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Assessing Market Timing Performance of Brazilian Multi-Asset Pension Funds using the Battese and Coelli's Stochastic Frontier Model (1995)

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Abstract

In this paper, we used the SFA (Stochastic Frontier Analysis) approach to evaluate the efficiency of 170 Brazilian multi-asset pension funds in the period from 2013 to 2017, which aims to assess the skill level of fund managers to outperform the benchmarks. The adoption of the Battese and Coelli's (1995) stochastic frontier model in market-timing analysis is new and the obtained empirical results are promising for future replications including for other types of pension funds, explanatory variables and observation periods, in different data models.

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1. Introduction

Investment funds, among other options, have stood out the most in recent years, both in terms of evolution and internal savings generation. They are crucial for the economic development of regions where their resources are invested in. According to Amaral, Vilaça, Barbosa and Bressan (2004), investment funds play an important role in generating internal savings to regional economy, when they act as agents of economic development, investing their resources in a productive manner.

According to the Industry Yearbook of Investment Funds, although Brazil experienced a contraction of 3.6% in its GDP in 2016, the economy has started to grow again (1% in 2017 and 1.1% in 2018), indicating a new bullish economic cycle. In this environment, the national industry expanded approximately 18% in 2017, compared to 2016, exceeding the amount of R$ 4 trillion of net worth (FUNDAÇÃO GETÚLIO VARGAS, 2018).

These numbers put Brazil among the 10 largest countries in the world in terms of investment fund management, comprising approximately 3% of the total world industry. It is also worth mentioning that, currently, more than 16,000 funds are under management in the country, representing a wide array of options and investor segments (FUNDAÇÃO GETÚLIO VARGAS, 2018).

Given this context, Baima (1998) and Kempf, Manconi, Spalt and Oliver (2017) mention that pension funds are extremely important, in a social context, because of the benefits they provide to their participants and the role they play in creating jobs. From an economic point of view, these funds are the most important institutional investors, applying long-term resources, which are essential for the generation of internal savings.

Pension funds are intended to receive technical reserves from pension plans and are therefore related to investor’s long-term goals in this class of funds (MALAQUIAS; EID, 2013).

The Brazilian Securities Commission (CVM) (2014), acknowledges social security funds, as those created for the application of resources from open or closed private pension entities; of their own social security regimes established by the Federal Government, States, Federal District and Municipalities; of complementary open pension plans and life insurance; and of Individual Programmed Retirement Funds (FAPI).

Multi-asset pension funds have the same features as funds of the class bearing the same name, that is, they must have investment policies that involve several risk factors, without a commitment to concentrate on any special factor. The funds can be distinguished by the origin of their resources, which are derived from pension plans and leverage is not granted to pension funds (MALAQUIAS; EID, 2014).

Due to the mistrust around the ability of the Brazilian social security system to make future payments, it is becoming increasingly common for people to join the private pension system (MALAQUIAS; EID, 2014). For this reason, the growth of pension funds is notorious, since they offer an income supplement to the citizen after retirement (using the capitalization system), with the perspective of maintaining the standard of living that they had while active in the labor market (LI; ZHANG; ZHAO, 2011).

However, when adhering to a supplementary pension plan, one of the factors that must be observed by investors is its ability to make future payments. Therefore, the decision on where the long-term resources will be invested, and the participation of each type of fixed or variable income asset in the total portfolio, is essential for the fund's ability to pay its clients (KEMPF *et al.,* 2017).

Not only in Brazil, but also elsewhere, pension funds are relevant players in financial and capital markets, both for the amount of resources under their management, as well as for long-term investment policies and strategies, and their risk rating should be aligned with their investors' profile (BAGGIO, 2012).

Among the studies that stand out in this field, Treynor and Mazuy (1966) was the first to analyze the annual earnings of 57 American mutual funds and concluded that only one of the funds in the sample managed to outperform the market - that is, managers were not able to beat the markets.

Shortly thereafter, Jensen (1968) evaluated the performance of US funds from 1945 to 1964 using a model derived from the Capital Asset Pricing Model (CAPM). Without making a distinction between selection and market timing, this researcher did not find any evidence that any fund would be able to outperform the market.

According to Fama (1970), the ability of fund managers to make predictions can be divided into micro- and macroforecasting. Microforecasting, named by the author as selectivity, is the ability to predict individual stock price movements. On the other hand, macroforecasting, known as market-timing, is the ability to forecast general stock price movements.

