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Economic Analysis

Return Simulations in the Private Pensions Industry in Peru



Abstract

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This document contains a series of simulation exercises aimed at modeling returns in the private pension funds industry in Peru over the next 50 years. The results support the argument that return losses registered in Pension Funds due to the global financial crisis are part of a set of temporary phenomenon. In this way, a long-term approach offers a higher growth prospective for returns than other savings alternatives. Also, we conclude that returns vary according to the risk profile of the fund chosen by the affiliates for their contributions, and that choosing the Type 3 Fund yields higher returns, albeit through more exposure to equities and thus greater volatility.

Introduction

The recent financial crisis had a major effect on all areas of the global economy. During the crisis, Pension Fund returns suffered major contractions that, as was to be expected, led to an intense debate in academic and political circles.

The main impact was due to reduced financial asset prices, both for equities and fixed-income instruments, where the Pensions Funds Administrators (PFAs) placed their investments. All Pension Systems, whatever their fund investment structure, saw their portfolios drop in value during the height of the crisis¹.

In Peru, the Private Pensions System (PPS) has a Multiple Fund Scheme comprised of three fund types with different risk levels. Each fund invests in fixed-income and equities and is differentiated by the level of investment in one of the security types. Fund 3 has a maximum investment limit for equity instruments set at 80% of the portfolio, a level which decreases progressively in Fund 2 and Fund 1, which are capped at 45% and 10%, respectively. As with other investment alternatives, during the financial crisis, the returns for the Peruvian Pension Funds were increasingly effected as the crisis intensified. Regardless of the type of fund, the three funds registered real negative returns year-over-year, from May 2008 to June 2009, with Fund 3 recording the highest contraction due to its higher exposure to equity securities. In this way, in October 2008, Fund 3 recorded a real negative year-over-year return of 43.4%, while Fund 1 and Fund 2 registered yields reduced by 13.7% and 31.5%, respectively.

However, it should be noted that by September 2009, all three funds returned registered positive gains. This is a clear sign that the losses recorded by the Pension Funds were only temporary and associated with the international financial crisis. Over the long term, it is possible to achieve stable returns, as demonstrated by the accumulated returns of the three types of Pension Funds since they were established. In this sense, Fund 2 has recorded a real year-over-year yield of 8.8% over the 16 years since it was established in 1993. Fund 1 and Fund 3 have recorded real yields of 6.2% and 21.8%, respectively, over the four years since they were established in December 2005. It is also worth mentioning that these yields increase considerably if the analysis period is limited so that the period associated with the recent crisis is not taken into consideration.

It is important to reiterate that, despite the fluctuations linked to the effects of any specific crisis, the historical returns for Pension Funds remain positive. As proof of this, this document presents return simulation exercises for each fund that forms the Peruvian PPS, using methods that allow fixed-income and equity instrument returns to be forecast, as well as verifying that sustained growth is recorded over the long term.

In order to corroborate the above hypothesis, this study has the following objectives: (i) to review the investment system, setting out the regulatory limits and the performance of PFA portfolios, (ii) to analyze the impact of the international financial crisis and previous crises on Peruvian Pension Funds, specifically in terms of returns, with an emphasis placed on the positive returns seen by Pension Funds since their establishment and, (iii) to demonstrate, taking the Monte Carlo method into account, that in the long term, the returns from the three funds comprising the PPS will all show positive curves, albeit differentiated by the type of fund.

In order to fulfill the aforementioned objectives, this document is divided into five sections. The first section sets out a summary of the investment system in Peru, showing the instruments allowed by regulations and the investment limits set for each of the three Pension Fund types. The composition of the PFA investment portfolio at three different moments (April 2008, April 2009 and October 2009), which shows the change in PFA portfolio composition to a higher share of fixed-income assets and, in turn, a lower equity weighting. The second section looks at the effects of the global crisis on the two main PFA investment instruments (stocks and bonds), showing how both assets recorded major yield decreases, particularly in the second half of 2008. Nonetheless, as the crisis abated, these instruments recovered at least partially due to the efforts made by the pensions industry to come up with strategies to mitigate the effects of the crisis. Section three offers a detailed analysis of the history of Pension Fund performance, highlighting their achievements and showing that, not including the period during the financial crisis, the annual returns increase to 10.6%, 10.1% and 45.3% for funds 1, 2 and 3, respectively. Section four offers yield simulations for the Pension Funds over a 50-year period.

¹: According to the AIOS (International Association of Pension Fund Monitoring Organizations), Pension Funds in 2008 recorded real negative yields in nearly all countries in the region (excepting Dominican Republic, 8%), falling in a range of -2% in Bolivia to -27% in Peru.

These projections are useful for showing that, despite the inherent volatility of financial instruments (especially equities) held by PFAs on behalf of contributors, on average, the invested resources yield higher returns than other savings alternatives with similar risk levels. To comply with the above objective, this section is organized as follows. The first part describes the model used to perform the simulations and also describes the procedures used to estimate both the equity and fixed-income instruments, as well as the portfolio comprised by both assets. After this, the representative variables that are used to perform the estimates are examined, along with the criteria taken into account for their selection. The last part in this section shows the results of the model, placing an emphasis on the long term returns. Finally, the last section offers conclusions confirming that, despite the short term negative returns registered, PFAs offer attractive benefits to contributors in the long term in terms of both risk and return.

1. Peru's Pension System

The Private Pensions System (PPS) was created by Act 25897 on December 6th, 1992, with an individual capitalization system that works alongside the Public System, which is run by a state institution that in the early 1990s suffered from major financial instability. From its inception, PPS incorporation was performed via workers affiliating themselves with Pension Fund Administrators (PFAs)², whose exclusive job is to invest the private capital on behalf of the affiliates. Since the creation of the PPS, the Superintendencia de Banca, Seguros y AFP (Superintendent of Banks, Insurance and Private Pension Funds, SBS) established guidelines for handling pension funds. According to Article 25 of Act 25897, PFAs are permitted to invest only in financial instruments, whether fixed-income or equities³, which are duly authorized by the regulatory framework in effect. The same article sets out the investment limits per asset type, stating that investments in fixed-income instruments must not individually go above 25% of the total fund value, while those in equities could not exceed 10%.

Later, in 1997 the Ordered Text of the Private Pension Fund Administrator System Act was published, whereby the instruments in which PFAs could invest were classified in the following manner: (i) Stocks; (ii) Bonds; (iii) Debt Swaps and (iv) Instruments Representing Rights over Short Term Bonds or Assets in Cash.

Furthermore, following the Chilean model, Act 27988 of July 2005 set up a multi-fund or multiple pension scheme with three different fund types according to expected returns and risks, thus providing more options for affiliates:

1. Capital Maintenance Fund or Conservative Fund (Fund 1). In accordance with the law, pension-savers over 60 years of age are obliged to keep their contributions in this fund, except for those who request in writing their wish to be in the Balanced Fund.
2. Balanced or Mixed Fund (Fund 2). By default, the contributions of a new affiliate will be allocated to this type of fund until he (she) chooses another type of fund.
3. Growth or Aggressive Fund (Fund 3). Designed for contributors who can take on a greater risk and are looking for above-average long term return.

