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How the use of Markov-Switching Sharpe Ratios can improve Mexican Pension Funds Investment Decisions

Cómo el uso de Razones de Sharpe cambiantes según un proceso de Markov puede mejorar las decisiones de inversión de los portafolios de pensiones mexicanos

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ABSTRACT

Towards the end of the 20th century, as part of the encompassing structural reforms that modernized the Mexican economy after decades of an obsolete imports-substitution model, overregulated economic sectors, and state-controlled productive sectors, the creation of an individual savings account pension system to replace the "pay-as-you-go" anachronic pension system prevalent since 1943, was necessary given the country's demographic trends.

The analysis presented in this paper uses a Markov-switching model to obtain the Sharpe ratio of different SIEFOREs portfolios for different subperiods and volatility regimes (normal and crisis). The results confirm that not all SIEFOREs are good (or bad)

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performers all the time. This evidence suggests that awareness of market conditions conveys information that can support rational decisions about when to change savings from SIEFOREs that are good performers during normal times to good performers during crisis periods. While these are preliminary findings, they represent a stating point for further analyses that should contribute to improved savers' decisions.

JEL Classification: C22. D81, G11, H55

Keywords: *Markov-Switching models, Sharpe ratio, Pension funds, Informed decision, Portfolio selection.*

Resumen

Hacia finales del siglo XX, como parte de las reformas estructurales que modernizaron la economía mexicana después de decenios de un modelo obsoleto de sustitución de importaciones, de sectores económicos sobre-regulados y sectores productivos controlados por el Estado, la creación de un sistema de cuentas de ahorro individual para reemplazar el sistema de pensiones "pay-as-you-go" prevalente desde 1943, resultó esencial en vista de las tendencias demográficas del país.

El análisis presentado en este documento hace uso de un modelo Markov-Switching para obtener la razón Sharpe de diferentes portafolios de SIEFOREs, para diferentes subperíodos y regímenes de volailidad (normal y crisis). Los resultados confirman que no todas los SIEFOREs se desempeñan bien (o mal) todo el tiempo. Esta evidencia sugiere que el conocimiento de las condiciones del mercado proporciona información que puede sustentar decisiones racionales sobre el momento adecuado para cambiar los ahorros de las SIEFORES que ofrecen buenos rendimientos durante tiempos normales a las que ofrecen buenos resultados durante períodos de crisis. Si bien se trata de hallazgos preliminares, abren la puerta a nuevos análisis que deberían contribuir a mejorar las decisión que toman los ahorradores.

Classificación JEL: C22. D81, G11, H55

Palabras clave: cambio de régimen con modelos de Markov, razón de Sharpe ratio, fondos de pensión, decisiones informadas, selección de portafolios de inversión.

Introduction

During the last three decades of the 20th century, the Mexican economy experienced significant structural reforms. There was a complete overhaul of the state-owned productive sector during the 1980s, that reduced its direct participation in the production of goods and services; the economy was opened to foreign trade and investment (Mexico joined the General Agreement on Trade and Tariffs in 1985); and, there was an encompassing deregulation and privatization of different economic sectors

(transportation, mining, communications, etc.). These structural reforms, aimed to the modernization of the economy, faced severe headwinds due to the collapse of oil prices at a time when exports of that product represented a large percentage of Mexican Exports (80% in 1982) and a very significant component of the government tax revenues (30 %), in addition to a devastating earthquake in Mexico City and other nearby cities which destroyed critical urban infrastructure, added to the environmental uncertainty and resulted in very high inflation and very slow economic growth.

During the last decade of the 20th century the government realized that the traditional pay-as-you-go pension system faced an increasing long-term sustainability challenge due to changing demographics. The demographic growth rate had decreased from 3.5% annually during the 1960s to 2.4% by the early 1980s, 2% at the beginning of the 1990s, and only 1.5% in the first years of the 21st century.[1] Without a major reform, an increasingly smaller base of contributors would support a larger aging population. That is, as the base of the pyramid was shrinking in size, it was gradually being transformed into an "inverted" demographic pyramid.

After careful analysis of the different alternatives to face that challenge, the Mexican government opted for a system similar to Chilean pension scheme developed during the 1980s, based on individual savings accounts for workers, and managed by private entities. In 1997, the Mexican government took a step forward to reorient the pension system, beginning a transition from a non-funded, defined benefit pensions system, towards a defined contribution system in which the workers, the Mexican government, and the employer make monthly contributions to a individual retirement savings accounts. These resources are invested in different assets, and these along with market returns obtained are continuously reinvested until retirement. The vehicle through which these portfolios are managed, is known as SIEFOREs. This paper explores what would be the implications of having better informed decision-makers who advise Mexican workers on who to use SIEFOREs. To achieve this goal, a quantitative method that evaluates the performance of SIEFOREs during periods of relative stability and compares it to periods of high volatility is proposed.

