



Global Journal of Business, Economics and Management



Volume 05, Issue 2, (2015) 70-76

<http://sproc.org/ojs/index.php/gibem>

Modeling the risk-return characteristics of the SB1 Mexican private pension fund index

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Suggested Citation:

Santillán-Salgado, R., J., Preece, M., M., & Herrera, F., L. (2015). Modeling the risk-return characteristics of the SB1 Mexican Private Pension Fund Index. *Global Journal of Business, Economics and Management*, 5(2), 70-76.

Received 25 September, 2015; revised 04 October, 2015; accepted 07 November, 2015.

Selection and peer review under responsibility of Prof. Dr. Andreea Iluzia IACOB, Bucharest Academy of Economic Studies, Romania

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Abstract

This paper analyzes the returns and variance behavior of the largest specialized private pension investment funds index in Mexico, the SIEFORE Básica 1 (or, SB1). The analysis was carried out with time series techniques to model the returns and volatility of the SB1, using publicly available historical data for SB1. Like many standard financial time series, the SB1 returns show non-normality, volatility clusters and excess kurtosis. The econometric characteristics of the series were initially modeled using three GARCH family models: GARCH (1,1), TGARCH and IGARCH. However, due to the presence of highly persistent volatility, the series modeling was extended using Fractionally Integrated GARCH (FIGARCH) methods. To that end, an extended specification: an ARFIMA (p,d,q) and a FIGARCH model were incorporated. The evidence obtained suggests the presence of long memory effects both in the returns and the volatility of the SB1. Our analysis' results have important implications for the risk management of the SB1.

Keywords: Private Pension Funds, Time Series modelling, GARCH models, Long Term memory series

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1. Introduction

Since before the 1980s Latin American countries' observed demographic trends would have been fully justified profound structural reforms to their traditional retirement pension systems, but the regional governments didn't engage in them due to the severe macroeconomic and financial crises repeatedly present in the region during the previous decades. In most cases, the crises were confronted with inappropriate economic policies to foster growth at any rate, and in some others populist policies that didn't consider the insertion of the labor force in a sustainable production model were enforced. So, to carry out a *second generation* social security reform would hardly have been considered an immediate task if the dimension of the challenges faced by the economic policy makers, and the technical and material constraints of most of the countries in the region are contemplated (Schmidt Hebbel, 1999). However, between 1981 and 1998, eight Latin American countries introduced profound reforms to their pension systems; they were: Chile (1981), Peru (1993), Colombia (1994), Argentina (1994) Uruguay (1995), Bolivia (1997), Mexico (1997) and El Salvador (1998).

At that time, government agencies in charge of the pensions system faced serious managerial problems, including inefficiency and corruption; also, several other reforms (fiscal, commercial and regulatory) were implemented in this period, so immersed in a changing regulations environment, a pensions system reform fitted well. One of the main traits that make the reformed pension systems unique is that contributions by (or in behalf) of active workers are deposited in individual accounts, so that total resources accumulated are used to support workers upon retirement. The accounts are privately managed by specialized entities whose main purpose is to invest workers' contributions and maximize returns at the time they minimize risks. This second pillar* is regulated and supervised by the government's authorities. In some cases, it is a complement to public funded schemes, and in others, it coexists with traditional pension systems.

2. The defined contribution system in Mexico

In the year 1997 the Mexican government put in place an individual account pension system (or defined contribution system) to replace the traditional scheme that prevailed during the second half of the 20th century. The system was created for workers incorporated to the Mexican Social Security Institute[†] system. By the year 2008 the reform incorporated all workers affiliated to the State Workers Social Security system. Even though the new pension system includes most of the active workers in the country, it still coexists with the traditional pension systems, also known as defined benefits, offered by some institutions to their workers[‡]. The current tendency is for these pension systems to progressively be transformed into defined contributions systems, managed privately through individual account schemes.