So that the Multiple Fund Scheme works properly, investment limits were set for each instrument type. The maximum limits per fund type and asset class, valid from the beginning of the Multi-Fund scheme, are:

Table 1

Multi-fund investment regime

Asset classes	Equity	Fixed-income	Derivatives	Certificates/ Assets on deposits
Fund Type 1 (Maintaining Capital)	10%	100%	10%	40%
Fondo Tipo 2 (Mixed Fund)	45%	75%	10%	30%
Fondo Tipo 3 (Growth Fund)	80%	70%	20%	30%

Maximum investment limits by asset classes as a percentage of the fund total
Source: TUO (2008)

2: Initially, eight PFA were in operation in the Peruvian PPS. These have now been reduced to four Management Companies.

3: The Peruvian case is unlike that of Mexico, where investments in equity by Retirement Fund Investment Companies (SIEFOPRES) were not allowed at the beginning. From 2005, with the introduction of multi-funds, AFORES were allowed to invest in this asset type.

4: http://www.sbs.gob.pe/RepositorioAPS/0/1/ger/SPDP_MULTIFONDOSDOS/NL20030604.pdf

Comparing the maximum investment limits by asset type that regulations allow with investments made by the PFA as of October 31, 2009, we can see (See Table 2) that the portfolios managed by the Pension Fund Administrators are diversified in both fixed-income and equities, although these percentages depend on the type of fund. Furthermore, investments are not only in instruments issued domestically since overseas investments are allowed⁵, thus taking advantage of opportunities outside the country and mitigating the risks of a slowdown in the Peruvian economy or in domestic stock markets. To that effect, Van Boom (2009) states that although the correlation between stocks in emerging markets, such as Peru, and stocks in developed markets was almost 1 during the crisis, bonds from industrialized economies registered a positive performance during the crisis periods, which should be taken into account since investors use them as a safe haven⁶.

Table 2

PFA and Asset Allocation (% of total of the portfolio)

Asset classes	To April 2008			To April 2009			To October 2009		
	Fund 1	Fund 2	Fund 3	Fund 1	Fund 2	Fund 3	Fund 1	Fund 2	Fund 3
Total domestic investment	90.7	87.0	81.5	92.9	88.0	86.2	89.5	80.1	77.5
Equity	8.2	36.1	62.3	4.0	23.4	52.4	5.9	28.2	56.9
fixed-income	80.2	48.6	18.7	83.1	58.9	31.3	67.1	46.8	18.0
Other domestic	2.3	2.2	0.5	5.8	5.7	2.4	16.5	5.0	2.6
Total foreign investment	9.6	13.0	17.9	7.5	11.7	13.8	10.6	20.5	23.5
Equity	1.0	1.7	4.8	0.3	1.6	2.8	1.2	7.4	14.4
debt certificates	3.6	2.4	1.7	3.0	4.4	4.7	4.4	5.3	3.1
Other foreign	4.9	8.9	11.4	4.2	5.8	6.2	5.0	7.8	6.1
Total	100	100	100	100	100	100	100	100	100

Source: SBS

An analysis of the investments by fund type shows that as of October 2009, Fund 1, representing around 9% of the total managed portfolio, had an average fixed-income share of 83%^{6B}. Fund 2, representing 72%⁷ of the total pension fund, had a balanced composition and held around 52% in fixed-income. Finally, Fund 3 held an average of 71% in equity.

A change was noted in the evolution of portfolio assets by fund type, which increased as the effects of the crisis worsened on the domestic stock exchange. In April 2009, Fund 3 had 55% exposure to equity, below the 67% figure seen the previous year. The situation was similar for Fund 2 and Fund 1, which had equity exposure in April 2009 of only 25% and 4%, respectively. It should be pointed out that it is difficult to state that PFAs reordered their portfolios by placing greater investments in equity assets. We should take into account that the fall in equity share was partly due to a price effect and not necessarily to liquidating positions in this asset type. On the other hand, fixed-income saw a quick price recovery thanks to expansive monetary policies put into practice in most countries.

5: In January 2010, the Central Bank increased to 24% from 22% the amount of private pension fund managers' (AFPs) total investments that they can allocate overseas. This increase represents approximately USD 500 million more than AFPs may invest in international markets.

6: In December 2008, the US 10-year benchmark Treasury bond yield fell to a five decade minimum to 2.01%.

6B: This amount and figures that refer to Table 2 include both domestic investment and foreign investment.

7: The significant weight Fund 2 represents in the total funds managed shows pension-savers' interest in placing their Individual Capitalization Accounts in a portfolio comprising both fixed-income and equity assets.

In this context, it should be highlighted that the investment limit for equities in the riskiest fund in Peru is equal to that of Chile (80%), but greater than that of Mexico (30%) (See Tables 3 and 4).

Table 3

Mexican Multi-fund Investment System

Asset Classes % of total assets	Siefore				
	SB1	SB2	SB3	SB4	SB5
Equity (stakeholder indices)	0%	15%	20%	25%	30%
Fixed-income	100%	100%	100%	100%	100%
Foreign securities	20%	20%	20%	20%	20%
Inst. Securitized	10%	15%	20%	30%	40%
Inst. Restructured	0%	5%	10%	10%	10%
Fibras 1/	0%	5%	5%	10%	10%

1/ Real estate and infrastructure trust

Source: National Commission for the Pension System (CONSAR)

Table 4

Chilean Multi-fund Investment System

Clases de Activos	Fund A	Fund B	Fund C	Fund D	Fund E
Public and Private Company Bonds+Public and Private Company Bonds exchangeable for shares+Tradable Items	60%	60%	60%	60%	60%
Public and Private Company Bonds exchangeable for domestic and foreign shares	30%	30%	10%	10%	3%
Shares of Open Corporations	80%	50%	30%	15%	5%

Source: Pension Superintendency of Chile (SAFP)

Specifically for Mexico⁸, Pension Fund Administrators (AFORES) have a set of funds comprising five different Specialized Retirement Fund Investment Companies (SIEFORES) investing workers' savings according to their age and risk preference via a lifecycle design⁹. The low-risk fund (Siefore Básica 1, SB1) in Mexico's pension system is not authorized to invest in equity. The SB2 has a 15% equity investment limit, while SB3, SB4 and SB5 have higher limits of 20%, 25% and 30%, respectively. In addition, all fund types are allowed to assign all resources to fixed-income.

For Chile¹⁰, the first country to incorporate a multi-fund system in October 2002, the PFA offers the contributor the option to choose from five types of funds, which have different composition in equities: from 5% for lower risk fund to 60% for higher risk fund.

Whatever percentage the pension fund portfolio invested in equity, the funds in both countries were affected by the global crisis, and recorded investment losses. During 2008, Mexican pension funds saw real returns down 6.5%, while Fund C (the Balanced Fund) in Chile recorded a loss of 18.9% over a similar period.

Nonetheless, it is hardly advisable to compare pension fund yields in different countries due to the different methodology used to find this variable. Antolín's study (2009) offers a portfolio reference for making international comparisons.

8: http://serviciodeestudios.bbva.com/KETD/fbin/mult/ETEND_080728_pensiontrends_09_tcm346-176037.pdf?ts=1922010cuentan con mayor edad.

9: This design means pension-saver contributions are exposed to a lower variable rate share the older they get.

10: <http://www.safp.cl/573/propertyvalue-1714.html>

2. Short-term crisis impact and measures

The June 2009 OECD report “Pensions at a Glance” stated that private pension funds contracted 23% in 2008 (US\$5.4 trillion).

