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Evolutionary models in cash management policies with multiple assets

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ABSTRACT

This work aimed to apply genetic algorithms (GA) and particle swarm optimization (PSO) in cash balance management using multiple asset investments. This problem consists of a stochastic model that does not define a single ideal point for cash balance, but an oscillation range between a lower bound, an ideal balance and an upper bound. Thus, this paper proposes the application of GA and PSO to minimize the total cost of cash maintenance, by obtaining the parameters of a cash management policy with three assets (cash and two investments), and using the assumptions presented in literature. Computational experiments were applied in the development and validation of the models. The results indicated that both the GA and PSO are applicable in determining the cash management policy, but with better results for the PSO model.

1. Introduction

Management of the available cash balance is a constant problem in all organizations. This is due to the daily in- and outflows of cash, whether by the activities of the company or financial transactions that it had negotiated. Thus, there is need to control financial resources to obtain the best result for the organization.

In this way, the function of cash management has responsibilities such as to mobilize, control and plan the financial resources of the companies (Srinivasan and Kim, 1986). With this, the use of models to support the decision-making with the application of metaheuristics becomes pertinent, since they can provide a comprehensive and optimization view of something that hardly can be obtained without using methodologies (Vob, 2001).

So, the use of models in the problem of defining the ideal level of available cash balance has arisen from the studies of Baumol (1952) and Tobin (1956), where the authors start with the assumption that the available cash can be defined as a commodity in inventory, i.e., a standardized-good, whose control can be done daily, weekly, monthly, etc., depending on the level of temporal details of the company.

For these authors, defining the optimal cash balance follows the standard of the inventory lot size models, where it is considered the available financial resource as an inventory, which has some costs associated with its origin and maintenance, but that it also generates indispensable benefits for the organization. Meantime, the application of the models of Baumol and Tobin is not possible for comparative purposes, due to the limitation of the models.

Considering this, the definition of the cash balance starts with having a quantitative approach to promote the optimization of this financial stock in order to minimize the costs associated with the maintenance or lack of cash. Posteriorly, Miller and Orr (1966) defined the cash balance as having an uneven fluctuation, characterizing a random variable, and proposed a stochastic model for the cash balance management.

Thus, understanding the reasons why the organizations have the need to keep cash resources is essential for a better financial management. Following this reasoning, Brealey and Myers (2005) pointed out four reasons for the maintenance of cash balance:

- Transactions — financial funds held in cash to meet commitments in view of the time lag between the outflow (payment) and inflow (receipt) of cash;
- Precaution — resources held in cash to maintain a safety reserve for contingencies;
- Speculation — funds held in cash to take advantage of opportunities to obtain discounts or favorable applications;
- Bank reciprocity — resources held in current accounts to meet the requirements of some banks as consideration.

Nevertheless, defining the amount of money to be maintained in cash is not easy to understand or perform. Another relevant factor in the policy management of cash balance management depends on constraint factors.

In United States of America, data from Economática for the period from 2006 to 2010 indicate that U.S.A. companies (non-financial) with shares traded in stock exchange, had a weighted average balance of availability of 11.98% in the period (Table 1).

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Table 1
Contribution of the cash in the total of assets — U.S.A. non-financial companies' activity (elaborated by the authors).
Source: Economática (2012).

U.S.A.	2010	2009	2008	2007	2006
% cash (average)	14.84%	15.07%	12.59%	13.07%	13.08%
Standard deviation	15.02%	15.33%	14.53%	15.31%	15.96%
Size (total assets — average)[a]	12,993	11,973	11,401	11,561	10,434
Number of companies	900	938	949	976	993

[a] Millions of dollars.

In this way, this study aims to present a comparison between two computational methods for determining the optimal level of cash, using as basis the model proposed by Miller and Orr, defining a complete cash management policy.

In order to meet the proposed problem, the general goal of the research is to develop a policy for available cash balance management, based on the assumptions of cost minimization, presented in Miller and Orr model, but using different transaction costs and more than one single investment, by using one with immediate liquidity and the other with variable days for selling the bond, and by using genetic algorithms (GA) and particle swarm optimization (PSO) for its parameterization.

The following methodology is used to achieve the proposed objective:

- Simulate historical series of cash flows, based on assumptions observed in literature about the subject;
- Develop the model of genetic algorithms and particle swarm optimization that have as objective function to minimize the cost of maintaining a cash balance;
- Perform experimentations with the models developed in the simulations of the cash flows and comparatively analyze their results, observing advantages and perspectives.