2.2 Investment Regime for SIEFORE Básica 1

During its first years, the SB1 portfolios included only government and private securities. Later on, investing in foreign securities was authorized, as long as they did not exceed a 20% limit of total assets. The December 10th, 2002 amendment approved investments in international securities, but it was not until the 2004 reform that it was possible to enforce the 2002 amendment. SB1 should also maintain at least 51% of total assets in debt securities

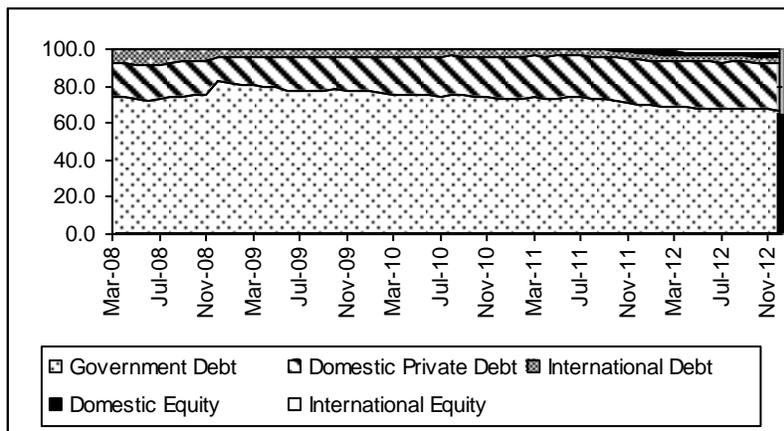
* Within the pension schemes, privately funded systems are considered as a second pillar, in contrast with publicly funded pension systems, which are regarded as the first pillar.

† Instituto Mexicano del Seguro Social, IMSS. It embraces most formal active workers in the country.

‡ Such is the case for the Federal Electric Commission (Comisión Federal de Electricidad, CFE), the Mexican Petroleum Company (Petróleos Mexicanos, PEMEX), several state governments and the Mexican Army.

denominated in Investment Units⁵ (UDIs) or Mexican pesos, with interest rates higher than the change observed in the UDIs. Also, the SB1 portfolios may incorporate up to 100% of net total assets in debt securities with AAA investment grade or equivalent, or up to 5% in debt securities with investment grade A. They may operate with derivatives as long as the maximum limits for debt securities with AAA, AA and A investment grades are maintained. SB1 can buy debt assets, both domestic and foreign, directly or indirectly through investment vehicles, as long as established limits are observed.

Several modifications to the investment regime reduced the amount of government debt securities included in the pension funds, allowing an increase of private domestic and foreign debt securities and the incorporation of domestic and foreign equity in pension funds, as shown in Graph 1. A high concentration on government debt assets may be noticed in the portfolio structure; this concentration could explain why, besides the intention to increase returns and decrease risk, a wide diversification of the SIEFORE was authorized.

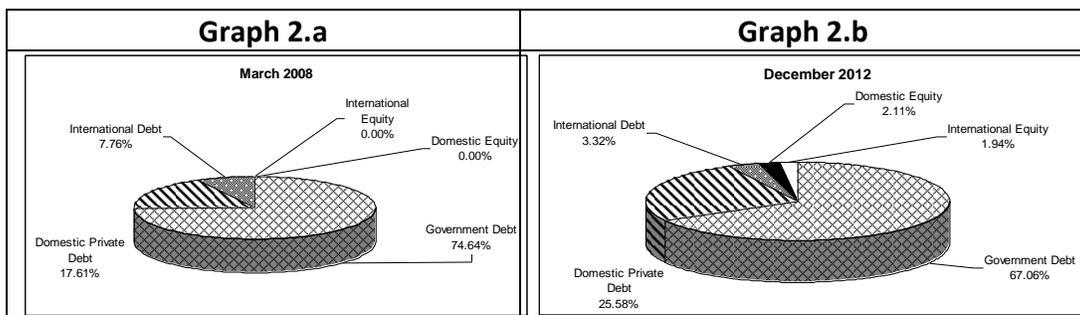


Graph 1. SB1 portfolio structure

By the end of 2012, the ratio of government debt had decreased and national and international equity had been included, as shown by Table 1 and Graphs 2.a and 2.b.

Table 1. SB1 Investment Portfolio Structure

	Government Debt	Domestic Private Debt	International Debt	Domestic Equity	International Equity
March 2008	74.6	17.6	7.8	0.0	0.0
December 2012	67.1	25.6	3.3	2.1	1.9



⁵ Mexico's Investment Units (UDIS) are reference indices based on price increases and are used to settle mortgage obligations or other commercial transactions. Banco de México publishes the value in pesos of the UDI for each day of the month in the Official Federal Gazette. Source: Banco de México.

