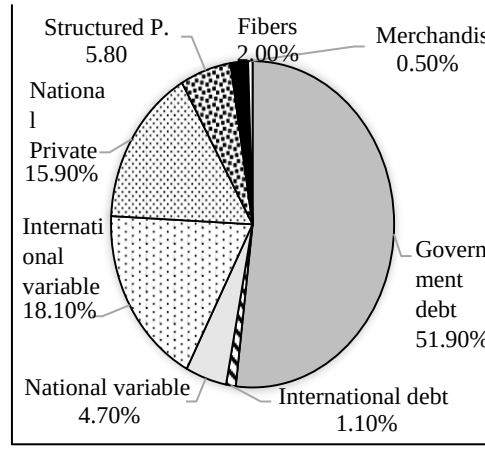


Figure 7. b) Proportion of assets under management by SBGs (December 2019)

Figure 7. Composition of investment funds
Source: created by the author with CONSAR data

The volume of total resources managed by SIEFOREs, unlike international pension funds, has not decreased due to the crisis, and at the end of the second quarter of 2020, it even showed an increase of 6.76%. This recovery is the result of the increase in the prices of fixed income instruments due to the drop in interest rates and the recovery of international stock markets, considering that 18.1% of pension funds are made up of international equities and only 4.7% of domestic equities. For the last two years, a quarter of government debt has been incorporated into SIEFORE portfolios. Given the current situation of capital outflows, SIEFOREs have become one of the main recipients of government debt, despite the attempts of the CONSAR to diversify pension funds and make investment policy more flexible.

## Methodology

After a review of the national and international economic environment and the outlook of the pension system, the conditional volatility of the daily returns of the pension system as a whole was modeled based on the daily prices of the Basic SIEFOREs registered on the Stock Exchange, from July 2, 2007, to June 29, 2020[9]. The returns were calculated as the logarithms of the first differences of the system index of the Basic Generational SIEFOREs. Given that in November 2019 CONSAR (2020c) stopped publishing the

[9]As of August 29, CONSAR had only published the prices of the SIEFOREs registered on the stock exchange for each of the generational SIEFOREs until June 29, 2020, which is why the performance of the SIEFOREs is analyzed only up to this date.

indices of each SIEFORE and the index of the system in general, a simple price index of the Basic Generational SIEFORE system, SBG, was constructed from the prices of each type of generational SIEFORE, as follows:

$$I_t = I_{t-1}\left(\frac{\sum\left(\frac{P_{it}}{P_{it-1}}\right)}{n}\right)$$

Where: $I_0$ =100, $I_t$ = Index on day $t$, $I_{t-1}$ = Index on day $t$-1, $P_{it}$ =, price of SIEFORE $i$ on day $t$, $P_{it-1}$= Price of SIEFORE $i$ on the previous day, $n$ = number of investment companies listed in each type of SIEFORE. The same procedure was used to calculate the System Index of the generational Basic SIEFOREs, but this time using the daily value of each index instead of the daily prices.

Given that the series is asymmetric and leptokurtic, as shown in the statistical data presented below, conditional volatility was estimated using different models of the family, GARCH (1.1), EGARCH (1.1), and TARCH (1.1), in order to capture the asymmetry. Finally, the Monte Carlo method was used to simulate the total accumulated savings at the end of a typical worker's working life, assuming different income levels.

## *GARCH models*

In the GARCH model developed by Bollerslev (1986), the conditional variance depends not only on the squares of the disturbances but also on the conditional variances of previous periods. Thus, the conditional variance of the GARCH model (1.1) is determined as:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (1)$$

## *Exponential GARCH model*

On the other hand, in financial series, it is very common to find that negative shocks have a more pronounced effect on volatility than positive shocks; this asymmetric behavior caused by external shocks can be treated with an exponential GARCH or the EGARCH model by Nelson (1991):

$$\ln\left(\sigma_t^2\right) = \alpha_0 + \alpha_1 \left|\varepsilon_{t-1}/\sigma_{t-1}\right| + \lambda\left(\varepsilon_{t-1}/\sigma_{t-1}\right) + \beta \ln\left(\sigma_{t-1}^2\right)$$

(2)