Several research document the benefits and the hurdles attributable to private pension systems. Calderón-Colín, Domínguez and Schwartz (2009),

[1] Source: http://www.worldometers.info/world-population/mexico-population/

Martínez and Martínez (2014), Alonso, Hoyo and Tuesta (2014), De la Torre, Galeana and Aguilasocho (2015) and De la Torre, Galeana and Martínez (2015) address both, the macroeconomic and microeconomic consequences of private pension systems in different contexts and periods.

Calderón-Colín, Domínguez and Schwartz (2009) suggest that future pensioners select a SIEFORE subject to confusion, due to the noisy information they receive, and prove that the selection of SIEFORE is a response to non-related to performance factors, such as management companies expenditure in marketing,[2] the fact that funds are managed by a well known financial group or insurance company, and the number of sales representatives that these companies employ. In sharp contrast to a market where investors benefit from the competition among suppliers of services, the increasing number of competitors in the Mexican pension funds industry has had a limited impact in the reduction of financial costs to savers.

Currently, the only performance measure published by the industry's supervisor, the CONSAR,[3] is the percentage variation of the stock value of each SIEFORE, and accordingly, investors have very limited information to choose among different SIEFOREs. That information does not reveal the quality of SIEFOREs' management nor how much risk is undertaken by their portfolios during periods of high and low volatility. So, there is a clear need for more detailed information about SIEFOREs' performance, management and riskiness, which should also be accompanied by an improved financial education of the population. Otherwise, the objective to empower citizens and let them take control of their pension fund savings is not likely to be attained. Better educated and better informed savers would allocate their savings to the best performing SIEFOREs, enhancing the demand elasticity for their services, and represent an important motivation for SIEFOREs' managers to continuously improve their performance (reduce their costs and reduce their fees), resulting in better pensions for the population.

This paper contributes to a better understanding of the characteristics of the industry that can enhance the long-term benefits enjoyed by future pensioners by studying the performance of SIEFOREs during periods of

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2 The acronym for the Mexican asset management company of a SIEFORE: Administradora de Fondos para el Retiro, AFORE. It is literally translated as "Retirement fund management company".

3 The acronym of Mexican regulatory entity for the Mexican pension system, specially for the supervision and regulation of SIEFORE: Comisión Nacional del Sistema del Ahorro para el Retiro or "National Retirement Savings Commission".

stability (normal periods) and periods of high volatility (crisis periods), with the use of Markov Switching econometric model that confirms that not all SIEFOREs are good (or bad) performes all the time. Good performers during normal periods are not so during periods of exacerbated turbulence and vice-versa. Market conditions convey information that can support rational decisions (when to change from one SIEFORE to another), to minimize risk and maximize returns.

The following section presents a brief literature review on Private Pension Fund Systems, with an emphasis on the recent evolution of the AFOREs/ SIEFOREs system in Mexico. Section 1 presents a review of the literature on private pension fund systems, Section 2 introduces and describes the SIEFOREs mechanism and its recent evolution. Section 3 presents the performance evaluation methodology proposal, and the performance evaluation results. Finally, the last section concludes the analysis, summarizes the findings and suggests some guidelines on how decisions makers may improve the SIEFOREs system considering an information availability perspective.

1. A brief review of the literature on private pension funds systems

While the literature on pension systems in different parts of the world is extensive, this research is focused on Latin American defined benefit pension fund systems.

Albo *et al*. (2007) make actuarial projections to estimate the replacement rate and financial perspectives of Mexico's 1997 new pension system. Their methodology and results later inspired the studies of Alonso, Hoyo and Tuesta (2014)limited the growing fiscal cost of the previous pay-as-you-go scheme. Sixteen years on from its creation, the Retirement Savings System (SAR, who improved the analysis by incorporating the impact of educational levels in Mexico.[4]

Following Albo *et al*. (2007), Fuentes *et al*. (2010) make another review to the reforms to the Mexican pension system and talk about the fiscal benefits that the new system brought. While the various reforms implemented since 1997 had different fiscal and economic benefits, they reiterate the need to increase the replacement rate to attain international standards, and to

[4] Specifically the financial education of the Mexican people.

introduce a universal pension system with portable rights across pension systems.

By focusing in the competitiveness of the pension fund management process in Mexico and other Latin American countries (Chile, Colombia, Costa Rica, El Salvador, Peru and Uruguay), Guillén (2011) uses Data Envelopment Analysis (DEA) to study the relative and absolute competitiveness of pension fund managers in those countries. He also performs a regression analysis with OLS, with fixed parameters and fixed time and country factors. The reported findings suggest that the Mexican case has an acceptable relation between its relative and absolute competitiveness, but policy makers must make legal improvements to enhance competitiveness.[5] His results lead to the conclusion that even when pension funds could have an influence in financial markets given their relative size, they are exposed to systemic risks. Therefore, a more intense competition among SIEFOREs could lead them to achieve better performance and to reduce their exposure to financial markets' volatility.