In turn, Merton (1981) formalized the analysis of value creation by market timing, according to which the manager predicts the highest return of the market in relation to the risk-free asset, and vice versa, but is unable to predict its magnitude. In the same year, Henrikson and Merton (1981) proposed two tests, a parametric and a non-parametric one, to examine the performance of funds according to the market timing, not requiring restrictive assumptions of a balanced market - thus consisting of a case of patterns of rationality and efficiency as considered by Fama (1970). Conducting those tests on the American market for the period ranging from 1968 to 1980, on 116 funds, Henrikson (1984) observed that only three funds demonstrated a positive market-timing ability, thus showing that it was virtually non-existent.

Grinblatt and Titman (1989) found evidence contrary to Henrikson (1984) by comparing the abnormal results of passive and active investment funds during the period from 1975 to 1984. They came to the conclusion that the high performance of some funds may be considered a consequence of the active management.

Carhart (1997) investigated the persistence in U.S. equity mutual fund performance during the period from 1962 to 1993. The author confirmed the hypothesis that skilled or informed mutual fund portfolio managers do not exist, by using his four-factor model (CARHART, 1995), which was based on the three-factor model of Fama and French (1993) plus the momentum effect of Jegadeesh and Titman (1993).

Chen, Jegadeesh and Wermers (2000) researched the operations of purchasing and selling stocks of mutual funds and reached the conclusion that, in general, funds buy stocks that present superior performance to those they sell. This supported the idea that active funds are better than passive funds, which suggests that their managers have better stock-picking skills.

Kosowski, Timmermann, Wemers and Hal (2006) pioneered the application of bootstrap simulations to estimate variables, thus eliminating the factor of luck from the analysis. They employed Carhart's (1997) four-factor model on U.S. funds from 1975 to 2002 and found indications of a significant number of funds with a superior performance.

Fama and French (2010), trying to distinguish skill from luck, investigated 3,156 active U.S. equity mutual funds from 1984 to 2006. The results indicated that active funds had "alpha" very close to zero, without considering their expenses, indicating that few managers had sufficient skills to produce above-market returns.

In Brazil, studies aimed at measuring performance of funds are still more modest than those carried out in other countries; a considerable number of them use methodologies that relate return to risk, such as the Sharpe index, the CAPM and the three-factor model of Fama and French (1993). In general, they have revealed the existence of managers with sufficient skills to outperform the market.

Ceretta and Costa Jr. (2001) measured the performance of 106 equity funds in the period from 1997 to 1999. Using Data Envelopment Analysis (DEA), they included other attributes besides risk and return and concluded that only 7 funds were efficient.

In turn, Franz and Figueiredo (2003) found no evidence of market-timing skill in 29 Brazilian equity mutual funds from 1995 to 2000. These authors used the models specified by Treynor and Mazuy (1966) and Henriksson and Merton (1981), which are derived from CAPM.

Santos, Tusi, Costa Jr. and Silva (2005) estimated the performance of 307 mutual funds of Brazilian stocks in the period from April 2001 to July 2003, using Battese and Coelli's (1992) stochastic frontier model. These researchers found that the funds efficiency increased due to the management skills to outperform the market. They also discovered that low volatility portfolios tended to be more efficient and that there was no relationship between the size and performance of funds, although this could be misunderstood as a survival bias.

Eid and Rochman (2007) evaluated 669 national funds from 2001 to 2006 using the Jensen's alpha and concluded that equity and multi-asset mutual funds would perform better than the market.

Leusin and Brito (2008) identified market-timing skills in a minority of fund managers in the period from 1998 to 2003. Apparently, the result can be explained by the greater ease in predicting large differences in return between the stock market and the risk-free interest rate.

Gomes and Cresto (2010) examined the performance of long-short funds in Brazil to verify if there was any generation of abnormal returns in this type of funds. They analyzed 76 funds from 2001 to 2008 and proved that only a few generated such returns.

Silva (2012) researched 75 Ibovespa actively managed funds in the period from January 1998 to December 2008, identifying those that generated results by the luck factor and those that generated results based on their managers skills, using the methodology proposed by Fama and French (1993). For the performance analysis of the funds, the methodology proposed by Fama and French (2010) was used. The study identified that most outperforming funds had their performance due to chance, and only three funds presented effective superior performance, due to their managers skills.