3. Econometric analysis of the SB1 returns and volatility

Descriptive statistics for the returns of SIEFORE Básica 1 are presented in Table 2. The daily average return is slightly larger than 0.045%; returns have a positive asymmetry coefficient, and present a high kurtosis.

Table 2. Statistical parameters of the SB1 returns

Average	Median	Maximum	Minimum	Standard Deviation	Asymmetry coefficient	Kurtosis
0.0456553	0.0493733	3.7853366	-2.768683	0.2002949	0.9196925	57.233061

To model the series we selected an ARMA (p,q) model, and used the Akaike criterion to determine its order. The screening process suggested a model with one constant, five autoregressive terms, and five-lagged stochastic disturbances. Table 3 shows the model's estimation results. The most relevant finding is that the Lagrange multiplier test rejects the hypothesis of absence ARCH effects. Accordingly, the original ARMA (5,5) model specification was expanded to capture them with different GARCH family models, as presented in Table 4.

Table 3: ARMA(5,5) Model

	Coefficient	p
m	0.045659	< 0.01
f_1	-2.751914	< 0.01
f_2	-3.003796	< 0.01
f_3	-1.371633	0.2688
f_4	0.105292	0.8889
f_5	0.22689	0.2302
q_1	3.091954	< 0.01
q_2	4.024859	< 0.01
q_3	2.63779	0.0856
q_4	0.672355	0.503
q_5	-0.035303	0.8967
ARCH(1) ML	661.4388	< 0.01

Table 4: Four different GARCH models estimated with the ARMA (5,5) equation

	GARCH(1,1)		TARCH(1,1)		IGARCH(1,1)		FIGARCH(1,1)	
	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p
m	0.054523	< 0.01	0.048044	< 0.01	0.057973	< 0.01	0.051573	0.0246
f_1	-0.439149	< 0.01	-0.456616	< 0.01	-1.325709	< 0.01	-0.21605	0.0438
f_2	0.373723	< 0.01	0.387042	< 0.01	0.394914	< 0.01	0.260282	< 0.01
f_3	-0.149337	0.0510	-0.146523	0.0619	1.500868	< 0.01	-0.119408	0.272
f_4	0.584136	< 0.01	0.569786	< 0.01	0.556636	< 0.01	0.39089	< 0.01
f_5	0.570465	< 0.01	0.582993	< 0.01	-0.135096	0.1115	0.680272	< 0.01
q_1	0.616298	< 0.01	0.635408	< 0.01	1.562406	< 0.01	0.275984	0.0283
q_2	-0.293577	< 0.01	-0.295264	< 0.01	-0.030194	0.8554	-0.29444	< 0.01
q_3	0.098073	0.2002	0.101116	0.1929	-1.505253	< 0.01	0.06978	0.5575
q_4	-0.579632	< 0.01	-0.561213	< 0.01	-0.90949	< 0.01	-0.398531	< 0.01
q_5	-0.612905	< 0.01	-0.616799	< 0.01	-0.066285	0.4583	-0.641938	< 0.01
w	0.000472	< 0.01	0.000452	< 0.01			0.091214	0.0298
a	0.171035	< 0.01	0.121985	< 0.01	0.088952	< 0.01	0.166137	0.1121
b	0.824135	< 0.01	0.831686	< 0.01	0.911048	< 0.01	0.500637	< 0.01
g			0.082563	0.0301				
d							0.133692	< 0.01
d							0.560486	< 0.01

The ARMA (5,5)-GARCH(1,1)** model shows that most of the terms in the mean equation are significant at a 1% level. The only two exceptions where the coefficient associated with the third lag of the SB1 returns, only significant at a 10% level, and the coefficient of the third term of the moving average of the stochastic disturbance, which was not significant at any conventional level. All the coefficients in the time-changing variance equation are significant at 1%. Additionally, when the specification is extended to include asymmetric effects in the variance equation model, i.e., the TARCH (1,1)** model, the results remain highly significant. However, the asymmetric volatility term is significant at only 5%.