Alonso *et al*. (2014), followed the steps of Albo *et. al*. (2007) and extend the latter by incorporating the "educational dimension". Their results suggest that, in order to increase the replacement rate and obtain better retirement conditions for individuals, the Mexican government should increase the whole mandatory contribution from 6.5% to 11.5% in 2017. If this happened, they suggest that the fiscal impact of pension payment could be reduced by 2.9% every year. They also suggest a periodically adjusted contribution system, (i.e., to change the total contribution), in response to changing economic conditions, and the creation of a single government-sponsored manager of pension funds. Finally, they argue, independent workers should be allowed to contribute for their retirement. This study is, by the lenght and depth of its proposals, a major contribution to the literature on modern pension fund systems.

Martínez-Preece and Venegas-Martínez (2014) study the performance of the Type 1 and Type 2 SIEFOREs with an equally weighted performance benchmark of each SIEFORE Type,[6] using ARIMA-GARCH models. They do

5 A related final result that we hope to achieve with the implementation of our proposal.

6 Even though they didn't claimed the proposal of a performance benchmark as in De la Torre, Galeana and Martinez (2015) or De la Torre, Galeana and Aguilasocho (2015), they used and studied, as a methodological solution, an equally weighted performance benchmark of these two Type of SIEFOREs.

this in two different time periods: June, 1997 to August, 2004 and September 2004 to December 2010. They show that, in terms of the Sharpe ratio, the Type 2 SIEFORES underperformed the most conservative Type 1. This happened due to a higher volatility (as expected) and to the asymmetry of the GARCH process inherent to the time series. In their conclusions, they make some recommendations that are in line with proposal of this paper, such as the need of a better performance measure for the management of the SIEFOREs and to inform the pension fund savers when they are in a scenario of higher volatility and potential loss.

Santillán-Salgado *et al*. (2016) made a similar review by studying the performance of the SIEFOREs in different subperiods (1997-2012, 2004-2012 and 2008-2012), and found that the investment policy and life cycle profile of the SIEFOREs has experienced changes. With the use of ARMA-FIGARCH models, the interpretation of their results concludes the presence of fractional integration in the returns time series. These authors again insist on the need of having more transparent public information that would allow savers to make more informed decisions regarding the SIEFORE in which they keep their savings.

Several papers mentioned in the brief review presented in this section consistently suggest that more informed decisions by investors would result in an increased competitiveness of SIEFOREs. What this work intends to prove is that, had Mexican pension-savers during the period of analysis, had more complex and detailed information about the performance of different SIEFOREs, and had there existed the administrative flexibility to allow them to switch from one SIEFORE to another in response to the quality of management and the conditions of the market, savers would have allocated their savings in a wiser and more profitable way. And, in the end, those conditions would have improved the performance of SIEFOREs' managers through the pressure of competition.

2. Some Background on SIEFOREs

The SIEFOREs are mutual funds where the pension savings of Mexican workers, affiliated to the public social security system known as IMSS,[7] are invested. There are five Types of SIEFORES: the basic Type 0 SIEFORE or SB0, and four additional Types. The higher the number in the name of

[7] IMSS is an abreviation of Instituto Mexicano del Seguro Social, or Mexican Social Security Institute.

the SIEFORE, the younger are the potential investors, e.g., SB4 or SIEFORE Type 4 is target to pension savers or investors with age under 36, SB3 has an investment policy for investors between 37 and 45 years old; SB2 focuses on workers between 46 and 59 years old, SB1 is for investors that are 60 years old or more and SB0 is for retired workers. The authorized investment policy for each Type of SIEFORE is given in Table 1. As mentioned, saving in SIEFOREs follows a life cycle investment policy.

Table 1. Investment levels used as IPS in the simulations

Asset Type restrictions (min/max)	**SIEFORE Basica pensiones (SB0)**	**SIEFORE Basica 1 (SB1)**	**SIEFORE Basica 2 (SB2)**	**SIEFORE Basica 3 (SB3)**	**SIEFORE Basica 4 (SB4)**
Mexican Government bonds 1/	(51%/100%)	(51%/100%)	(0%/100%)	(0%/100%)	(0%/100%)
Mexican corporate bonds 1/	(0%/100%)	(0%/100%)	(0%/100%)	(0%/100%)	(0%/100%)
Mexican equity market	(0%/5%)	(0%/5%)	(0%/25%)	(0%/30%)	(0%/40%)
Government and corporate global bonds 2/	(0%/100%)	(0%/100%)	(0%/100%)	(0%/100%)	(0%/100%)
Global equity markets 3/	(0%/5%)	(0%/5%)	(0%/25%)	(0%/30%)	(0%/40%)
Commodities 4/	0%	0%	(0%/5%)	(0%/10%)	(0%/10%)
FX risk limits	**SIEFORE Basica pensiones (SB0)**	**SIEFORE Basica 1 (SB1)**	**SIEFORE Basica 2 (SB2)**	**SIEFORE Basica 3 (SB3)**	**SIEFORE Basica 4 (SB4)**
FX denominated securities	0%	(0%/20%)	(0%/20%)	(0%/20%)	(0%/20%)

1/ Only financial assets with a mxA or haigher credit score.

2/ Only asset with an A+ or higher credit quality.

