Analysis of the model DEA-CCR in the selection of investments of the Pension Funds Entities.

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Abstract. The present work aims to show an assessment of the CCR model of Data Envelopment Analysis in the selection of actions in the Brazilian market, observing the rules relating to the application of technical reserves are guarantors of the actuarial benefits of the Pension Fund Entities. We analyze alternative parameters to those suggested in the literature for the DEA-CCR model. The study found significant results for the period between 2001 and 2007, achieving returns about three times higher than those obtained by these entities when they use passive investment techniques. As a result of this study was carried out a software tool that can be used for this specific purpose.

Keywords: Portfolio Selection, DEA, Stock Market, Pension Funds.

1 Introduction

Over the past year we have seen a profound professionalization of the private pension sector in Brazil. This has been required by the legislation and by the expectation of decreasing real interest rate charged by the financial market, mainly due to structural improvements occurring in the Brazil. This fact makes difficult to obtain consistent returns without a solid and long-term investment policy. Until the 90s, the Closed Entities of Private Pension allocated its financial resources primarily in fixed income segment (government bonds), since they made possible returns sufficient for efficient return on pension reserves. Actually, with the recent investment grade earned by Brazil and the constant decline in real interest rates, the need for increasing investments in equities segment (and related actions). So, the present study aims at an efficiency comparison between the use of the tool DEA - "Data Envelopment Analysis" in the selection of asset allocation and passive in the Corporate Governance Index, besides presenting the traditional methods used by the financial market for asset allocation in equities segment.

On section 2 we describe the operations of equity investments in private pension funds. Section 3 presents an overview of the Brazilian financial market behavior and indicators that govern it. Sections 4 and 5 present the DEA in the context of implementation of the financial market. On sections 6 and 7 we evaluate and show the results of the DEA-CCR model in the context of applications in the Brazilian stock market for the period 2001 to 2007.
2 Operationalizing the Entities of Pension Funds

The Private Pension Entities are responsible for paying benefits for a limited period or indefinitely to participants. Overall benefit plans receive contributions from its participants for a certain period and the second funding plan previously designed by an actuary. Cited contributions are administered by applying them in the various financial market segments in order to promote the returns that will ensure the remaining amount required for the payment of postretirement benefits for the period described in the hiring of these. Historically, the Brazilian federal public debt provided to these entities a way to invest their resources without risk and with high rates of return, well above those required in their design. These rates range between 12 or 13% real over the years when the maximum legally allowed in the design of the plans was 6%. So there has never been great concern on how to invest their financial reserves. Because of this "asset allocation" in some companies who made mainly in fixed income segment, federal government such small parcels were invested in real estate and equities. But it appears that in recent years have seen profound structural transformations in global economies have been crowned with the Investment Grade assigned to Brazil for two agencies rating international. There is therefore a profound decrease in financial returns generated by federal government securities that now range between 3% and 5% per year, with projections from 2% to 3% in the short term. These projections are no longer sufficient for a proper appraisal of pension reserves, since generally require return of 6%, and required the migration of the fixed income segment for the segment of equities, mainly shares. In most developed economies, which received the degree of investment, the variable income segment is what can provide the returns needed to pay their pension plans.

3 The Financial Market and Investment Selection Techniques

Variable income segment have basically two types of management: passive and active. In passive management, the investor only replicates certain index (IBOVESPA, IGC, IEE, among others), requiring only to buy a portfolio similar to provisions in the index composition is published at regular intervals by the Stock Exchange of St. Paul. In active management, the investor prepares its portfolio that seeks to achieve returns higher than market rate, thus causing a high dispersion of returns in relation to the aforementioned index. Considering the context of investing optimized we activates the resources of private pension funds in the variable income segment, which is presented as an alternative to data envelopment analysis. It is clear that modeling tools like Markowitz deal so only the returns and volatility of past prices to suggest a portfolio of investments. Other tools, such as fundamental analysis, using static information in many cases, they despise the risks involved in past returns and their correlation with market assets in general, thus disregarding the effect of diversification. Tools such as technical analysis also downplayed the effect of diversification. So, it is necessary a tool capable of evaluating multiple criteria simultaneously and select the assets that have better efficiency in the sets of criteria. Thus we suggested the use of envelope data analysis, as described in Oliveira (2009).
4 Data Envelopment Analysis in Financial Markets

In 1978, Charnes, Cooper & Rhodes Farrel widespread study of both in order to work with multiple sources and multiple results, and to obtain an indicator that meets the concept of Koopmans efficiency. The Data Envelopment Analysis - DEA (or DEA Data Envelopment Analysis), as presented by Charnes, Cooper and Rhodes (1978) states that DEA "is the use of mathematical programming for" ex post facto "the relative efficiency of results of the managers, whether planned or executed."