In the previous two specifications, estimated coefficients suggest the presence of a highly persistent conditional variance because their added value is very close to 1; that means that it is likely that the SB1 returns' volatility is non stationary. For that reason, we decided to estimate an ARMA (5,5)-IGARCH(1,1)** model, constraining the sum of the terms associated with the square errors of the previous period and the volatility of the most recent period to be equal to 1. When compared with the results for the two previous models, some of the IGARCH coefficients show a reduced statistical significance. Others, that were non-significant, become significant; and in some cases, there is a change of sign. However, it is important to highlight

**Bollerslev (1986) [2] extended the ARCH model of Engel (1982), makes possible to model the time changing volatility with less parameters by taking into account its changing volatility in previous periods.

** This model was developed by Rabemananjara and Zakoian (1993) [3] and Zakoian (1994) [4] to take into account the presence of asymmetric effects in conditional volatility.

** The fact that the sum of the relevant parameters of the GARCH model was close or equal to the unity motivated the development of the IGARCH model (cfr. Engle and Bollerslev 1986) [5].

that the values for the estimated coefficients of some terms, are notoriously greater than 1, suggesting that the SB1 returns may indeed be non-stationary.

To study the non-stationary returns process, as well as the high persistence of volatility suggested by the above tests, we proceeded to estimate a Fractionally Integrated model (5, d , 5), for the equation of the mean, and a FIGARCH(1, d , 1)⁵⁵ model for the conditional variance equation. The results of that estimation appear to be more congruent with the first two models, in which no IGARCH(1,1)-type restrictions were imposed; i.e., most of the estimated parameters for the ARFIMA-FIGARCH model are numerically equivalent to those of the first two specifications and all of the estimated coefficient signs remain the same. A notorious difference is that neither the third lag of the mean-returns coefficient nor the square of the stochastic disturbance term of the variance equation coefficient appear to be statistically significant. However, the positive values for d_m , the integration parameter of the mean-returns equation, and d_v , the coefficient for the integration parameter in the variance equation, and their high statistical significance (<1%), suggest that both stochastic processes are long-memory processes.

4. Conclusion

The experience of countries that have adopted an individual contribution retirement savings systems suggests that economic benefits are brought along by domestic savings' accumulation, since those resources may be invested to build up the productive capacity and the infrastructure. However, other derived benefits include the modernization of the financial industry, the multiplication and the specialization of participating intermediaries, and a greater depth of the financial markets. In turn, the latter one brings along direct benefits to the real sector of the economy by increasing liquidity and reducing the opportunity cost of financial resources accessible to firms and governments.

However, it is very important to remember that the most important objective of such a system is to improve the life quality standards of the population that reaches retirement age. So it is essential to reinforce transparency, operational discipline and technical excellence in the management of the worker's retirement funds. If the objective of the system is to maximize the individual accounts returns and accumulation, it will be unavoidable to incorporate some risky investments into the pension funds' portfolios. But portfolio risks must be properly studied, evaluated and managed to minimize the probability of losses.

The utilization of econometric techniques to measure and model the volatility of returns of the SB1 portfolio is of the greatest importance to determine its risk levels, and to design hedging strategies that can help avoid patrimonial damages to the workers' retirement savings.

The evidence obtained from the SB1 returns time series' statistical analysis confirms its time-varying volatility, as was initially suggested. In addition, the tests discussed support the presence of long memory effects in the returns and volatility of returns of the SB1 portfolio; that means that present returns may be correlated with their own distant-past lagged values. The main theoretical implication of the presence of long memory effects is that it is not congruent with a Gaussian geometric Brownian motion, but to a process better described as a Fractional Brownian motion, i.e., that the behavior of SB1 returns is not congruent with the notion of an Efficient Financial Market, as we know it. That fact represents a strong motivation to further study the SB1 series properties in order to enhance our understanding of the long memory problem. To guarantee the solvency of the pension funds and to obtain maximum "safe" returns for the savers it is essential to discern which factors affect the evolution of the SB1 returns'.

⁵⁵Baillie *et al.* (1996) [6] proposed the fractionally integrated GARCH model (FIGARCH) and demonstrated that it can improve the modeling of a dynamic volatility is a parameter is included to capture the effects of long-term memory. Chung (1999) [7] proposed a better method to estimate the model. The estimations presented in this work are based on that method.

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