3/ Only through benchmarks allowed in the Appendix M of the CONSAR (2016) rules

4/ In the present paper the commodities will be assumed as local assets even though they are US denominated.

Source: Based in CONSAR (2016).

Table 2. The SIEFORES analyzed in the present paper

Azteca	Inbursa	Principal	XXI Banorte
Banamex	Invercap	Profuturo GNP	
Coppel	Metlife	SURA	

Source: CONSAR (2014).

The SIEFOREs covered in this analysis for each of the four investment Types are presented in Table 2.

These are the only SIEFOREs for which daily information for the period from November 30, 2008 to December 30, 2014 is available.

To protect savers, there are legal restrictions that forbid investors to change from one SIEFORE to another. Workers must hold the same SIEFORE for, at least, a twelve-month period. As mentioned by Colín, Domínguez and Schwartz (2009), there is a lot of noise and, as a consequence, confusion in the selection of the best SIEFORE.

3. A performance metrics proposal and performance results

The main contribution of this work is the introduction of more refined measures to evaluate the performance of SIEFOREs beyond the simple metrics published by CONSAR. In order to achieve that end, Sharpe ratios for "normal" and "crisis" periods for each SIEFORE Type are estimated.

The empirical analysis ranks the SIEFOREs' performance during normal and crisis periods, compared with the actual ranking method of the net return. In order to measure the performance in "normal" and "crisis" time periods, historical daily public mutual fund price of each SIEFORE is shown in table 2.

The percentage price variation reflects the net return paid by the SIEFORE between period t and period $t-1$. These public prices are published daily by the Mexican Stock Exchange and can be found in CONSAR (2016). In order to make the performance analysis, the historical prices from November 30, 2008 to December 31, 2014 are used. Even though the historical prices collected by CONSAR are given since 1997, it is important to mention that the actual investment policy authorized by CONSAR started in March of 2008 with five Types of SIEFORES but in February they were reduced to four. Therefore, November 30 2008 is chosen for two reasons. First, to start the analysis with nine months of historical data for a better fit of the initial values in the model and, second, CONSAR published the historical stock prices for each SIEFORE incorporating the value of the mergers and splits among SIEFORES since 2008. It is well known that, in 2008, Mexico had five Types of SIEFORES available to workers according to their age.[8] In February 2013, two SIEFORES were merged, and the age range dis-

[8] As it is in a life cycle investment style briefly described in the introduction section.

tribution changed, leaving only four Types of SIEFOREs. The prices reported by CONSAR consider the merger effect in historical prices due to the aforementioned changes.

In order to analyze the data, the prices of each SIEFORE are compounded:

$$\Delta\%(P_t) = \ln(P_t) - \ln(P_{t-1}) \tag{1}$$

Hamilton's (1989) filter is used to calculate observed daily mean returns and their standard deviations for two regimes: a low volatility regime $(k=1)$ and a high volatility regime $(k=2)$, also identified as "normal" and "crisis" periods, respectively. Normal and crisis periods are a latent process that can be modeled with a two state Markovian process with a probability of being in regime of normal times $(k=1)$ or crisis times $(k=2)$ denoted with π_1 and π_2 respectively.

In order to determine these two parameters, the filter *i* was implemented in a Gaussian two-state Markovian process (each state k for each regime –normal or crisis):

$$\Delta\%(P_t) = \begin{cases} \mu_{k=1} + \varepsilon_t, \varepsilon_t \sim \Phi\left(0, \sigma_{k=1}\right) \text{ if } \pi_1 > 0.5 \\ \mu_{k=2} + \varepsilon_t, \varepsilon_t \sim \Phi\left(0, \sigma_{k=2}\right) \text{ if } \pi_2 > 0.5 \end{cases} \tag{2}$$

It is important to remember that the observance of state k in t is modeled with a fixed transition probability matrix that contains the probability of being in regime $k=i$ in time t and transiting to regime $k=j$. This transition probability is denoted by $p_{i,j}$:

$$\mathrm{P} = \begin{bmatrix} p_{1,1} & p_{2,1} \\ p_{1,2} & p_{2,2} \end{bmatrix} \tag{3}$$

Once the mean and standard deviation were estimated for each of the ten SIEFOREs in the four investment regimes, a Markov-switching Sharpe ratio is estimated as follows:

$$S_{k=i} = \frac{\mu_{k=i} - E\left(\Delta\%rf\right)_{k=1}}{\sigma_{k=1}} \tag{4}$$

In the previous expression, $\mu_{k=i}$ and $\sigma_{k=i}$ are as previously defined in (2) and (3) and $E(\Delta\% rf)_{k=1}$ is the expected return for the risk free asset[9] in the *k´th* regime.[10]

Using the above mentioned methods, a ranking determined by the expected return and Sharpe ratios of each SIEFORE in each investment style or Type was estimated.

The historical performance of each Type of SIEFORE is presented in Tables 3 to 6, in terms of accumulated returns, along with daily mean return, standard deviation, and minimum and maximum values. The performance ranking in terms of net accumulated return of each SIEFORE[11] is shown in the last column. The three best SIEFOREs are shaded in grey.