This equation shows the asymmetric response in volatility due to positive or negative past shocks. Generally, the larger the external shock, the greater the difference in volatility impact. The three features that distinguish it from the GARCH model are: 1) the conditional variance equation is in a log-linear form, which means that regardless of the magnitude of the $\ln(\alpha_t^2)$ , the implied value of $\alpha_t^2$ can never be negative; 2) instead of using the value of $\varepsilon_{t-1}^2$ , the EGARCH model uses a standardized value of $\varepsilon_{t-1}$ (which is obtained by dividing $\varepsilon_{t-1}$ by $\sigma_t$ ), which makes possible a more natural interpretation of the size and persistence of the shocks; 3) and the most important, is that this model makes it possible to measure leverage effects. The parameter $\lambda$ represents the leverage effect of $\varepsilon_{t-1} / \sigma_{t-1}$ . The model will present asymmetry if $\lambda \neq 0$, and in most financial applications, it is expected that $\lambda < 0$ Tsay (2005).

## *TGARCH model*

The TGARCH model, like the EGARCH model, considers asymmetric effects in a time series. This model was developed by Rabemananjara and Zakoian (1993), Zakoian (1994), and Glosten, Jaganathan, and Runke (1993), although independently. The conditional variance is given by:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 + \gamma\ \varepsilon_{t-1}^2\ I_{t-1}$$

In the model $I_{t-1} = 1$ if $\varepsilon_{t-1} < 0$; otherwise, $I_{t-1} = 0$. The condition for the leverage effect is reflected in $\gamma > 0$. The condition for non-negativity will be $\alpha_0 > 0, \alpha_1 > 0, \beta \geq 0,$ y $\alpha_1 + \gamma \geq 0$; however, the model will be valid, even if $\gamma < 0$, as long as 1 $\alpha_1 + \gamma \geq 0$, (Brooks, 2014).

## *Monte Carlo simulation*

This numerical method is attributed to J. von Neumann and S. Ulam, who designed it in 1949. Since the Monte Carlo method makes it possible to simulate values of random variables, it was considered an appropriate technique for simulating the yield and estimating the total amount saved by a typical worker during the accumulation stage with different income levels. The above provides a basis for the comparison between the current conditions of the pension system and the proposals for reforming the pension system

presented in September 2020. The returns of the estimated SIEFORE index were considered as a stochastic variable, and the Monte Carlo method, assuming a logarithmic distribution, was used to calculate the total accumulated amount:

$$F = \left( \frac{A\left[ 1-\left( 1+\frac{i}{t} \right)^{-n}\left( 1+\frac{j}{t} \right)^{n} \right]}{\frac{i}{t}-\frac{j}{t}} \right)(1+i) \qquad j \neq i$$

Where: $F$= future value of the contributions, $A$ = workers' quarterly contributions, $i$ = annual rate of return, $j$= increase in workers' salaries, $n$ = number of two-month periods during which tripartite contributions will be made[10], $t$= number of periods in a year[11]. The future values of the contributions to be made by workers with three, five, seven, and eight minimum wages were calculated in order to estimate whether the amount accumulated at the end of their working life will be sufficient to acquire perpetuity so they can obtain a pension of at least two minimum wages per month so that they will not have to depend on the minimum guaranteed pension, which currently is equivalent to 1.3 minimum wages. This study performed 100,000 iterations for each case and assumed an annual increase in the minimum wage of 5% per year during the accumulation phase.

## Results

This section presents the pension system's indices, yields, and volatility dynamics through the estimation of conditional volatility. The last section analyzes the level of contributions and the contribution time proposed by the pension reform proposal in light of the drop in workers' income caused by the crisis.

### *The performance of the pension system*

Figure 8 presents the SIEFORE indices and annualized daily returns. Figure 8. a) shows the behavior of the index and its returns up to November 2019[12]. In 2008, the pension system suffered its worst drop, with a 10% loss between October 2 and October 29. It took eleven months for the system to recover from the

[10]The weeks of contribution required to receive a bimonthly pension were adjusted, since this is the way in which the workers' resources are deposited in the individual account.
[11]In this case it is 6, which corresponds to the number of two-month periods in a year.
[12]On this date, CONSAR published for the last time the Index of the basic SIEFORE system, comprised of the five types of basic SIEFORES that existed before the restructuring.

crisis, from the first pre-crisis symptoms in May 2008 until it returned to its pre-crisis level on April 30, 2009. Yields have shown wide fluctuations, not only those caused by the 2008 crisis and the current crisis caused by the pandemic but also in 2013. In that year, the pension system recorded significant losses due to high international volatility caused mainly by the uncertainty about the decisions of the US Federal Reserve regarding the increase in interest rates. Figure 8. b) shows the index and returns of the system with the generational SIEFOREs, SBG, during 2020. The index of the system with generational SIEFOREs showed a decrease of 8% following the announcement of the pandemic in March 2020. The index level before March was not reached until May 20. During the last days of May and until June 2020, it maintained an upward trend. At the end of June 2020, the system had recovered the losses of the first quarter (CONSAR, 2020a), accumulating capital gains of 220 billion pesos compared to losses of more than 130 billion pesos at the end of the first quarter.