The Peruvian PPS was no exception. The international financial crisis had a major impact on the domestic stock exchange, registering a 61.1% fall between May 2008 and February 2009 (See Chart 1). This negative performance impacted pension funds. However, a large part of the reduction in pension fund values was also linked to a fall in fixed-income instrument prices, long term Sovereign Bonds¹¹ (See Chart 2) – assets where PFAs hold a large share. It should be highlighted that before the start of the financial crisis there was an increase in public debt interest rates in a context where the Central Bank of Peru (CB) made consecutive adjustments to its monetary policy benchmark rate¹² in the face of supply shocks affecting domestic food and fuel prices.

Chart 1

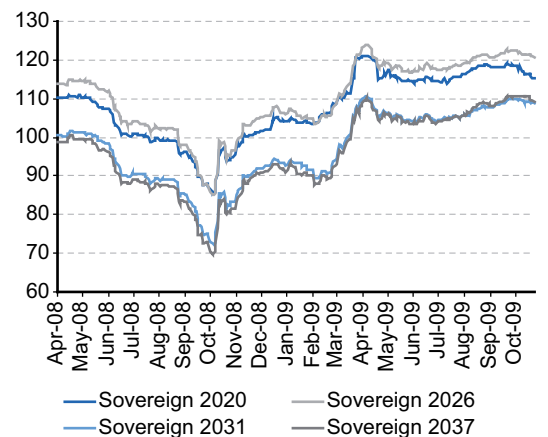
**Peruvian Stock Market
(Lima Stock Exchange, points)**



Source: Lima Stock Exchange (BVL)

Chart 2

Sovereign Bond Price (points)



Source: Bloomberg

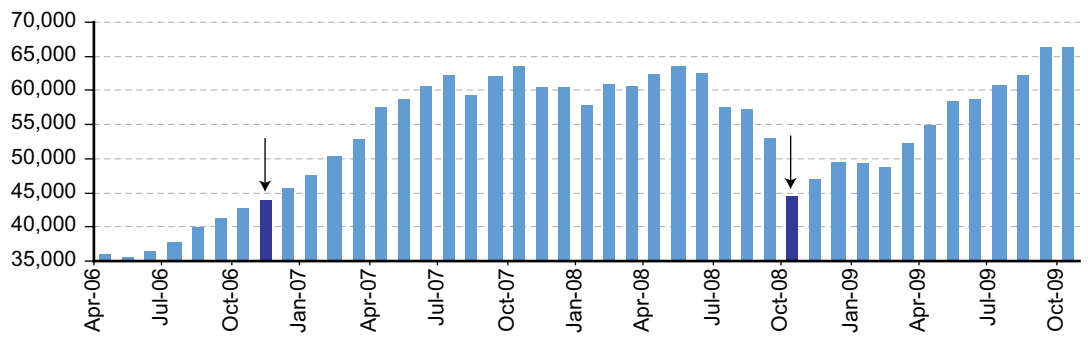
Thus, in October 2008, amid the international financial crisis, the book value for pension funds was similar to that seen two years previous (November 2006), falling to approximately S/. 45 billion¹³ (See Chart 3). Since that month and in line with the recovery seen on the Lima Stock Exchange (BVL) and the increase in Sovereign Bond values issued by the Peruvian government, a positive trend has been registered in pension fund values that in September 2009 surpassed previously recorded levels, reaching a historical high near S/. 67 billion.

11: Domestic currency bonds.

12: The benchmark interest rate had increased by 125 bp in October 2008 in comparison to January the same year, reaching 6.5%, where it remained until January 2009. From then on, the BCR initiated a series of reductions to the present 1.25%.

13: From May to October 2008, the portfolio managed by pension funds fell 30.1%. A year later in October 2009, fund values had recovered and increased by 49.2% to around S/. 67 billion.

Chart 3

Pension Fund

Source: SBS

During the international financial crisis, in order to protect the funds of pensioners and appropriately invest their contributions while simultaneously improving the development of their respective countries, several proposals were developed. They include:

- A project to create a fourth fund which could not invest in variable income assets, instead investing in short-term assets and debt securities which provide stable returns. This would be aimed primarily at workers over 60. The SBS presented the proposal in October 2008.
- The SBS released an announcement in the second half of 2009 regarding the revision of a World Bank proposal to set up a new benchmark parameter for calculating minimum yield. In accordance with Legislative Decree 1008 of the SPP, a minimum yield exists but was basically nullified after the creation of the Multiple Funds Scheme in 2005.
- A Central Bank (CB) proposal to establish a maximum limit between 40 and 50 percent for investments in foreign currencies without coverage made by PFAs, in order to better guarantee appropriate pension levels.

Consequently, some measures were passed during the crisis with long-term impacts requiring proper assessment:

- The creation of two instruments to improve PFA investment in infrastructure: the Infrastructure Fund and Infrastructure Trust. The first was created by the government at the beginning of 2009 with a major contribution from PFAs, while the second was set up by PFAs to invest a minimum of US\$300 million in infrastructure. The impetus behind both instruments is to allow pension funds to be directed towards financing large projects, with appropriate returns and reasonable risk levels, and with both sources of funds contributing to the development of the country's infrastructure.
- The Early Retirement System law was passed for the unemployed in the Private Pensions System. This temporarily allows early retirement (up to December 2012) for contributors over 50 (for women) and 55 (for men) who are unemployed for a year or more.

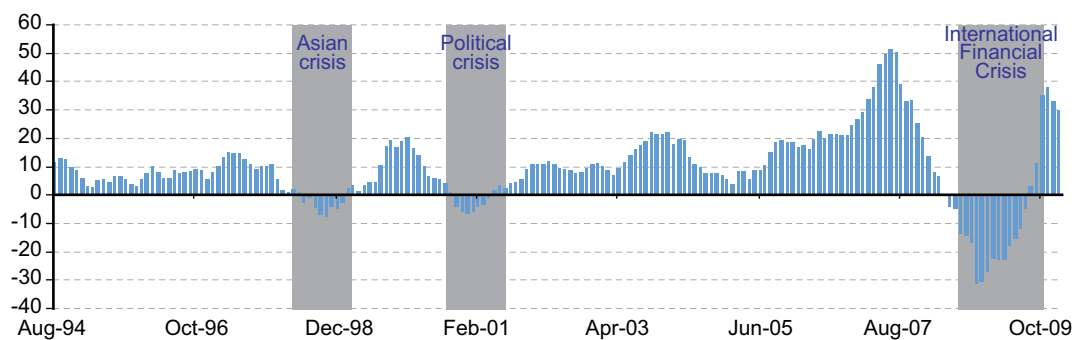
3. Multi-fund returns over a long-term retrospective perspective

Despite the impact of the present crisis and all those in the past that affected pension fund returns, the record for pension fund returns remains positive. The Asian and Russian crises in 1998 affected pension fund returns from June 1998 to January 1999. SBS data (2001) shows that, despite the crisis in late-90s, real average year-over-year yields for pension funds rose to 5.3% between 1993 and 2000. In addition, the political crisis in 2000¹⁴ led to an increase in the national risk level and a decrease in share prices and other equity instruments, leading to a 6.7% fall in real yield for Fund 2 that year.

By fund type, we can see that Fund 2 (See Chart 4) registered real historical yields of 8.8% per year over the last 16 years. This yield increases to 10.1% if the effect of the international crisis is eliminated and only the period between April 1994 and April 2008 is taken into account¹⁵.