Table 3. Performance of Type 1 SIEFOREs

Type I Siefores (exclusive for savers with age>60 years)						
SIEFORE	Accumulated returns (%)	Mean St.D. %Pt	St.D. D%Pt	Min	Max	Ranking (accumulated returns)
Azteca	41.6939	0.0205	0.3016	-2.7631	3.7071	9
Banamex	56.0163	0.0261	0.3181	-2.9774	3.7608	2
Coppel	37.9507	0.0189	0.2608	-2.4035	3.4427	10
Inbursa	42.5623	0.0208	0.0515	-0.3473	0.5969	8
Invercap	49.9814	0.0238	0.5486	-5.1596	6.1683	4
Metlife	46.2641	0.0224	0.3341	-2.9513	4.0988	7
Principal	49.2131	0.0235	0.3097	-2.6327	3.8274	5
Profuturo GNP	48.9634	0.0234	0.3407	-2.4265	3.5459	6
SURA	60.2435	0.0277	0.3316	-2.6167	3.6709	1
XXI Banorte	54.1112	0.0254	0.2984	-2.6267	3.6851	3

Source: Prepared by authors with data of CONSAR (2014).

9 The observed mean percentage variation of daily prices, provided by Valmer's CETES benchmark.

10 The percentage variation of the 28 day CETEs benchmark provided by Valmer and Economatica is used.

11 This is done following CONSAR's information published in its web site.

Table 4. Performance of Type 2 SIEFOREs

Type 2 Siefore (46<age<59)						
SIEFORE	Accumulated returns (%)	Mean %Pt	St.D. %Pt	Min	Max	Ranking (accumulated returns)
MaxS_SB2	78.6591	0.0341	0.2430	-1.6282	3.5249	
Azteca	54.7712	0.0257	0.4517	-4.2608	6.0676	7
Banamex	66.7534	0.0301	0.5897	-6.2040	7.5927	3
Coppel	49.3377	0.0236	0.3433	-2.6603	4.2136	8
Inbursa	45.4089	0.0220	0.1533	-1.3026	2.4528	10
Invercap	48.3325	0.0232	0.8957	-9.5861	10.6091	9
Metlife	57.9638	0.0269	0.5492	-4.9977	7.2582	5
Principal	57.3600	0.0267	0.4943	-4.2647	6.7360	6
Profuturo GNP	67.2276	0.0302	0.5934	-5.5666	8.0109	2
SURA	80.2124	0.0346	0.5868	-5.6833	7.6747	1
XXI Banorte	64.4401	0.0292	0.4874	-4.3543	6.1060	4

Source: Prepared by authors with data of CONSAR (2014).

Table 5. Performance of Type 3 SIEFOREs

Type 3 Siefore (37<age<45)						
SIEFORE	Accumulated returns (%)	Mean %Pt	St.D. %Pt	Min	Max	Ranking (accumulated returns)
Azteca	54.5497	0.0256	0.4517	-4.2608	6.0676	7
Banamex	66.3378	0.0299	0.5897	-6.2040	7.5927	3
Coppel	48.9884	0.0234	0.3433	-2.6603	4.2136	8
Inbursa	45.2263	0.0219	0.1533	-1.3026	2.4528	10
Invercap	47.8636	0.0230	0.8957	-9.5861	10.6091	9
Metlife	57.4945	0.0267	0.5492	-4.9977	7.2582	5
Principal	56.8235	0.0265	0.4943	-4.2647	6.7360	6
Profuturo GNP	66.6194	0.0300	0.5935	-5.5666	8.0109	2
SURA	79.4187	0.0344	0.5869	-5.6833	7.6747	1
XXI Banorte	63.7382	0.0290	0.4874	-4.3543	6.1060	4

Source: Prepared by authors with data of CONSAR (2014).

Table 6. Performance of Type 4 SIEFOREs and their benchmark.

Type 4 Siefore (age<36)						
SIEFORE *benchmark*	**Accumulated returns (%)**	**Mean St.D. %Pt**	**%Pt**	**Min**	**Max**	**Ranking (accumulated returns)**
MaxS_SB4	84.5739	0.0360	0.2868	-2.5008	4.4361	
Azteca	58.8722	0.0272	0.4567	-4.1835	6.0705	7
Banamex	77.5416	0.0337	0.6868	-7.0281	8.7374	2
Coppel	52.2202	0.0247	0.3689	-2.7509	4.4076	8
Inbursa	47.3222	0.0228	0.1891	-1.5881	2.8411	10
Invercap	51.9527	0.0246	0.9573	-9.6013	11.2249	9
Metlife	64.8502	0.0294	0.6035	-5.2141	7.4481	5
Principal	62.2513	0.0285	0.5517	-4.7023	7.2674	6
Profuturo GNP	77.4764	0.0337	0.6884	-6.7161	9.2224	3
SURA	91.8834	0.0383	0.6699	-6.4055	8.6372	1
XXI Banorte	68.6266	0.0307	0.5585	-4.7777	6.6833	4

Source: Prepared by authors with data of CONSAR (2014).