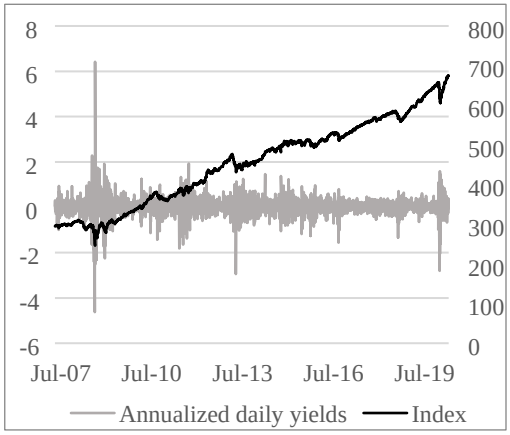


Figure 8. a) SIEFORE system index before SBGs (November 2019)

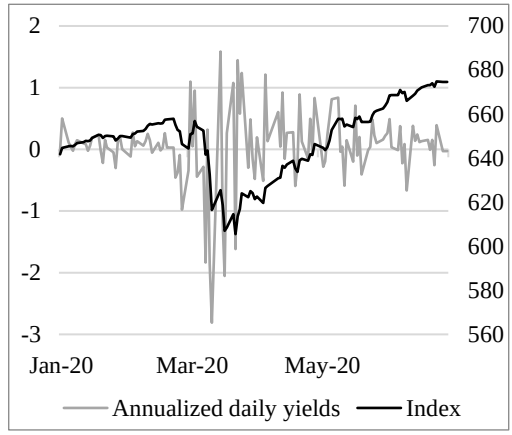


Figure 8. b) Index of the system with the creation of SBGs

Figure 8. SIEFORE System Index
Source: created by the author with CONSAR data

Table 1 presents the descriptive data of the SIEFORES system price index and the daily returns derived from it. Both series present skewness and leptokurtosis and do not follow a normal distribution.

Table 1
Descriptive statistics and ARCH effect

| Parameters | Index | Yields |
|---|---|---|
| Mean | 354.04 | 0.000252 |
| Median | 303.90 | 0.000324 |
| Maximum | 674.82 | 0.059102 |
| Minimum | 99.55 | -0.042599 |
| Standard Deviation | 145.09 | 0.0033811 |
| Bias | 0.28 | 0.426596 |
| Kurtosis | 2.06 | 3.46698 |
| Jarque-Bera | 286.13 | 126571.5 |
| ARCH-LM* | | 795.559 |

*The test result is the value of the F-statistic
Source: created by the author with CONSAR data

A test for autoregressive conditional heteroscedasticity (ARCH) was performed on the residuals of an ARMA model (1.1) applied to price returns. The result was a probability of less than 1%, which is highly significant, so the null hypothesis of the absence of the ARCH effect in the series is rejected, accepting that the variance of the errors changes over time, so volatility will be modeled from models that make it possible to incorporate lagged observations of its variance.

## *Conditional volatility*

As mentioned above, the conditional volatility of returns was calculated with the first differences of the price index of the system, for which the series was first verified to be stationary. The results of the unit root tests Augmented Dickey-Fuller (DFA), Phillip-Perron (PP), and Kwiatkwski-Phillips-Schmidt-Shin (KPPS) are presented in Table 2.

Table 2
Unit root tests

| Variable | DFA Statistic | P value | Critical Value 1% | Critical value 5%. | Critical value 10%. | Result |
|---|---|---|---|---|---|---|
| DFA | -45.43477 | 0.0001 | -3.432161 | -2.862226 | -2.567179 | Stationary |
| PP | -44.59966 | 0.0001 | -3.432161 | -2.862226 | -2.567179 | Stationary |
| KPPS | 0.037925 | | 0.739000 | 0.463000 | 0.347000 | Stationary |

$H_0$: Unit root exists
Source: created by the author with CONSAR data

Once it was verified that the time series of yields was stationary, a unit root test with structural break was performed; as observed in Figure 11. a), the 2008 crisis could have caused a break in the yield series. Table 3 displays the test results, which determined the presence of a structural break on October 29, 2008, due to the financial crisis of that year.