Chart 4

Annual real historic return in Fund 2 (Accumulated 12 months, as a percentage)

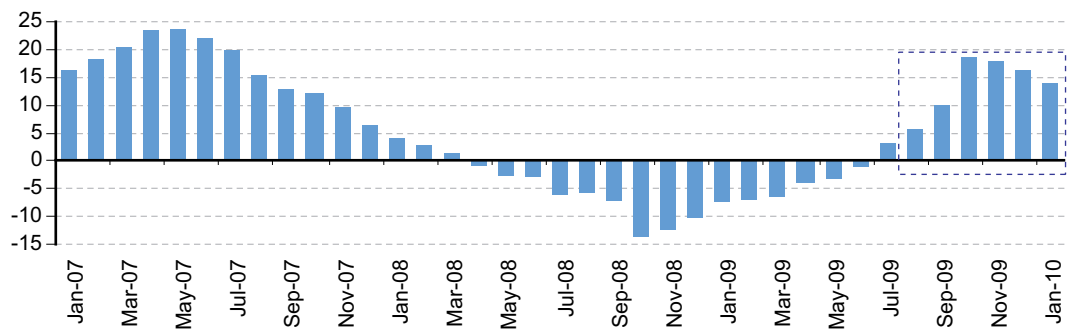


Source: SBS

Real annual yield over the last four years for Fund 1 (See Chart 5) is 6.2%, running to 10.6% from April 2006-April 2008.

Chart 5

Annual real historic return in Fund 1 (Accumulated 12 months, as a percentage)



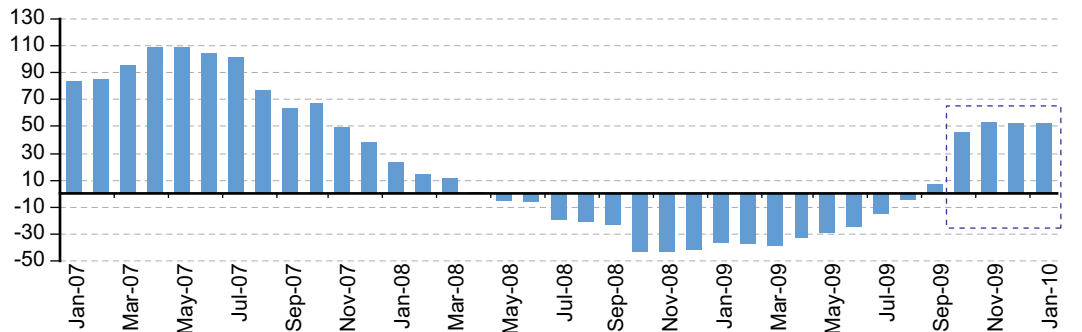
Source: SBS

14: On November 22 that year, Congress passed the declaration of presidential vacancy due to permanent moral incapacity.
15: three fund types recorded their first negative yield in May 2008 due to greater effects of the international financial crisis.

Fund 3, which registered major gains in the period before the crisis¹⁶, has a 21.8% year-over-year yield (See Chart 6), increasing by 45.31% from April 2006-April 2008.

Chart 6

Annual real historic return in Fund 3 (Accumulated 12 months, as a percentage)



Source: SBS

Taking the entire period into consideration, we can conclude that Fund 3 registered greater returns than Fund 1 and Fund 2 (See Table 5).

Table 5

Annual real historic return (Annualized variation, as a percentage)

Fund type	Last 16 years	April 1994-April 2008	Last 4 years	Abril 2006- Abril 2008
Fund type 1	nd	nd	6.2	10.6
Fund type 2	8.8	10.1	10.4	20.6
Fund type 3	nd	nd	21.8	45.3

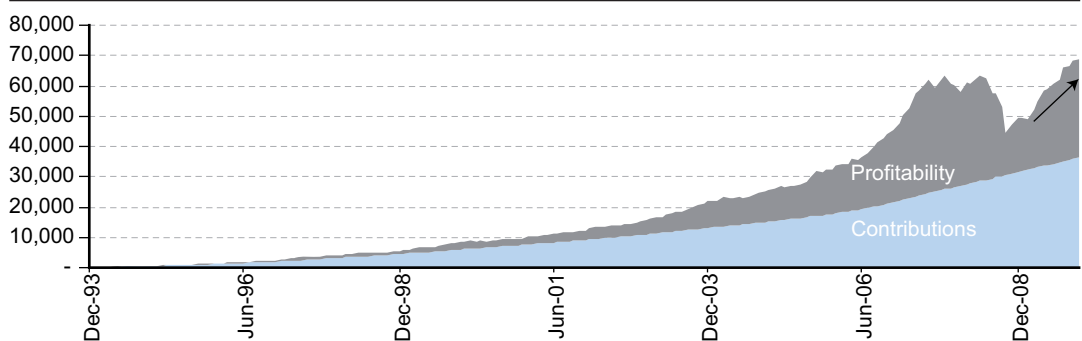
Rentabilidad real anualizada
Source: SBS

Further, fund yields returned to positive terrain after September 2009. In January 2010, Fund 1, 2 and 3 registered real annual yields of 13.8%, 30.1% and 52.1%, respectively.

Finally, pension fund values have continually increased since they were established. In December 2009, contributions and yields represented 53% and 47% of the total managed by PFAs, respectively; this shows that the high yield levels in recent months mean the losses recorded due to the crisis have been recovered and, over a more extended timeline, show a positive trend.

Chart 7

Pension Fund Returns and Contributions (Millions of soles, Dec. 1993-Dec. 2009)



Source: SBS, October 2009

16: Related to the high growth in the Lima Stock Exchange (BVL) in 2006 and 2007. This stock was the most profitable market in the world in 2006.

4. Multi-fund returns in a long-term perspective

Despite the figures that show historically positive PFA returns for pension-saver, the same trend may not necessarily continue in the future. In this sense, past pension fund returns are not a guarantee of future performance. Any random events, such as the recent crisis, may occur and negatively affect financial asset yields and, therefore, pension fund portfolios.

Due to this, future pension fund investment appraisal has to take into account a variety of different scenarios covering possible price performance for the different asset types that compose the portfolios of each fund in the investment system.

One way of presenting possible scenarios on future price performance for financial assets is to carry out simulation exercises. This document, therefore, uses the Monte Carlo Simulation technique to project prices for the main asset types: fixed-income and equities with investment timelines ranging from 1 to 50 years.¹⁷

4.1. Model for the long-term dynamics of financial asset prices

These exercises offer asset price simulations for fixed-income and equities to model as random variables using a multiplication method with the following general characteristics:¹⁸

$$P_T = P_0 e^{gT}$$

The model indicates that the price of a financial asset at time $t = T$ is equal to the price of the asset at the time $t = 0$ increased exponentially at rate “g” over a T-year horizon.

As a result, the behavior of the price of the asset depends on the behavior of “g”. One widely used hypothesis in the financial sector for the possible behavior of “g” is that it behaves as a random variable (r.v.) with a normal probability distribution and constant average and variance.

The relevance of “g” being a r.v. and having a normal probability distribution is that when we take the logarithm of the financial asset prices they also behave as a r.v., but with a lognormal probability distribution. This lognormal distribution makes it possible to capture at least three important characteristics of financial asset prices:

1. Prices are always positive.
2. At all points in time, prices are uncertain since they are affected by the variance of “g”. However, when the variance has the value “zero”, there is a determinist model for the price of a fixed-income asset where the interest rate is determined a priori for a particular term, as occurs in the case of “zero coupon” bonds.
3. In short timescales, price changes are continuous.

¹⁷: The Monte Carlo simulation is an algorithm that carries out repeated random sampling of securities that are then used as the input in a performance equation for an interest variable.