The data envelopment analysis can be considered as a set of concepts and methodologies with various possibilities of interpretation (Charnes et al. In 1978, Cooper, Lewin and Seiford, 1994). The proposed models most widely used since then are:

1. CCR model (1978) - developed by Charnes, Cooper and Rhodes (1978), which allows an objective assessment of the overall efficiency and identifies the sources and estimated amounts of inefficiencies identified;
2. BCC (1984) - created by Banker et al. (1984) distinguishes between technical and scale inefficiencies by estimating pure technical efficiency, according to a given scale of operations, and identifying whether these economies of scale are increasing, decreasing and constant.

Various definitions of data envelopment analysis can be found in the literature in the context of portfolio selection. One can use the following, second Pigatto (2005), George et al. (2004:1), Cooper et al (2004).

This methodology allows "identify the empirical production frontier, identify the units best practice, provide a reference set (efficient units) for the inefficient units, providing scores (in) efficiency and suggest multiple targets for achieving efficiency." Lopes (1998) also refers that DEA compares the performance of the decision-makers with the best performance achieved on rather than comparing them with standards considered ideal, but nevertheless unattainable.

The mathematical formulation of the original CCR model can be given (and Ceretta Niederauer, 2000) by:

Maximize $h_k = \sum_{r=1}^{s} u_r y_{rk}$, $k=1,...,n$ (7)

Subject to

$\sum_{r=1}^{m} u_r y_{ij} - \sum_{i=1}^{n} v_i x_{ij} \leq 0$, $j=1,...,n$ (8)

$\sum_{i=1}^{n} v_i x_{ik} = 1$, $k=1,...,n$ (9)

$u_r, v_i \geq 0$, $r=1,...,m$, $i=1,...,n$ (10)

$y$ = products; $x$ = input; $u, v$ = weights; $m$ = number of products; $n$ = number of inputs.

The original formulation of the CCR model is oriented to inputs in order to minimize the consumption of raw materials to produce the minimum level of production as expressed by maximizing the sum of the quantities produced multiplied by their weights. The constraint (8) can be regarded as the result of the production unit, since it is the difference between the sum of the quantities produced and the sum multiplied by the weights of the quantities consumed of the inputs multiplied by the weights. In constraint (9), the sum of the product of the quantities of resources consumed by specific gravity is equal to 1, so if the firm k is
efficient, \( h_k \) is equal to 1.

Applications of DEA can be seen also in the selection and evaluation of financial assets. Ceretta and Costa Jr. (2001) promote the use of data envelopment analysis in investigating the performance of investment funds in stocks. They also suggested the DEA model as an alternative assessment funds invest in stocks when compared to traditional forms that take into account only the volatility (risk) and return (performance).

The study used the database contains 106 (one hundred and six) investment funds in the form of free portfolio, taken in the period 1997 to 1999. We used a total of three inputs (level of risk at one year, risk level in two years and the administration fee) and two products (average monthly return in a year and the average monthly return in two years). The results identified seven dominant funds, which were compared with seven funds less efficient ones to their differences in terms of attributes and weights, even as Ceretta & Costa Jr. (2001).

Jennifer Power & Patrick R. McMullen (2000) used the DEA model to evaluate a set of 185 shares of the U.S. market. Considered as outputs attributes that are beneficial to the actions and inputs attributes that are considered undesirable costs. The authors used a total of eight items, and five output (Return 1, 3, 5 and 10) and three input (price-earnings, beta and sigma). The article selected a total of 14 actions as efficient among the four subject to review and close to the efficiency. According to the authors the advantages of this model is that it provide information of how much to improve the entries to make the stock near the efficiency efficient.

5 Methodological Procedure

The nature of this research is quantitative, descriptive and exploratory, since the objective is to conduct a comparative evaluation of traditional methods of selection of portfolio shares and the application of Data Envelopment Analysis - DEA through the CCR model and offers greater familiarity with the methodologies mentioned.