More recently, Borges and Martelanc (2015), using the model proposed by Fama and French (2010), conducted ten thousand simulations of Brazilian stock investment funds, in the period from 2000 to 2013, and registered instances of skill by some stock investment fund managers in obtaining abnormal superior returns.

Given this context, in our study we sought to contribute to the expansion of perspectives of the assessment of the managers' skill level to outperform the benchmarks. In this sense, we tested the Battese and Coelli's (1995) stochastic frontier model on 170 Brazilian multi-asset pension funds in the period from 2013 to 2017. Using this model, we estimated the simultaneous variation of the frontiers of profitability and efficiency, distinguishing influences associated with frontier shifts, from those related to the dissemination (or not) of best practices in management.

2. The Stochastic Frontier Analysis (SFA) Model of efficiency with Panel Data

The theoretical framework of the SFA (Stochastic Frontier Analysis) model has its origin in the proposition of Aigner, Lovell and Schmidt (1977) of a stochastic frontier production function. Idealizing this model, it considered the average technical efficiency calculation for all sample observations, but not an estimate for each Decision-Making Unit (DMU). The solution to the decomposition problem was provided five years later by Jondrow, Lovell, Materov and Schmidt (1982).

After six years, Battese and Coelli (1988) generalized the above results for panel data and deviations with half-normal distribution.

Moving away from the two-stage models used until then, Kumbhakar, Ghosh, and Mcguckin (1991), Reifschneider and Stevenson (1991) and Huang and Liu (1992) proposed models in which the frontier and inefficiency equation parameters are estimated simultaneously. Such formulations assume the existence of a distribution associated with the cross-sectional data of the sample units.

Battese and Coelli (1995) extended Huang and Liu's (1992) model to a data panel and created a specification in which efficiency is expressed as a function of specific variables, including the "time trend", and a random term. Because this model assigns a structure to technical efficiency, it is possible to analyze the simultaneous variation of production and efficiency frontiers, separating the trends associated with frontier shifts from those related to the dissemination (or not) of production best practices. This specification has the advantage of relaxing the hypothesis of time-invariant technical efficiency levels and technological frontier. So,

$$y_{it} = \beta_0 + X_{it}\beta + V_{it} - U_{it} \tag{1}$$

and

$$y_{it} = \beta_{0it} + X_{it}\beta + V_{it} \text{ and } \beta_{0it} = \beta_0 - U_{it} \tag{2}$$

where y_{it} is the production/service of the DMU$_i$ at time t; X_{it} is an input vector associated with the units under analysis, in each observation period; β is the vector of parameters to be estimated (β_0 is the intercept of the production frontier); V_{it}s are stochastic shocks assumed to be iid in a normal distribution $N\left(0,\sigma_v^2\right)$ and independently distributed of the U_{it}s; the U_{it}s are non-negative random variables associated with inefficiency of production which, by hypothesis, have a normal distribution truncated with a mean of $Z_{it}\delta$ and variance, σ^2; Z_{it} is a vector of explanatory variables associated with the technical inefficiency of the firms involved in the production process; and δ is a vector of unknown coefficients to be estimated.

The technical efficiency U_{it} is, by hypothesis, a function of "explanatory" variables Z_{it} s and of a vector of unknown coefficients δ. It is expected that this set of variables is associated with the observed production deviations in relation to the stochastic frontier $\exp(X_{it}\beta + V_{it})$. Individual effects related to U_{it}, can be specified as

$$U_{it} = Z_{it}\delta + W_{it} \tag{3}$$

where the random variable W_{it} is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-Z_{it}\delta$, i.e., $W_{it} \geq -Z_{it}\delta$. These assumptions are consistent with U_{it} being a non-negative truncation of the $N\left(Z_{it}\delta,\sigma^2\right)$ distribution.

The basic assumption of this model is that U_{it} and V_{it} are independently distributed for all $t = 1, 2, ..., T$ and $i = 1, 2, ..., n$. The *i-th* firm efficiency, at the *t-th* time of observation, is defined by $TE_{it} = \exp(-U_{it}) = \exp(-Z_{it}\delta - W_{it})$ and is based on a conditional mean of the given hypotheses. It is important to note that $Z_{it}\delta + W_{it} \rangle Z_{i't}\delta + W_{i't'}$, for $i \neq i'$, does not necessarily imply $Z_{it'}\delta + W_{it'} \rangle Z_{i't'}\delta + W_{i't'}$, for $t' \neq t$. It follows that the same order of the DMUs, in terms of technical efficiency of production, does not apply in all periods.