Tables 3 to 6 show a similar net return performance analysis to that of CONSAR. In all cases SURA, GNP and Banamex had the best results and Inbursa had the worst.

Tables 7 to 9 present the results of the expected return, risk and Sharpe ratios observed in each SIEFORE by using (2) and (4) i.e. the normal and crisis periods. The same Tables show the ranking of the ten SIEFOREs in each investment Type, given their observed Sharpe ratio in normal and crisis times. The new ranking is compared with the returns previously shown in tables 3 to 6. As expected, the best performing SIEFOREs with the original method are not always the best when one differentiates between normal and crisis periods. For example, SURA is a middle rank SIEFORE in normal times, but the second best performer in crisis times. As expected, Inbursa is the worst performer in normal times, but the most stable during crisis periods, suggesting the possibility of active investment management, as long as investors have the necessary information.

In order to determine the Sharpe ratio in normal and crisis times, daily 28 CETES yield to maturity is observed at time t in the secondary market

Table 7. Performance of Type 1 SIEFOREs during normal and crisis periods.

Gaussian MS analysis for Type 1 SIEFOREs					
Panel A SIEFORE MS parameters	**Accumulated returns (%)**	**Expected return "normal"**	**Expected return "crisis"**	**Expected risk "normal"**	**Expected risk "crisis"**
MaxS-SB1	72.8608	6.987***	20.641	2.1692	10.7210
Azteca	41.6939	6.2808***	1.8377	2.5344	8.1996
Banamex	56.0163	7.9772***	2.1275	2.6799	8.8850
Coppel	37.9507	6.6128***	-0.3589	2.1561	7.1758
Inbursa	42.5623	4.5389***	10.152***	0.4772	1.9336
Invercap	49.9814	8.5699***	-9.2593	4.0682	17.6880
Metlife	46.2641	7.607***	-0.422	2.8267	9.2518
Principal	49.2131	7.907***	0.3849	2.7015	8.2567
Profuturo GNP	48.9634	8.6142***	-0.6648	2.8248	8.7931
SURA	60.2435	7.786***	4.4733	2.9248	8.8978
XXI Banorte	54.1112	7.7262***	1.8701	2.5587	8.4907
Panel B SIEFORE MS rankings	**Sharpe ratio "normal"**	**Sharpe ratio "crisis"**	**Sharpe ranking "normal"**	**Sharpe ranking "crisis"**	**Acumulated normal Ranking**
MaxS-SB1	1.2216	1.4643			
Azteca	0.7669	-0.3786	9	5	9
Banamex	1.3583	-0.3168	2	3	2
Coppel	1.0554	-0.7388	7	9	10
Inbursa	0.4225	2.6942	10	1	8
Invercap	1.0404	-0.8029	8	10	4
Metlife	1.1568	-0.5798	6	7	7
Principal	1.3214	-0.5520	4	6	5
Profuturo GNP	1.5141	-0.6377	1	8	6
SURA	1.1792	-0.0527	5	2	1
XXI Banorte	1.3245	-0.3618	3	4	3

This table presents the normal and crisis periods expected return, risk and Sharpe ratios of Type 1 by using Hamilton's (1998) filter. SIEFOREs. * means significant that the expected return is significant with 10% of probability, ** at 5% probability and *** at 1% probability.

Source: Prepared by authors using CONSAR (2014) data.

Table 8. Performance of Type 3 SIEFOREs during normal and crisis periods.

Gaussian MS analysis for Type 3 SIEFOREs					
SIEFORE	**Accummulate return (%)**	**Expected return "normal"**	**Expected return "crisis"**	**Expected risk "normal"**	**Expected risk "crisis"**
MaxS-SB3	80.4675	7.4087***	27.5168	2.2616	13.2726
Azteca	54.5497	8.0396***	2.555	3.7723	12.8368
Banamex	66.3378	11.2076***	-5.9178	4.4714	17.9074
Coppel	48.9884	8.5871***	-1.2068	3.0487	8.9592
Inbursa	45.2263	5.0423***	7.4191	1.2934	5.0257
Invercap	47.8636	7.5452**	-2.4154	6.3824	29.5054
Metlife	57.4945	10.6193***	-4.8003	4.5470	15.1421
Principal	56.8235	9.8238***	-3.4818	4.1774	13.9098
Profuturo GNP	66.6194	10.7755***	-2.8298	4.7552	16.8531
SURA	79.4187	10.4332***	1.8412	4.7747	17.5326
XXI Banorte	63.7382	9.8012***	-1.0482	4.3233	13.6834
SIEFORE	**Sharpe ratio "normal"**	**Sharpe ratio "crisis"**	**Sharpe ranking "normal"**	**Sharpe ranking "crisis"**	**Accumulated returns ranking**
MaxS-SB3	1.3581	1.7008			
Azteca	0.9815	-0.1860	8	3	7
Banamex	1.5365	-0.6065	1	8	3
Coppel	1.3940	-0.6864	2	10	8
Inbursa	0.5451	0.4928	9	1	10
Invercap	0.5026	-0.2494	10	4	9
Metlife	1.3816	-0.6434	3	9	5
Principal	1.3134	-0.6056	5	7	6
Profuturo GNP	1.3540	-0.4612	4	6	2
SURA	1.2767	-0.1769	6	2	1
XXI Banorte	1.2638	-0.4378	7	5	4

This table presents the normal and crisis periods expected return, risk and Sharpe ratios of Type 3 by using Hamilton's (1998) filter. SIEFOREs. * means significant that the expected return is significant with 10% of probability, ** at 5% probability and *** at 1% probability.