The present study focused on the quantitative methodology of financial management. For this are used the techniques of genetic algorithms and particle swarm optimization in the development of a cash balance model, requiring the introduction of the concepts to be applied in addressing the problem, as well as the method proposed for its elucidation. Hereafter the theories that support this study are presented, first of all, by reviewing the concepts of cash balance management and the models of genetic algorithms and particle swarm optimization.

2. Cash management models

The cash management models were originated from the work of Baumol (1952). In this study, the author draws a parallel between the cash and the other of the companies.

In the case of the inventories in general, the most common approach according to Slack et al. (1997), when it is needed to define the stock replenishment is the economic order quantity (EOQ), which aims to find the better positioning between advantages and disadvantages of owning inventory.

Despite that, the EOQ has restrictions when using the assumptions of fixed and predictable demands, as well as instant deliveries when stock replenishment is requested (Slack et al., 1997).

According to Baumol (1952), the cash balance can be seen as an inventory of a means of exchange. In this model, adapted from the EOQ for the cash optimization, the optimal configuration is obtained as a function of the relationship between the opportunity cost and the transaction cost. In the model, the transaction cost increases when the company needs to sell bonds to accumulate cash; and the opportunity costs increase with the existence of cash balance, since it is an application without revenue (Ross et al., 2002).

The model analyzes the cost associated with the maintenance of cash balance, i.e., the cost of opportunity determined by the interest that the company does not receive by not applying the resources, and the cost of obtaining cash by the conversion of investments into cash (Ross et al., 2002). The transaction cost represents the expenditure incurred in the application or redemption of financial resources, such as fees and taxes. Posteriorly, Miller and Orr (1966) presented a model that meets the randomness of cash flows, despite still considering the existence of only two actives, cash and investment, in which the latter represents a low risk option with high liquidity (Fig. 1).

In this model, two bounds are defined for the level of cash balance: the lowest and the highest, so that, when achieving the maximum level (time T1), represented by the higher bound (H), the application of resources is performed, in an amount that provides the cash balance back to the optimal level (Z). And, when reaching the minimum level (time T2) in the lower bound (LB) it should be made a ransom to obtain an optimal level of cash (Ross et al., 2002).

Thus, when working on the liquid cash flows (inflows minus outflows), the Miller–Orr model allows the optimization of the cash, based on the transaction costs (represented by F) and opportunity (represented by K), by obtaining the following equation (Ross et al., 2002):

$$Z* = \sqrt[3]{3F\sigma^2/4K} + LB$$

where the "Z*" denotes optimal values and σ^2 is the variance of liquid cash flows. Even with the gain in relation to the Baumol model, by considering the unpredictability of cash flow, the Miller–Orr model requires the definition of the lower bound (LB), i.e., the risk of cash shortage, associated with a minimum safety margin, depends on the administration choice and it is not treated in the model.

Therefore, the definition of the lower bound (LB) impacts the cash cost and the risk associated with cash shortage, since the lack of LB indicates a company that does not maintain a minimal precautionary background.

At this point lies the problem which is addressed in this study. Once the Miller–Orr model does not define the lower bound, it is necessary to use the GA and PSO for this problem in order to find the optimal policy that is able to minimize the cost of cash maintenance. Besides, the original model has the limitation of one single investment, and assumes a fixed cost of transaction.

Moreover, most studies have used the same assumptions of the original models, mainly of Miller–Orr, differing by a stochastic modeling of the problems, such as the studies developed by Tapiero and Zuckerman (1980), Milbourne (1983), Hinderer and Waldmann (2001), Baccarin

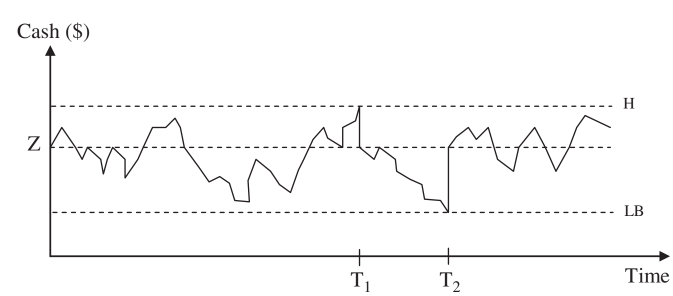

Fig. 1. Variation of the cash flows.
Adapted from Miller and Orr (1966).