3. Applying the Battese and Coelli's (1995) Stochastic Frontier Model to the Efficiency Analysis of Brazilian Multi-Asset Pension Funds

These papers adopt the following empirical version of the stochastic frontier analysis model for panel data (equations 1 and 3), respectively:

$$lnRENTA_{it} = \beta_0 + \beta_1\, lnRISCA_{it} + \beta_2\, lnPATLA_{it} + V_{it} - U_{it} \tag{4}$$

and

$$U_{it} = \delta_0 + \delta_1\, TEMPO_{it} + \delta_2\, RENTS_{it} + \delta_3\, RISCS_{it} \tag{5}$$

where:

$RENTA_{it}$ is the profitability of the *i-th* fund in the *t-th* year, expressed as a percentage, for i = 1 to 170 and t = 1(2013) to 5(2017) – these indexes are also valid for the other variables of the model;

β_0 is the constant coefficient (profitability frontier intercept), β_1 and β_2 are the explanatory variables coefficients, $RISCA_{it}$ (annual risk – in standard deviation units of monthly profitability) and $PATLA_{it}$ (annual net worth – in R$ 1.00), respectively;

V_{it} s are the stochastic shocks;

U_{it} s are non-negative random variables, associated with technical inefficiency of profitability, which have, by assumption, truncated normal distribution with mean, $Z_{it}\delta$, and variance, σ^2;

Z_{it} is a vector of explanatory variables (equations 3 and 5) associated with technical inefficiency of the funds, defined by the time in years, $TEMPO_{it}$, the semi-annual profitability, $RENTS_{it}$ and the semi-annual risk, $RISCS_{it}$; δ_o is the constant coefficient; δ_1, δ_2 and δ_3 are the coefficients for the time, semi-annual profitability and semi-annual risk variables, respectively.

The explanatory variables *RISCA* and *PLATA*, included in the profitability function (equation 4), were defined because they are the most common in studies and researches on investment fund returns found in specialized literature. The use of the explanatory variables, *TEMPO*, *RENTS* and *RISCS*, in the inefficiency function (equation 5), was intended to verify the directions and magnitudes of their influences on efficiency, regarding the time trend, the semi-annual risk and return. The definition of these last two variables follows, partially, the understanding of Ceretta and Costa Jr. (2001).

It was decided to research the multi-asset pension funds, among other Brazilian investment funds, due to their importance in social and economic development and to their evolution dynamics in recent years. Monthly data, restricted to variable-income operations, were collected, upon authorization, on the website of the Brazilian Association of Financial and Capital Market Entities (ANBIMA), considering the 170 funds that remained active from 2013 to 2017. This time frame was defined because it contains information of events prior to, during and after the Brazilian economic crisis faced by the market at that time.

4. Results, Verification e Interpretation

In the quantification of the stochastic frontier panel of efficiency of Brazilian multi-asset pension funds was performed using the software FRONTIER version 4.1, available on the website of the *Centre for Efficiency and Productivity Analysis* (CEPA, 2018), which follows Battese and Corra's (1977) parametrization, where σ_V^2 and σ_U^2 are replaced, respectively, by $\sigma^2 = \sigma_V^2 + \sigma_U^2$ and $\gamma = \frac{\sigma_U^2}{\sigma^2}$, with the objective of measuring the influence of the one-tailed component on the global variance, i.e., the relative importance of the inefficiency term in the panel estimation. In such conditions, γ must be bounded between zero and one.

This estimation process works with two vectors of explanatory variables. The first vector influences the profitability level in the frontier (Equation 4); and the second, influences the technical inefficiency (Equation 5). These features are satisfied in the stochastic frontier model for efficiency with panel data, conceived by Battese and Coelli (1995). The final results of the estimation of the profitability and inefficiency equations are presented in Table 1.

Table 1. Final result of the estimation of the efficiency stochastic frontier panel for Brazilian multi-asset pension funds

The final mle estimates are:			
	coefficient	standard-error	t-ratio
Equation 4			
β_0	0,25108767	0,013568623	18,505021
β_1	-0,012441340	0,0014380878	-8,6513080
β_2	0,0023938902	0,00088529451	2,7040608
Equation 5			
δ_0	0,28053627	0,0090085033	31,141274
δ_1	-0,0026499754	0,00099292692	-2,6688524
δ_2	-0,011745889	0,00034643550	-33,904981
δ_3	-0,0044105516	0,0013992672	-3,1520438
log likelihood function = 1722,8167			
LR test of the one-sided error = 1248,9436			

Source: Data were processed by the authors using FRONTIER 4.1 software (CEPA, 2018).