¹⁸: An alternative way of specifying the asset price model would be additive. However, a specification of this type would not lead to a lognormal distribution for asset prices which, as we mention later, enables us to capture various relevant characteristics. For more details of these alternative specifications and their limitations, see Luenberger (1998).

In the multiplicative model mentioned, the value of “g” is obtained by applying logarithms on both sides of the equation:

$$\begin{aligned} \ln(P_t) &= \ln(P_0) + gT \\ \ln\left(\frac{P_T}{P_0}\right) &= gT \\ g &= \left(\frac{1}{T}\right) \ln\left(\frac{P_T}{P_0}\right) \end{aligned}$$

The rate “g” is therefore an annualized rate of return over a timeline from zero to T. In this context, “gT” may be interpreted as an accumulated growth rate which also has a normal probability distribution.

According to a number of researchers, such as Luenberger (1998) and Hull (2008), the variable “gT” follows a stochastic pattern described as Geometric Brownian Motion (GBM) or the Wiener process “dz”.

Under this hypothesis, any random variable “x” exhibits a dynamic over time given by a stochastic differential equation of the type:

$$dx_t = vdt + \sigma dz_t$$

Where:

$$dz_t = \varepsilon_t \sqrt{dt}$$

With:

$$\varepsilon_t \sim N(0,1)$$

This stochastic equation has an analytical solution given by the equation:

$$x_t = vt + \sigma dz_t$$

Therefore, under the GBM hypothesis for “gT”, prices would behave as follows:

$$P_T = P_0 e^{vT + \sigma dz}$$

Where “gT” is distributed as a normal r.v. with constant average and variance:

$$gT \sim N(vT, \sigma^2 T)$$

The change over time in the asset price behaves as follows:

$$\ln\left(\frac{P_T}{P_0}\right) = vt + \sigma dz_t$$

$$d\ln(P_t) = vt + \sigma dz_t$$

This behavior could be expressed equivalently in terms of P (t) as follows:

$$\left(\frac{dP_t}{P_t}\right) = \mu dt + \sigma dz_t \quad \text{where } \mu = v + \frac{1}{2} \sigma^2$$

Following Luenberger (1998), the previous stochastic process for the price of a financial asset may in turn be extended to the case of an asset in a portfolio with n assets, in such a way that the price of the i-th asset where i=1, 2, 3,...n is given by a behavioral equation as follows:

$$\left(\frac{dP_i}{P_i}\right) = \mu dt + \sigma dz_t$$

With covariance:

$$\text{Cov}(dz_i, dz_j) = \sigma_{ij} dt,$$

Based on the above, the change in price for each asset i , at any instance in time t , has a lognormal probability distribution with an expected value and variance given by the following equations, respectively:

$$E\left[\ln\left(\frac{dP_i(t)}{P_i(0)}\right)\right] = vt \left(\mu_i - \frac{1}{2} \sigma\right)t$$

$$\text{Var}\left[\ln\left(\frac{dP_i(t)}{P_i(0)}\right)\right] = \sigma_i^2 t$$

A portfolio with “ n ” assets is built by assigning a weight $w(i)$ to each asset $i=1, 2, 3, \dots, n$ where the sum of all the weights $w(i)$ is equal to 1. As a result, the instantaneous rate of change of a value in a portfolio V is given by the equation:

$$\frac{dV}{V} = \sum_{i=1}^n w_i \frac{dP_i}{P_i} = \sum_{i=1}^n w_i \mu_i dt + w_i \sigma dz_t$$

Where the variance in the stochastic term $dz(t)$ is given by:

$$E\left(\sum_{i=1}^n w_i dz_t\right)^2 = E\left(\sum_{i=1}^n w_i dz_t\right) E\left(\sum_{j=1}^n w_j dz_t\right) = \sum_{i,j=1}^n w_i w_j \sigma_{ij} dt$$

Therefore, for a lognormal portfolio $V(t)$, the expected value of its return and its variance are given by the following equations:

$$E\left[\ln\left(\frac{dV}{V}\right)\right] = vt = \sum_{i=1}^n w_i \mu_i t - \frac{1}{2} \sum_{i,j=1}^n w_i w_j \sigma_{ij} t$$

$$\sigma^2(t) = vt = \sum_{i,j=1}^n w_i w_j \sigma_{ij} t$$

Where “ v ” gives the annualized growth rate of the portfolio’s value and is a function of the assignment of assets through the $w(i)$.

$$v = \frac{1}{t} E\left[\ln\left(\frac{dV}{V}\right)\right]$$

Furthermore, it should be stated that if the aforementioned model makes it possible to capture the individual behavior of some fixed-income instruments, in this study it was decided to build an index or weighted average of interest rates with different maturity terms, which was weighted by the share each has of fixed-income instruments in the PFA investment portfolio.

However, producing an interest rate index also requires simulation of the behavior of the interest rate curve over time. In order to do this, a working hypothesis was used where the prices of fixed-income assets over differing terms are proportional to the prices of short-term instruments, and that all the volatility in the prices comes from the volatility of the short-term instruments.

A functional form which is compatible with the above is given by the Ornstein-Uhlenbeck behavior equation for short-term rates $r(t)$ cited by Vasicek (1977), which is specified as:

$$dr = \alpha (\gamma - r)dt + \sigma dz$$

with $\alpha > 0$

It should be noted that this equation contrasts with the Wiener process used in modeling equity, as it defines stationary behavior for the r.v. As a result, in this equation the term “ $(\gamma-r)$ ” represents a force which takes the process towards its average long-term value gamma “ γ ”. The value of alpha “ α ” is known as the velocity of regression to the average.

Vasicek (1977) demonstrated that it is possible to construct an interest rate curve for different terms based on the Ornstein-Uhlenbeck equation by calculating prices for “zero coupon” bonds using equations which are only dependent on the alpha and gamma parameters.

Vasicek’s starting point is that the performance of any bond at time t and with maturity of T is given by an internal rate of return in t , which is an inverse function of its price.

$$R(t, T) = -\frac{1}{t} \ln(P(t, t+T)) \quad \text{with } T > 0$$

Based on the above, the short-term interest rate is defined as an instantaneous rate when t tends to zero.

$$r(t, T) = R(t, 0) = \lim_{T \rightarrow 0} R(t, T)$$

Vasicek demonstrated that the price of a bond with a maturity of T is given by a specific functional form:

$$P(t, T, r) = \exp\left[-\frac{1}{\alpha} (1 - e^{-\alpha(T-t)})(R(\infty) - r) - (T-t)R(\infty) - \frac{\sigma^2}{4\alpha^3} (1 - e^{-\alpha(T-t)})^2\right] \quad \text{with } t \leq T$$

Where, R(∞) represents the performance on maturity of a bond with a very long term (when T tends to infinity).

$$R(\infty) = \gamma + \frac{\sigma}{\alpha} - \frac{1}{2} \frac{\sigma^2}{\alpha^2}$$

Based on these equations, Vasicek demonstrated that the interest rate structure for different terms can be calculated using the following equation:

$$R(t, T) = R(\infty) + (r(t) - R(\infty)) \frac{1}{\alpha T} (1 - e^{-\alpha T}) + \frac{\sigma^2}{4\alpha^3 T} (1 - e^{-\alpha T})^2 \quad \text{with } T \geq 0$$