Source: Prepared by authors with data of CONSAR (2014).

Table 9. Performance of Type 4 SIEFOREs during normal and crisis periods.

Gaussian MS analysis for Type 4 SIEFOREs					
SIEFORE	**Accummulate return (%)**	**Expected return "normal"**	**Expected return "crisis"**	**Expected risk "normal"**	**Expected risk "crisis"**
MaxS_SB4	84.5739	7.7026***	27.9104	2.2650	15.4548
Azteca	58.8722	7.3399***	4.4955	4.1234	13.9030
Banamex	77.5416	11.9422***	-6.6582	5.6242	21.8903
Coppel	52.2202	8.9117***	-0.7887	3.3525	9.5121
Inbursa	47.3222	5.5227***	6.3058	1.6013	5.8973
Invercap	51.9527	7.6493**	-1.9218	7.4342	33.0012
Metlife	64.8502	11.6949***	-6.7435	5.4128	16.8809
Principal	62.2513	9.9803***	-3.8619	4.9847	16.2989
Profuturo GNP	77.4764	12.4356***	-6.1237	5.7758	20.3634
SURA	91.8834	11.9408***	-0.1402	5.7760	20.6066
XXI Banorte	68.6266	11.0362***	-5.5034	5.3858	16.2890
SIEFORE	**Sharpe ratio "normal"**	**Sharpe ratio "crisis"**	**Sharpe ranking "normal"**	**Sharpe ranking "crisis"**	**Accumulated returns ranking**
MaxS_SB4	1.4858	1.4861			
Azteca	0.7282	-0.0321	9	2	7
Banamex	1.3522	-0.5299	4	5	2
Coppel	1.3645	-0.6025	2	8	8
Inbursa	0.7403	0.2312	8	1	10
Invercap	0.4455	-0.2080	10	3	9
Metlife	1.3593	-0.6923	3	10	5
Principal	1.1321	-0.5402	7	6	6
Profuturo GNP	1.4021	-0.5434	1	7	3
SURA	1.3164	-0.2466	5	4	1
XXI Banorte	1.2438	-0.6413	6	9	4

This table presents the normal and crisis periods expected return, risk and Sharpe ratios of Type 4 by using Hamilton's (1998) filter. SIEFOREs. * means significant that the expected return is significant with 10% of probability, ** at 5% probability and *** at 1% probability.

Source: prepared by authors with data of CONSAR (2014)..

(Banco de México 2016). Using Hamilton's filter for the CETE's rate, results in an expected risk-free rate of 4.3372% for the normal periods and 4.9423% for the crisis periods, so these values are used to estimate the Sharpe ratios as suggested in (4).

In table 7, the expected return in all Type 1 SIEFOREs is significantly different from zero during normal periods, and only Inbursa has an expected return different from zero during crisis periods. This is due to the more stable historical performance that leads the SIEFOREs to underperform their investment policy benchmark. Panel b) of the same Table presents the Sharpe ratio results for each SIEFORE in each volatility regime, and presents the ranking of each SIEFORE according to their Sharpe ratios for each volatility regime.

Conclusion

A defined benefit pension fund system should encourage competition among pension fund managers to motivate a search for better performance. Calderón-Colín, et al. (2009) and Guillen (2011) mention that there is low competition among Mexican pension funds (SIEFOREs) due to informational asymmetry (noisy or uninformed decisions), and the absence of legal incentives.

The analysis presented in this paper uses Markov-switching models to calculate the Sharpe ratio $\left(S_{i.k}\right)$ of SIEFOREs for different sub periods, identifying two volatility regimes (normal with $k=1$ and crisis with $k=2$). The results confirm that not all SIEFOREs are good (or bad) performers all the time. In some cases, good performers during normal periods are not so during crisis periods and vice-versa. This evidence suggests that awareness of market conditions conveys information that can support rational decisions to change savings from good performers during normal times to good performers during crisis periods. While this is a preliminary finding, it opens the door for further analyses that should lead to optimal investment decision rules.

The current Mexican legislation allow changes from one SIEFORE to another only every twelve months, so the implementation of a more informed and flexible investment framework requires the liberalization of the current legislation. However, the findings reported in this study give support to such an initiative, and should be regarded as evidence that the current legislation is too rigid, frustrating the opportunity that well informed rational investors improve their retirement savings returns in the long run.

