Available online at www.sciencedirect.com
ScienceDirect
Expert Systems with Applications 36 (2009) 2727–2734
Expert Systems with Applications
www.elsevier.com/locate/eswa

# A partitioned portfolio insurance strategy by a relational genetic algorithm

Jiah-Shing Chen, Yao-Tang Lin *

*Department of Information Management, National Central University, Jhongli 320, Taiwan*

**Abstract**

This paper proposes a new portfolio insurance (PI) strategy named partitioned portfolio insurance (PPI) strategy and a new relation-based genetic algorithm named relational genetic algorithm (RGA) to optimize the proposed PPI strategy. Our PPI strategy extends the traditional PI strategy to become a more aggressive one. In our PPI strategy, we attempt to correctly partition the portfolio into several similar sub-portfolios and then insure the sub-portfolios individually. It not only avoids the downside risk, but also further explores the upside profit successfully. In addition, our RGA which adopts a relational encoding and has a set of problem-independent operators is designed to solve the induced portfolio partitioning problem. The relational encoding eliminates the redundancy of previous GA representations for partitioning problems and improves the performance of genetic search. The problem-independent operators we redesigned manipulate the genes without requiring specific heuristics in the process of evolution. Moreover, our RGA works without requiring a preset number of subsets in advance. Experiments for developing optimized PPI strategies by RGA are performed. Experimental results show that our optimized PPI strategies are significantly better than the traditional PI strategy and our RGA works well for solving the portfolio partitioning problem.


*Keywords:* Partitioned portfolio insurance (PPI) strategy; Relational genetic algorithm (RGA); Grouping genetic algorithm (GGA); Relational encoding

## 1. Introduction

In practice, portfolio insurance (PI) strategies are the most popular way to protect the investment assets. However, traditional PI strategies are defensive and passive as the downside risk-aversion is their primary concern. They avoid the downside risk with passive insurance mechanism, and are highly dependent on the underlying portfolio and the rebalancing frequency (Bird, Dennis, & Tippett, 1988; Rubinstein, 1985). Besides, they may incur a large amount of trading costs, including capital loss and transaction fee, from repeated buying high and selling low in flat markets. Several rebalancing disciplines, such as time discipline and market move discipline, have been proposed to address this problem, but no single discipline can effectively reduce costs in all market situations and the trade-off between precision and cost has to be considered (Etzioni, 1986). For these reasons, more aggressive PI strategies are needed.

To create a more aggressive PI strategy, this paper develops a partitioned portfolio insurance (PPI) strategy by partitioning the portfolio into several similar sub-portfolios and then insuring the sub-portfolios individually. Since the securities in the portfolio often have different price movement patterns in the same period, if we can correctly partition the portfolio into several sub-portfolios with similar price movement pattern and then insure the sub-portfolios individually, we will be able to capture the upside potential of rising sub-portfolios and to avoid the downside risk of falling sub-portfolios simultaneously. As a result, the PPI strategy has a better chance to outperform traditional PI strategies.

In addition, to analyze which kinds of partitions can produce good performance, a simplified model of PI and PPI strategies is built and the portfolio partitioning

* Corresponding author.
*E-mail addresses:* jschen@cc.ncu.edu.tw (J.-S. Chen), ytlin@mgt.ncu.edu.tw, david@timeshare.club.tw (Y.-T. Lin).

0957-4174/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2008.01.081

problem is then induced. The portfolio partitioning problem, which has no natural heuristic and has a variable number of subsets, is a special set partitioning problem. The set partitioning problem belongs to the class of NP-hard problems (Holland, 1975), many of which have been solved by genetic algorithms (GAs) due to their comprehensive search capability. However, previous works of applying GAs to solving the partitioning problem have the drawbacks of redundant encoding, heavy dependence on problem-specific heuristics, or requiring a preset number of subsets (Brown & Sumichrast, 2005; Eiben, van der Hauw, & van Hemert, 1998; Falkenauer, 1992; Jones and Beltramo, 1991; Smith, 1985). Therefore, a new relation-based genetic algorithm named relational genetic algorithm (RGA) is designed in this paper to solve the induced portfolio partitioning problem.