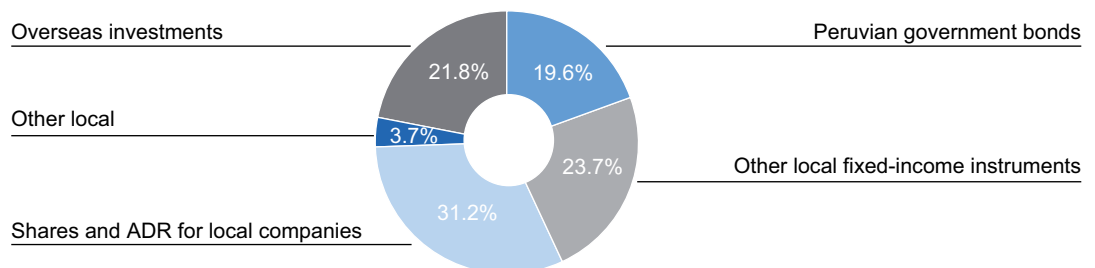
4.2. The choice of representative variables for financial assets

One of the main elements in these exercises is the choice of appropriate financial variables to simulate pension fund returns over a timeline of 1 to 50 years. We need the chosen variable to reflect asset performance for PFA investments for this to be successful, as well as a series of sample data contributing to guaranteeing higher confidence in the performed simulations.

Peruvian PFAs mainly invest in two asset types: fixed-income and equities (See Chart 8). In this way, the simulations aim to reproduce the yields for the representative instruments for both assets.

Chart 8

Managed portfolio composition (As a percentage, December 2009)



Fuente: BCRP, octubre 2009

As of December 2009, PFAs placed investments in government bonds (19.6% of the total managed fund) and other fixed-income instruments from financial and non-financial companies (23.7%) for fixed-income. Bearing in mind that the PFA have more than one instrument for making fixed-income investments, it would be wise for the representative variable to be given by a weighted yield index based on the share of each of these instruments in the PFA fixed-income portfolio. The variations in this index would give the performance of this investment type. However, there are some disadvantages in the use of the above indicator:

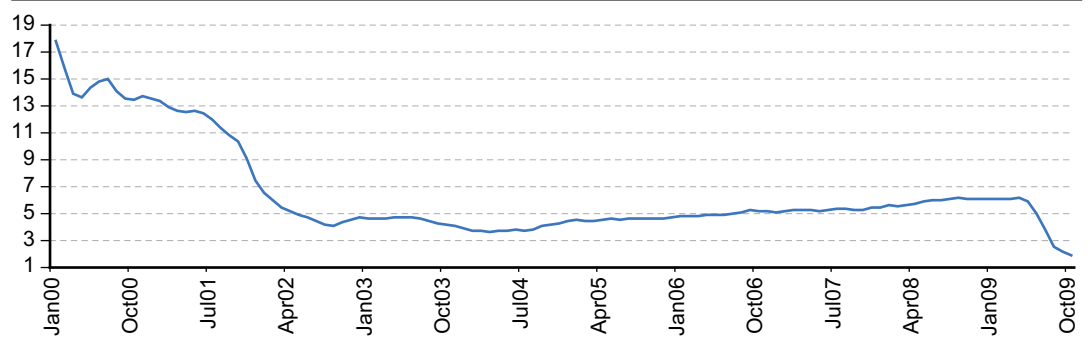
- a. The SBS has provided information on the managed portfolio by issuer instrument type since August 2002. The Peruvian SPP began in August 1993 meaning that this information is not available for around ten years. In addition, these data are published every four months, making monthly monitoring of the fixed-income indicator even more difficult.

- b. The SBS data published does not provide the details for bonds purchased by the PFAs. Only the issuer is provided, with no mention of the security type, amount or bond placing rate. These specifics are provided for government-issued sovereign bonds, available via the Ministry of Economy and Finance, with the main holders by maturity of the sovereign bond being recorded on its website. However, these details are not given for fixed-income issuances made by companies.
- c. Fixed-income instruments where PFAs make investments have different maturity terms and most exceed 5 years. As stated in the first part of this section, in order to carry out fixed-income simulations we need to have a benchmark short-term instrument.

Moving on from these obstacles, this is why the Certificates of Deposit from the Central Bank (CDR) issued for a maturity term under 3 years is seen as an ideal asset for these calculations, because it is a short-term instrument and for its series and frequency length. The CB has issued these securities since June 1992, but we consider it more convenient to work with the series from January 2002, since from this period there is price stability¹⁸ and greater financial solidity.

Chart 9

Interest Rates of Certificates of Deposit of the Central Bank 2000-2009 (%)



Source: Central Bank, October 2009

It is advisable to use the Peru Exchange Traded Fund¹⁹ for equities comprising a basket of the 25 heaviest-weighted stocks on the Lima Stock Exchange. However, publication of this index is a recent occurrence and we only have data since June 2009, which means the sample will not be significant. A reconstruction of the index was performed to overcome this disadvantage, although it could only be replicated back to 2002 since this is when the most heavily weighted stocks began listing. This sample period is sufficient to carry out the equity indicator simulations since the analysis period will be the last seven years, excluding the performance of stocks listed on the domestic stock market before 2002.

18: The BCR has followed an inflation targeting scheme since 2002. The announcement and systematic compliance with this target allows public inflation forecasts to be pegged at this level.

19: Called All Peru Capped Index Fund operating under the exchange sign EPU.

Faced with this limitation, we decided to work with the BVL General Index (IGBVL) which shows the listing trends for the main stocks listed on the Lima Stock Exchange based on a current portfolio²⁰, represented by the most liquid stocks on the market. Although there are other equity indicators such as the Selective BVL Index (ISBVL) and the National Capitalization Index (INCA), the IGBVL has major advantages over these indexes:

- a. It represents the 32 most traded or liquid stocks on the market, while the ISBVL only groups the top 15 listings. In turn, the INCA comprises the 20 most liquid stocks listed on the exchange, whose importance level is directly linked to market capitalization. The IGBVL is the widest index and, covers 32 stocks, includes a large percentage of stocks comprising the other mentioned indices.
- b. The IGBVL is the oldest domestic stock exchange and has records dating from February 1990 while the ISBVL has been calculated since July 1993. The INCA is more recent and data is only available since June 2007.
- c. Furthermore, the performance of most stock investments made by PFAs are included on the IGBVL. In this sense, 21 of the 32 stocks listed on this index are part of pension fund portfolios.

In turn, so as to adjust growth rates in pension fund portfolios for inflation for different future timelines and thus obtain real yields, an annual inflation rate of 1.5% was taken as a base. This is in line with the long-term CB inflation target of reaching 2% inflation in a range of +/- one percentage point.