Table 3
Unit root test with a structural break

| | | Statistical-t | P value |
|---|---|---|---|
| DFA test statistic | | -48.6678 | < 0.01 |
| Critical values | at 1% | -5.347598 | |
| | at 5% | -4.859812 | |
| | at 10% | -4.607324 | |
| Date of structural failure: | | October 29, 2008 | |

$H_0$: There is a unit root with a structural break in both the series' trend and intercept.
Source: created by the author with CONSAR data

Table 4
Results of the GARCH family models used

| GARCH 1.1 model | | | EGARCH 1.1 model | | | TARCH 1.1 model | | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | P-value | | Coefficient | P-value | | Coefficient | P-value |
| M | 0.000362 | 0.00000 | M | 0.000294 | 0.00000 | M | 0.000293 | 0.0000 |
| α0 | 4.07E-07 | 0.00000 | $\alpha_0$ | -0.572436 | 0.00000 | α0 | 3.37E-07 | 0.0000 |
| α1 | 0.184047 | 0.00000 | $\alpha_1$ | 0.283139 | 0.00000 | α1 | 0.086799 | 0.0000 |
| β1 | 0.805527 | 0.00000 | λ | -0.101245 | 0.00000 | γ | 0.149511 | 0.0000 |
| | | | $\beta_1$ | 0.967832 | 0.00000 | β1 | 0.824451 | 0.0000 |
| Dum | -1.81E-07 | 0.01100 | Dum | -0.028525 | 0.00090 | Dum | -1.17E-07 | 0.0631 |
| | | | Information criteria | | | | | |
| AIC | -8.963633 | | | -8.982865 | | | -8.980162 | |
| Schwarz | -8.954317 | | | -8.971686 | | | -8.968983 | |
| H-Q | -8.960297 | | | -8.978862 | | | -8.976158 | |
| ARCH-LM* | 0.797700 | | | 0.953500 | | | 0.617100 | |

*The values refer to F probability.
Source: created by the author with estimation data[13]

[13]GARCH model estimations were performed with E-Views 11.

A dummy variable was incorporated to add the structural break detected in the GARCH models. Since the parameters in the descriptive statistical data show the presence of asymmetry, GARCH (1.1), EGARCH (1.1), and TARCH (1.1) models were used; the latter two captured the asymmetry effects that could be present in the conditional volatility. Table 4 presents the results.

The *dummy* variable was significant at 10% in the three models. However, for the EGARCH model it was highly significant, with a probability of less than 1%. The results of the ARCH-LM test make it possible to accept the null hypothesis of the absence of the ARCH effect since in all cases the associated probability is greater than 10%, so it can be said that since there are no ARCH effects in the standardized residuals, the variance was correctly specified. The EGARCH model is the one with the lowest probability of having ARCH effects. On the other hand, although the information criteria are very similar, the EGARCH model has the lowest information loss.

The GARCH and TARCH models show high volatility persistence, which is observed in the sum of the coefficients $\alpha_1$ and $\beta_1$ very close to 1, especially the GARCH model (1.1). The EGARCH (1.1) and TARCH (1.1) models captured the skewness effect. In the case of the EGARCH model (1.1), the coefficient $\lambda$ is negative, which means that negative shocks have a larger impact than positive shocks of the same magnitude. In the TARCH model, the coefficient $\gamma$ is positive, which, according to the specification of this model, also means that the effect of negative shocks is greater than positive shocks of the same size. With these results, it was found that there is persistence of volatility and that negative shocks have a greater impact than positive ones.

Figure 9 shows the graph of the conditional volatility obtained from the EGARCH model (1.1). This work presents the conditional volatility represented by the daily conditional standard deviation. The largest increase in conditional volatility occurred during the 2008 crisis, followed by the increase in volatility caused by the COVID crisis, showing the impact of the current crisis concerning the risk incurred by the pension system since 2008. The peak that appears in 2013 represents the system's instability during that year.