The work of Jennifer Powers & Patrick R. McMullen (2000), and Ana Lucia Miranda Lopes (2006) are taken as the main references of this study. Lopes (2008:7) states that the process of building a portfolio must contain the following steps: gathering information on possible indicators of efficiency of the asset (step 1), selection of indicators that make up the model (Step 2), treatment of indicators (Step 3), choice of DEA model to be used (etapa4), application d DEA model chosen (Step 5), identification of assets that comprise the portfolio (Step 6) and evaluation of portfolio performance (Step 7). To optimize the pool of assets available to the model we create a "step zero" in which we applied an initial filter which we tested the actions that would be used in this study. For this study we evaluated the two major portfolios in the market, ie those that generate the IBOVESPA and IGC. It was shown, through regression techniques, the number of active trainers PMI premium is paid by the highest level of transparency.

We used as source of information the site of BOVESPA, in addition to the software Economática ® and Excel ®. The information relates to the period between 2001 and 2007. For Steps 1, 2, 3, 5, 6 and 7, we developed an application that allows the user to the system have the freedom to experiment with various input and output attributes, and change the subset of assets to be considered and their parameters. According Pigatto (2005) "for data to be used in evaluating the DEA, they need to be
standardized, or better standard. This action does not affect the final result, but makes the data closer to avoiding the disparity of the data.” So we proceeded to the standardization of the attributes, using the following formula as Power & McMullen (2000):

$$Z_{ij} = \frac{(X_{ij} - \bar{X}_j)}{\sigma}$$ (15)

$Z_{ij}$ = i the result of action for indicator j; $X_{ij}$= value of indicator j for stock i; $ar{X}_j$= average of the indicator j for all actions; $\sigma$= standard deviation of the indicator j.

According to Pigatto (2005) it is necessary also the rescaling and subsequent normalization, thus avoiding the presence of unacceptable negative values in the model. Such procedures are possible from the equations (16) and (17) below:

$$RZ_{ij} = \text{Abs}(\text{Min} Z_j) + Z_{ij},$$ (16)

$$MRZ_{ij} = \frac{RZ_{ij}}{\text{Maximo da coluna}},$$ (17)

$RZ_{ij}$, is re-scaled value for each attribute j; $MRZ_{ij}$, is the standardization of stock i on attribute j;

At step 3, on which have been standardized, and re-scaled normalized all indicators are available on the application, developed for this purpose. The fourth step is the selection of the DEA model for the implementation of portfolio analysis.

Maximize $h_i = \sum_{r=1}^{s} u_{ij}O_{ij}$, $i=1,...,n$ (18)

Subject to

$$\sum_{j=1}^{s} u_{ij}O_{ij} + \sum_{j=1}^{n} v_{ij}I_{ij} \leq 0, i=1,...,n$$ (19)

$$\sum_{j=1}^{n} v_{ij}I_{ij} = 1, i=1,...,n$$ (20)

$$u_r, v_i \geq 0, r=1,...,s, i=1,...,n$$ (21)

$O$ = products; $I$ = input; $u$, $v$ = weights; $n$ = number of inputs; $s$ = number of products.

According Powers & McMullen (2000) the weights must be between 0.2 and 5. Therefore, we have, for the products and restrictions for the inputs (22) and (23) the following:

$$0.2 \leq \frac{u_i}{u_{i+1}} \leq 5, \quad i=1,...,n-1$$ (22)

$$0.2 \leq \frac{v_i}{v_{i+1}} \leq 5, \quad i=1,...,n-1$$ (23)

6 Analysis and Results

Were considered for producing the actions of the Bovespa and given in the IGC - Corporate Governance Index and its parameters observed in the period between 2001 and 2007. It was found that the frequency of generation of portfolios has an impact on overall profitability,
and for the data set studied the best return was the order of 1250.70% for the period between 2001 and 2007 against the return of passive portfolio of IGC 595.41% for the same period. The return of the annual allocations for the same period was around 347.24%, or less than the passive portfolio of the IGC. This is due to not taking advantage of high volatility in this market.

7 Conclusions

The DEA-CCR model showed amazing results, beating around three times the values obtained by the index adopted by private pension portfolios, IGC, in the assessments between the Jul/2002 and Dec/2007. The result of the consistency analysis shows that the card obtained by CCR-DEA model provides a more positive than negative deviations compared to those obtained by IGC, allowing to infer the robustness of the model form in good yield portfolios.

8 References