4.3. Simulation results

The results of the 250 simulation exercises forecasting returns for pension-savers and their volatility according to the fund type are given in this section. This is done sequentially. The first stage develops the simulation exercises based on fixed-income and equity instruments separately. Then, these exercises are used to construct a portfolio comprising both instruments, receiving a weighting that varies according to fund type.

a. Fixed-income

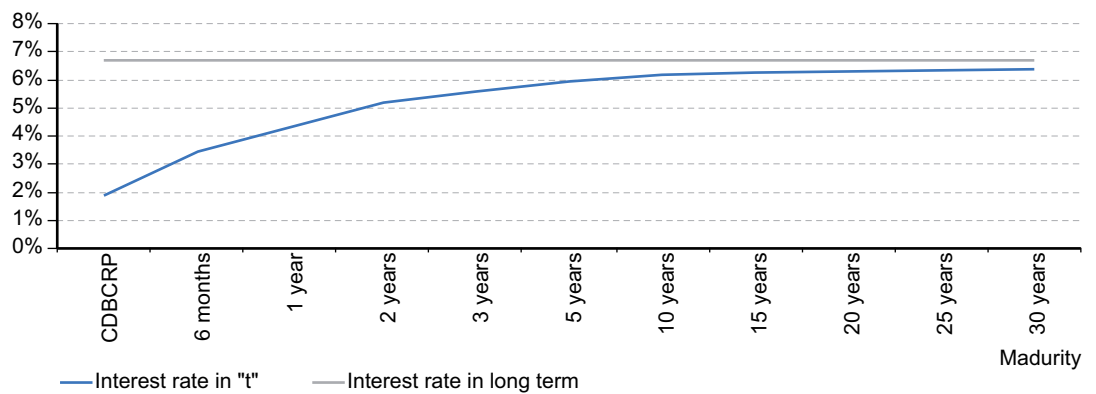
For fixed-income assets, the methodology used by Vasicek makes it possible to simulate the behavior of CDR interest rates and to use this to produce an interest rate curve for each point in time. Chart 10 shows the average regression, implicit in the Ornstein-Uhlenbeck equation, confirming that as the investment timeline increases, interest rates converge towards the long-term level, which for the Peruvian economy comes in at 6.7%²¹.

20: A new portfolio was established after January 4, 2010. Portfolio updates are performed every six months, in January and July.

21: This growth rate is based on the long-term growth rate of 5.2% and an estimated inflation rate of 1.5% (the average for the BCR target range).

Chart 10

Interest rate (Fixed-income)
Simulation of 250 scenarios for timelines from 1 to 50 years (600 months)

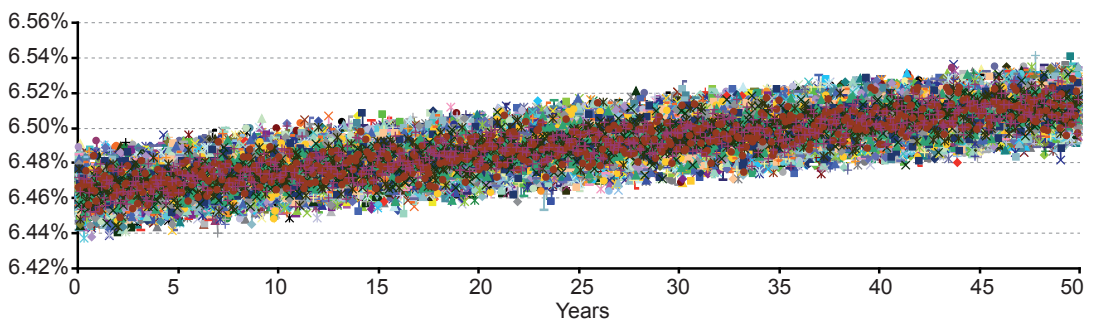


Source: Bloomberg. Elaborated by: BBVA ERD

The above curve makes it possible to calculate the average weighted interest rate for fixed-income instruments (See Chart 11). The results show an interest rate range for each investment timeline.

Chart 11

Interest rate (Fixed-income)
Simulation of 250 scenarios for timelines from 1 to 50 years (600 months)



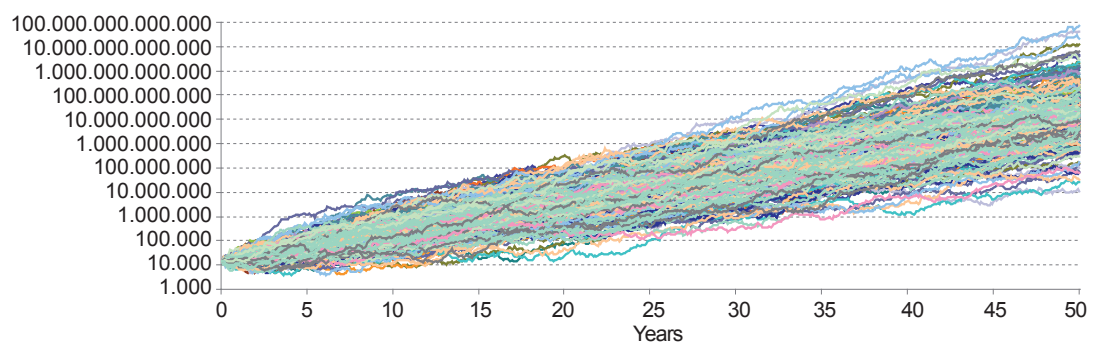
Source: Bloomberg. Elaborated by: BBVA ERD

b. Equity

Taking into account the theoretical framework, it is to be expected that the multiplication model used to simulate equity asset performance produces random paths, which show a wide range of possible yields. In this way, accelerated growth can be seen linked to an upward trend in equity asset performance (See Chart 12).

Chart 12

IGBVL performance (Equity)
Simulation of 250 scenarios for timelines from 1 to 50 years (600 months)



Source: Bloomberg. Elaborated by: BBVA ERD

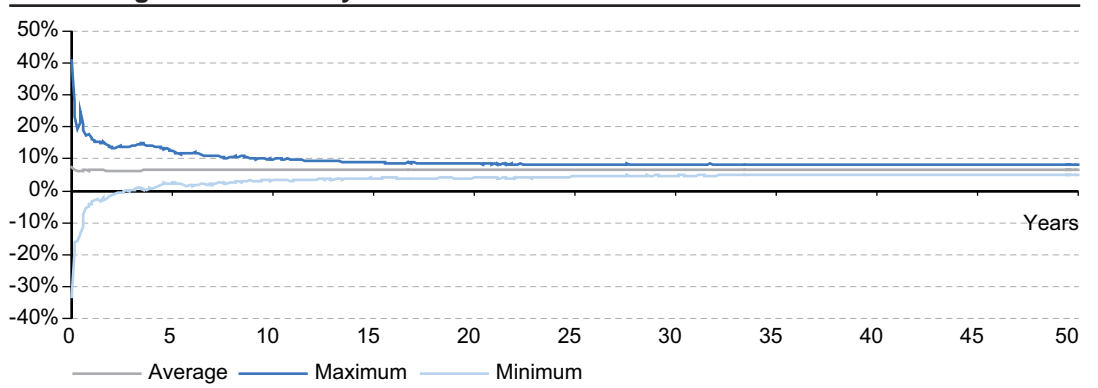
c. Results

After concluding the corresponding simulations, both for fixed-income and equity assets, the next step comprises putting together a portfolio simulation including both assets, giving different weights to each as per the projected fund type. In this way, the portfolio of Fund 1 receives a 10% equity weighting and a 90% to fixed-income weighting, since this is the most conservative fund in the system. In Fund 2, 45% of the funds are assigned to equities, while Fund 3 invests 80% of the total managed portfolio in this asset class.

The results from the 250 simulations for each fund type over the analysis period show that, on average, the real annual yield for Fund 1 is 6.5% (See Chart 13) while that of Fund 2 and Fund 3 reach 12.5% and 22.9%, respectively (See Charts 14 and 15). These yields are in line with real historical performances seen by the three fund types that are published by the SBS. As stated in section 3, these performances come in at 6.2%, 8.8% and 21.8% for Fund 1, 2 and 3, respectively.