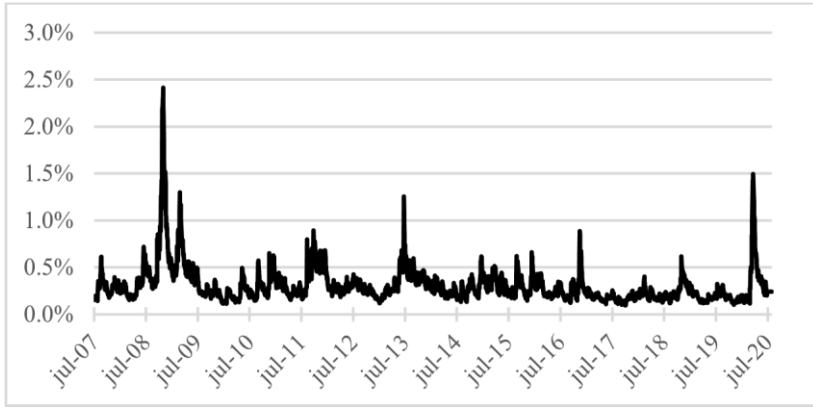


Figure 9. Conditional Volatility of the Pension System
Source: created by the author based on the estimation results

## *Effects of the crisis on the pension system and the proposed reform of the system*

A direct effect of the crisis, and perhaps the one that will have the greatest impact on the pension amounts workers will receive, is unemployment. Despite the growth in the resources managed by the AFOREs in the second quarter of 2020, CONSAR reported an increase in partial withdrawals from workers' accounts due to unemployment[14], at the end of June 2020, of 8,570 million pesos (CONSAR, 2020b), a figure superior by 37.52% to what was reported in the same month last year.

Unemployment has caused workers to partially use the resources accumulated in their accounts to weather the economic crisis. The above will have the effect of reducing the total accumulated savings for their pension. This element, in addition to having direct negative consequences for those workers who use this benefit, adds pressure to the system since its sustainability has been questioned on several occasions, as mentioned above. The proposed reform of the system includes measures intended to increase the level of total savings. Therefore, its application could be very convenient at this time if the proposed changes have the potential to reverse some of the negative effects of the crisis on the total resources that workers will be able to accumulate.

[14]This benefit is available to workers with at least 46 days of unemployment, and who have not made any withdrawals in the last five years (CONSAR, 2020).

## *The reform proposal in the face of the crisis caused by COVID-19*

On September 29, a proposal to modify the pension system was submitted to the Chamber of Deputies through the reform, addition, and repeal of various provisions of the Social Security Law and the Law of the Retirement Savings Systems. Among the most important points is the increase in the number of contributions, the reduction of commissions, the reduction of contribution weeks, and the fact that workers not affiliated with the IMSS or the ISSSTE may open an individual account for their pension.

Given that withdrawals due to unemployment will cause the worker's total balance to decrease, as will the number of weeks contributed, which will be subtracted from the accumulated contribution time in proportion to the withdrawal made, as mentioned above, it was decided to analyze two essential points for the worker to accumulate sufficient resources to obtain a pension above subsistence level. These two points are contributions and contribution time.

Regarding the tripartite contributions, the reform proposes to increase them from 6.5% to 15%—increasing the employer's contribution from 5.15% to 13.7%. The above is done according to a table with the applicable percentages according to the worker's salary and the contribution of the state, tending to support workers with lower incomes starting in 2023 until reaching the maximum ceilings in 2030, also according to a reference table. Undoubtedly, increasing contributions will increase the accumulated amount at the end of the worker's active life. However, the effect of reducing workers' contribution weeks must also be considered. The reform contemplates reducing these from 1250 to 750, which will increase to 1000 in 2031.

In order to determine the effect on the total accumulated at the end of the accumulation period, three scenarios were considered. The first scenario is the case of continuing to contribute under the current scheme. In the second, an increase in contributions will be included. In the third scenario, contributions will be increased, but the number of weeks of contributions will be reduced to 750.

As explained in the methodology, the Monte Carlo method was used to simulate the total savings accumulated by the workers under the three scenarios described above. The yield was considered the random variable, and a 5% annual[15] salary increase was assumed during the worker's active life[16] in all scenarios. Table 5 shows how much could be saved under the current scheme assuming total contributions of 6.5% of the worker's salary, concluding that workers earning less than 8 minimum wages will hardly be able to buy perpetuity that offers them a pension of two minimum wages per month or more, which

[15]These increases were incorporated into the simulation on a bimonthly basis, considering an equivalent rate of 5% per annum.
[16]The worker's active life is considered to be 1,250 weeks of contributions under scenarios 1 and 2 or 750 under scenario 3.

would make it possible for them not to depend on the minimum guaranteed pension of 1.3 minimum wages[17]. In the second scenario, a 15% annual increase in contributions was assumed, in which case workers with more than three minimum wages would be able to receive pensions above the minimum guaranteed pension. The third scenario assumed an increase in contributions but with a reduction in the contribution period from 1,250 weeks to 750 weeks, as initially indicated in the reform proposal. In this case, the worker would be slightly worse off than without the reform. The worker would have to work for fewer years but, in the end, depend on the minimum guaranteed pension.