In our RGA, a relation-oriented representation (or relational encoding) is adopted and corresponding genetic operators are redesigned. A chromosome of relational encoding is represented by an equivalence relation matrix. Since the class of equivalence relation matrices has a 1–1 and onto correspondence with the class of all possible partitions, the relational encoding eliminates the redundancy of previous GA representations and improves the performance of genetic search. The generalized problem-independent operators we redesigned manipulate the genes without requiring specific heuristics in the process of evolution. Moreover, our RGA works without requiring a preset number of subsets.

Experiments for developing optimized PPI strategies by RGA are performed. Experimental results show that our optimized PPI strategies are significantly better than the traditional PI strategy and our RGA works well for solving the portfolio partitioning problem.

The rest of this paper is organized as follows. Section 2 reviews traditional PI strategies. Section 3 develops our partitioned portfolio insurance strategy and describes the induced portfolio partitioning problem. Section 4 reviews partitioning problems and previous GAs for solving them. Section 5 describes our relational genetic algorithm. Section 6 presents some experimental results which demonstrate the feasibility of the PPI strategy and the RGA. Finally, conclusions and future works are summarized in Section 7.

## 2. Traditional portfolio insurance strategy

Portfolio insurance is a specialized form of hedging which not only avoids the downside risk but also keeps the upside potential for the insured portfolio (Abken, 1987). Investors pay few insurance premiums for their portfolios and defensively protect the positions they hold.

Two types of approaches for portfolio insurance have been proposed in the past and are described in following subsections, i.e., static and dynamic approaches. Their bottlenecks that have to be addressed are described at the end of this section.

### 2.1. Static approaches

Static approaches initiate active security positions and corresponding derivatives from the start, and then hold them until maturity. The most typical strategy of static approaches is protective put. It consists of some index-futures and corresponding put options. The put options conceptually play the role of insurance policy, and the costs of them can be treated as insurance premiums. Investors use them to offset the downside risk of index-future positions.

Static approaches are very simple, but they have some limitations in practice which include limited specifications of derivatives (particular underlying assets and exercise prices), short maturities, and lack of early exercise rights (Abken, 1987). Owing to the limitations of static approaches, dynamic approaches are usually adopted in practice.

### 2.2. Dynamic approaches

Dynamic approaches distribute capital into two types of assets, active securities and risk-free securities, and then vary the active security position dynamically and continuously. In the process of varying positions, a trade-off between precision and cost has to be considered, and rebalancing disciplines are required (Etzioni, 1986). As a result, a complete dynamic PI strategy should be composed of an effective dynamic insurance mechanism and an appropriate rebalancing discipline.

Dynamic insurance mechanisms focus on the insurance capability. They create similar effect of static approaches via repeated buying high and selling low without having the above-mentioned limitations of static approaches. Two types of mechanisms have been proposed and adopted in practice, i.e., model-driven mechanisms and equation-driven mechanisms. A model-driven and dynamic option-based portfolio insurance (OBPI) approach, named synthetic put option (SPO) strategy, simulates static protective put strategy by dynamically position rebalancing according to the famous Black–Scholes option pricing model (Rubinstein & Leland, 1981). In addition, some simple equation-driven approaches, such as constant proportion portfolio insurance (CPPI) strategy (Black & Jones, 1987), time invariant portfolio protection (TIPP) strategy (Estep & Kritzman, 1988), and modified stop loss (MSL) strategy (Bird et al., 1988), can also be easily implemented by rebalancing according to some simple equations.

On the other hand, rebalancing disciplines (exposure-adjustment strategies) describe the timing and ratios of exposure adjustments. Appropriate rebalancing disciplines facilitate insurance effect and cost reduction for PI strategies. Etzioni proposed three traditional rebalancing disciplines which include time discipline, market move discipline, and lag discipline. Time discipline defines that full adjustments are taken at a fixed time period. Market move discipline defines that full adjustments are taken