All coefficients are statistically significant at 1% levels, as shown in Table 1. It can also be seen that the application of the stochastic frontier panel for inefficiency effects is statistically justifiable, as demonstrated by the one-tailed likelihood-ratio test (LR = 1248.9436).

Regarding the empirical interpretation of the coefficients β_1 and β_2, variations in the annual risk and net equity, over the five-year period, were reflected, respectively, inversely and directly in the annual profits of the funds.

The risk-return ratio, widely accepted in finance, which states that the higher the risk managers undertake, the higher the expected return; and the lower the risk, the lower the expected return - did fail. The negative sign and the statistical relevance of β_1, suggest the opposite, indicating that funds which assumed higher risks, in general, yielded lower returns, and was consistent with the paper of Santos, Tusi, Costa Jr. and Silva (2005), who found similar results.

In turn, contrary to the assessments made by Grinblatt and Titman (1989), Ciccotello and Grant (1996), Chen, Hong, Huang, and Kubik (2004), Chen and Chen (2009), the increases in equity had direct impact – positive sign of β_2 – on the increase of the annual profit. The direct impact of the fund's size – represented by the equity value – over its profitability, corresponds to the findings of Latzko (1999), Heaney (2007), Milani and Ceretta (2013) and

Moura and Fonseca (2015), meaning that the greater the amount of resources available to managers, the better were their strategic choices; and the more favorable became the opportunities to achieve a better performance in the future. This can also be interpreted as the influence that the size of the fund exerted on the investors' choice; or, as the trend that funds with higher returns over a period, began to receive greater contributions in the following periods.

With respect to the estimation of the inefficiency function, all coefficient estimates reveal inverse relationships.

In the case of δ_1, it indicates that over the years, fund managers have generally managed to decrease inefficiency rates (their inefficiencies have decreased). This is proven by the increased average annual efficiency of the funds. (See Table 2)

Table 2: Average annual efficiency of the funds

2013	2014	2015	2016	2017
0.746732015	0.806130203	0.815439579	0.827784944	0.820501022

Source: Data processed by the authors.

The estimate of δ_2 indicates that the half-year profit growth tended to be followed by a reduction of the funds' annual inefficiency levels, pointing out that the profitability achieved in each half-year of the period had an impact on managers' behavior, making them more confident to reach higher levels of efficiency.

Finally, the negative sign of the coefficient δ_3, shows that the semi-annual risk growth led to reductions in the annual inefficiency index, which can be explained by the fact that managers, seeking to increase fund returns, managed to be more efficient when faced with higher risks.

5. Conclusions

In this paper, we used the SFA (Stochastic Frontier Analysis) approach to evaluate the efficiency of Brazilian multi-asset pension funds and assess the skill level of managers to produce higher results than the benchmarks. The analysis was carried out considering the 170 funds that remained active from 2013 to 2017, which encompasses the period before, during and after the Brazilian economic crisis.

Empirical results show that fund managers have positively contributed, over the years, to the efficiency ratios in general terms, due to their performance in the biannual earnings and risk management. In the first case, the contribution came significantly from advances in increasing half-year profit; and in the second case, because managers, seeking to increase the funds half-year profit, managed to be more efficient in the face of greater risks.

In terms of profitability, over the five-year period, in general terms, the variation in annual risk and equity reflected inversely and directly, respectively, on the annual funds' profits. The risk-return ratio indicates that the funds which assumed higher risks, in general, had lower returns. On the other hand, the fund's size - represented by the equity value over its profitability, had a direct impact on both managers' and investors' decisions. For the former, the greater the amount of available resources, the better their investment choices were; and, for the latter, it weighed into their selection criteria.

Considering the recent approval of the Brazilian Social Security System reform, the topic addressed in this paper is recognizably both up-to-date and relevant. This reform is inserted into the new government's agenda which intends to institutionalize new management practices, decidedly efficient and effective, especially regarding managers' conduct. Under such conditions, we recommend the replication of the preliminary results found, including for other types of pension funds, explanatory variables and observation periods, in different data modeling.

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