More research is needed to fully understand the multiple areas of potential improvement to the current Mexican Pension Funds system. This is a first contribution in that direction, and we expect that others will follow. While the adoption of a modern Pension Funds System opens numerous possibilities, the main objective, which is to guarantee the living standards of future pensioners should be the highest priority.

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Appendix 1. The use of Markov-Switching Sharpe ratios of the SIEFOREs in a partially informed scenario

In this Appendix is presented the decision-making algorithm that a theoretical group of pension savers would have followed if they have had access to the Markov-Switching Sharpe Ratios such as the ones presented in table 3 and tables 7 to 9, along with the probability of being in "normal" or "crisis" periods. The assumption stated is that even if the investors had access to this information, they suffer the impact of some externalities such as the fact that their SIEFORE is managed by a division of a big financial institution, or that the marketing efforts of their SIEFORE lead them to decisions not entirely informed. It is also assume that the impact of the legal restriction to move retirement proceedings only once a year has an impact in the investment levels. Therefore, in order to simulate the partially informed scenario portfolio the next algorithm is followed:

Definitions:

$S_{i,j}$ = Sharpe ratio of the i-th SIEFORE at time time, given the k-regime.

$I_{MaxSharpe}$ = The Max Sharpe portfolio that measures the performance of all the SIEFOREs in a given Type or investment regime such as SB1, SB2, SB3 or SB4.

$E\left(\Delta\%I_{MaxSharpe}\right)_k$ = The expected return, observed at t, of the Max Sharpe portfolio, given the k volatility regime.

$\sigma\left(\Delta\%I_{MaxSharpe}\right)_k$ = The expected risk or standard deviation, observed at t, of the Max Sharpe portfolio, given the k volatility regime.

$E\left(\Delta\%SB_i\right)_k$ = The expected return, observed at t, of the i-th SIEFORE, given the k volatility regime.

$\sigma\left(SB_i\right)_k$ = The expected risk or standard deviation, observed at t, of the i-th SIEFORE, given the k volatility regime.

$P\left(k=2\left|\Delta\%I_{MaxSharpe}\right.\right)$ = The probability that the performance or investment policy of the SIEFOREs in a given investment style or Type is in regime 2 or "crisis", given the pas observed data of the benchmark.

Algorithm:

For February 2010 to December 2014

1. To calculate the Markov Switching values of $E\left(\Delta\%SB_i\right)_k$ and $\sigma\left(SB_i\right)_k$ by using all the historic data of $\Delta\%SB_i$ at t in each SIEFORE.

2. To calculate, the expected return $E\left(\Delta\%I_{MaxSharpe}\right)_k$ and risk $\sigma\left(\Delta\%I_{MaxSharpe}\right)_k$ of the performance benchmark, along with the probability of being in regime 2 or "crisis" time. $P\left(k=2\left|\Delta\%I_{MaxSharpe}\right.\right)$

3. To define the regime k as follows:

$$k=\begin{cases} 1 \text{ if } P\left(k=2\left|\Delta\%I_{MaxSharpe}\right.\right)>50\% \\ 2 \text{ if } P\left(k=2\left|\Delta\%I_{MaxSharpe}\right.\right)\leq 50\% \end{cases}$$

4. For all the SIEFOREs in the simulated Type or investment regime determine the smoothed or actual Markov-Switching Sharpe ratio, by using as risk free rate the monthly rate of the 28 day CETES:

$$S_{i,k}=\frac{E\left(SB_i\right)_k-rf}{\sigma\left(SB_i\right)_k}$$

5. To calculate the investment level in each SIEFORE by using the next expression:

$$w_i=\begin{cases} \dfrac{S_{i,k}}{\sum S_{i,k}} & \text{if } S_{i,k}\geq 0 \\ 0\% & \text{if } S_{i,k}<0 \end{cases}$$

6. To use the investment level in each SIEFORE to calculate the weighted mean return of the simulated portfolio P:

$$\Delta\%P_t=\sum_{j=1}^{N} w_i\Delta\%SB_{i,t}$$

end

By running this, we used a base-100 value at January 2010 in each SIEFORE Type by using the SIEFORES described in table 2.

Appendix 2. The use of Markov-Switching Sharpe ratios of the SIEFOREs in a fully informed scenario.

In order to simulate the portfolio of this scenario, we followed the same definitions and steps of the algorithm given in Appendix 1. The only difference in this scenario is that we relaxed the actual legal restriction that allows Mexican investors to change their savings to another SIEFORE only once a year. Had this happened, we assume that all investors are fully informed with our performance metric and all change their proceedings to the best performer SIEFORE (the one with the highest Markov-Switching Sharpe ratio). To do this, we change only the step 5 of the algorithm of Appendix 1 with this one:

5. To calculate the investment level in each SIEFORE by using the following expression:

$$w_i = \begin{cases} 100\% & \text{if } S_{i,k} = \max\left(S_{i,k}\right) \\ 0\% & \text{if } S_{i,k} < \max\left(S_{i,k}\right) \end{cases}$$