Chart 13

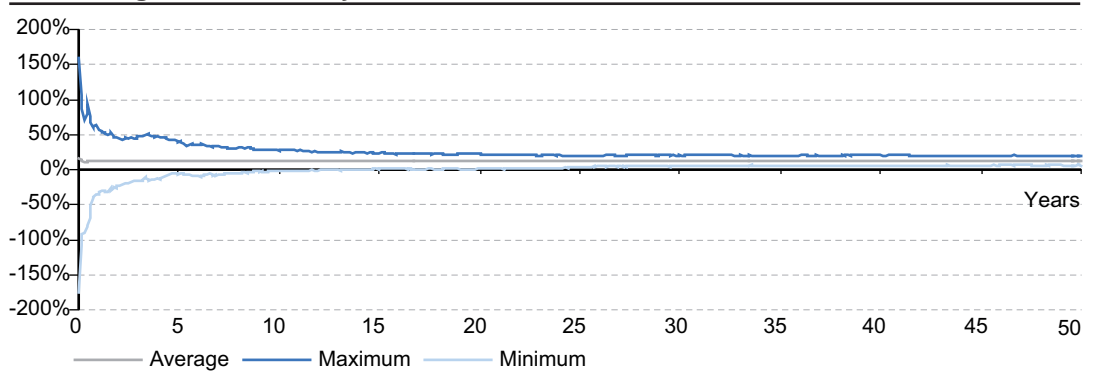
Type 1 Fund Profitability for each timeline
% annual growth rate in T-years



Source: Prepared by BBVA ERD based on Bloomberg data

Chart 14

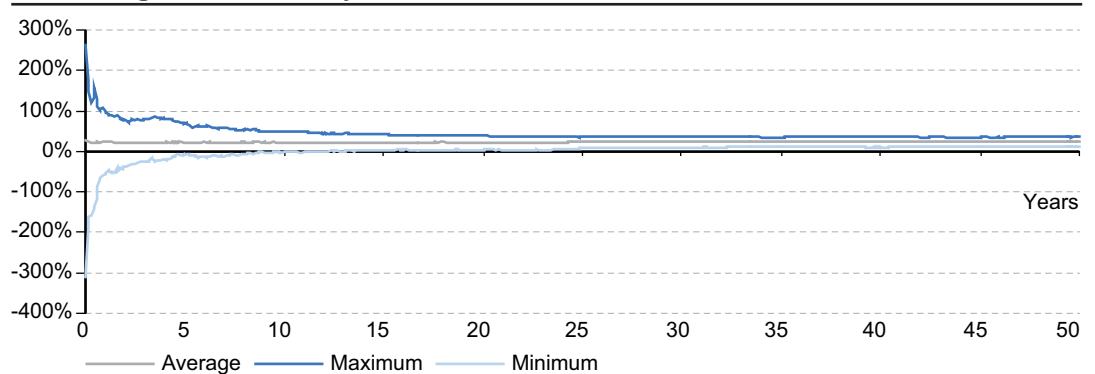
Type 2 Fund Profitability for each timeline
% annual growth rate in T-years



Source: Prepared by BBVA ERD based on Bloomberg data

Chart 15

Type 3 Fund Profitability for each timeline
% annual growth rate in T-years



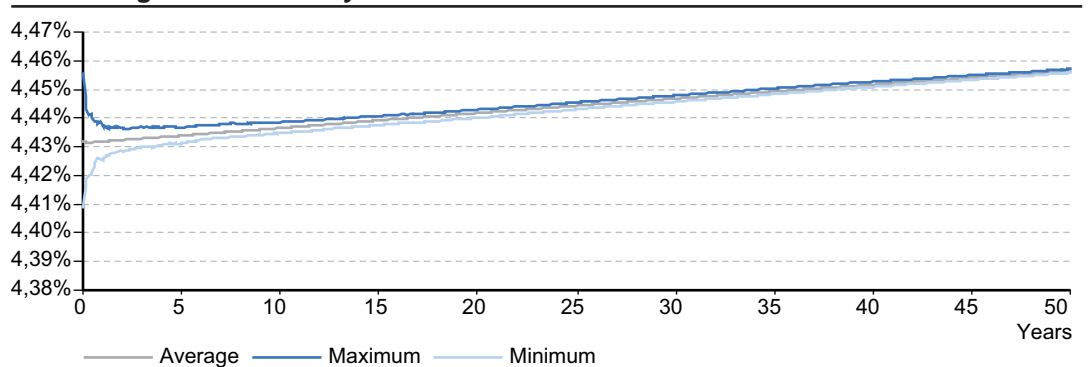
Source: Prepared by BBVA ERD based on Bloomberg data

The simulation results shown here lead us to conclude that, despite the temporary shocks that could present themselves, real pension fund returns are historically positive. Other studies, such as D’Addio et al (2009), show similar results. In this way, based on information from over 25 years of stock and bond performance in a group of OECD countries, real pension fund yields were simulated for a period running over 45 years. The results show that the real average return is 7.3% for each balanced portfolio (same percentage in stock and bonds). This increases to 8.9% for a portfolio investing entirely in equity and falls to 5.2% for a portfolio investing entirely in bonds.

Finally, an additional simulation exercise is based on the SBS proposal at the end of 2008. This is the creation of a Type 4 Pension Fund, in addition to those already in operation, which is aimed at pensioners over 60, where all investments are in fixed-income and offers increased protection for those nearing retirement. As analyzed in a recent OECD study (2009), those close to retirement were more affected by both crises (economic and financial) among the pension-saver groups. In this way, mechanisms offering coverage for these shocks are required. One alternative would be the implementation of the Type 4 Fund which would stabilize portfolio profitability (See Chart 16) and greatly reduce associated volatility.

Chart 16

Fund 4 Profitability for each timeline
% annual growth rate in T-years



Source: Prepared by BBVA ERD based on Bloomberg data

5. Conclusions

The highly volatile international environment, like the one recently experienced by the global economy, severely affected financial systems, and pension funds were not immune to these ups and downs. For over a year, from April 2008 to July 2009, pension funds in the Peruvian Private Pensions System experienced profit losses that opened up wide debates. However, these losses were temporary and recovered significantly in recent months, with pension funds expanding in an upward trend. The analysis and simulation exercises in this study show that it is possible to draw certain conclusions.

Regardless of the pension plan and investment system followed by management companies in the pension system, the financial crisis had a major, negative effect on contributor's pensions. Nonetheless, random shocks, like the one we recently experienced, are temporary blips that, although they affect investments made in domestic and overseas financial markets, their effects are diluted over a longer timeline.

Secondly, the Peruvian PPS investment system has performed favorably since December 2005 with three fund types offering contributors different risk and return profiles. Fund 1 withstood the crisis best due to its low exposure to equities (10% maximum), affording older pension-savers and those near retirement adequate resources in unstable times.

In this context, and as per the simulation exercise results in the last section, positive returns can be seen for the three fund types over a 50-year timeline. As is to be expected, Fund 3 shows relatively higher performance to those seen in the Conservative and Balanced Funds due to its higher equity weighting, although this translates into greater volatility.

These exercises are useful because they simulate different scenarios, such as the recent financial crisis, providing results that are more valid and solid. We can see that pension fund yields over 50 years run close to 6.2% for the low-risk fund, 8.8% for Fund 2 and 21.8% for Fund 3. In this sense, despite the inherent volatility of stock markets and, to a lesser extent, the volatility associated with fixed-income instruments and the impact these fluctuations may have on pension fund performances, returns are affected in the short-term, but in the long-term their expansion is solid.

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