Table 5
Amounts accumulated at the end of the worker's active life

| I. No reform | 3sm* | 5sm | 7 sm | 8sm |
|---|---|---|---|---|
| Mean | 834 026 | 1 390 043 | 1 946 060 | 2 224 068 |
| 90% probability | 749 829 - 927 033 | 1 249 715 - 1 545 055 | 1 749 600 - 2 163 077 | 1 999 543 - 2 472 088 |
| II. With reform: increase in contribution, same contribution time | 3 sm | 5 sm | 7sm | 8 sm |
| Mean | 1 924 674 | 3 207 791 | 4 490 906 | 5 132 465 |
| 90% probability | 1 730 374-2 139 37 | 2 883 956-3 565 5 704 | 4 037 539-4 991 511 | 4 614 330- 715 817 |
| III. With reform: increase contribution, less contribution time | 3sm | 5sm | 7 sm | 8sm |
| Mean | 705 276 | 1 175 460 | 1 645 | 645 |
| 90% probability | 661 494 - 752 711 | 1 102 490 - 1 764 983 - 2 | 1 543 485 - 1 254 519 | 1 756 326 007 230 |

* sm, initials for minimum wage
Source: created by the author with simulation data

Given the current situation, it would be advisable to re-analyze the points included in the reform. The best scenario is the second one, maintaining the 1,250 weeks of contributions with an increase in the contributions; this combination would result in a significant increase in the total accumulated amount. The above situation would benefit all workers in the pension system but would especially help those who have taken early retirement and stopped contributing due to unemployment. In this way, the pension system would be structured in such a way as to help compensate for the amounts that would no longer be saved due to the crisis.

[17]The reform does not repeal the universal pension for senior citizens, which would serve as a supplement to the pension obtained from the retirement savings system or the guaranteed minimum pension.

## Conclusions

A review was made of the economic environment and the main effects of the crisis on it. How the new generational SIEFOREs were constituted given the restructuring of the pension system's investment regime was explained, as well as the behavior of the prices and volatility of the system from July 2007 to June 2020, covering the 2008 crisis and the current crisis caused by the pandemic. The risk to the pension system was analyzed concerning the dynamics of conditional volatility, detecting that there is persistence of volatility and an asymmetry effect that causes negative shocks to have a greater impact than positive shocks, thus affecting the system's behavior in the face of external negative movements. This effect occurred even though 68.9% of the financial instruments included in the investment portfolios are debt instruments, and of these, just over 50% represent government debt. However, this does not necessarily mean that the risk to the system in general has increased, ruling out the first hypothesis. As of September 2020, the system had a rapid recovery.

On the other hand, it was also shown that unemployment caused by the crisis led to early withdrawals, so the total accumulated during the worker's active life was simulated to determine whether the negative effects of the crisis could be offset by the changes in the structure of the pension system proposed by the pension system reform. The effect of the increase in contributions and the reduction of the term was analyzed, concluding that it is important to increase contributions. However, it is not desirable to reduce the contribution term to avoid annulling the positive effect of the increase in contributions on the accumulated total. This point is important from different points of view. For workers, it is obvious that the possibility of accumulating larger total balances at the end of their active life will allow them to consume above the subsistence level, which is the ultimate objective of the current pension system. From the fiscal perspective, making appropriate reforms that enable workers to receive a pension above the minimum guaranteed pension will reduce the fiscal pressure, as more workers will be able to buy perpetuity and will not depend on the minimum guaranteed pension offered by the government.

Considering the above, new lines of research are presented, especially concerning the performance of the investment policy in the face of the creation of the generational SIEFOREs, since the new investment regime allows for the incorporation of a greater proportion of debt instruments for younger workers. It is also important to analyze each point of the pension system reform in detail, as the crisis adds elements that must also be considered. The impact of the crisis on employment levels produces an increase in the discontinuity of career paths and changes in contribution density, which must be considered to evaluate the pension system from the perspective of its viability and sustainability.

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