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Evaluating the efficiency of currency portfolios constructed by the mining association rules

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ABSTRACT

We propose a new portfolio, an association currency portfolio (*ACP*), constructed by the recommendations of the mining association rules, to strengthen mean-variance efficiency. We empirically analyze the efficiency of currency portfolios using 15 countries' exchange rates denominated by the Taiwanese Dollar. Our findings suggest that the *ACPs* outperform other portfolios constructed by the Pearson's correlation model. The mining association rule is useful for recommending candidate currencies for international investors, to help them establish efficient portfolios.

1. Introduction

Currencies are investable assets which are traded between nations in foreign exchange markets. Besides facilitating the payment of bills in local currency, traders can earn profits from speculating on the movements of exchange rates, or diversify risks to balance their asset portfolios. Modern portfolio theory has suggested that holding currencies in a portfolio can efficiently diversify exchange rate risks (Addae-Dapaah & Hwee, 2009; Bergin & Pyun, 2016; Chatsanga & Parkes, 2017; Dumas & Jacquillat, 1990; He, Hkorhonen, Guo, & Liu, 2016; Kotkatvuori-Örnberg, 2016; Kristoufek & Vosvrda, 2016; Mueller, Stathopoulos, & Vedolin, 2017). Specifically, by looking at the expected return and variance of currencies, traders can construct more efficient portfolios when they seek lower variance for a given expected return.

In this study, we propose a new currency portfolio, the association currency portfolio (*ACP*), which is constructed by the recommendations of the mining association rules. An association rule is a pattern presenting the association between item sets in the data mining analysis. Our *ACPs* are constructed by selecting candidate currencies between association rules with a greater lift value, in which the lift value is a measure of the performance of an association rule in classifying cases. Therefore, our *ACPs* involve two specifications. First, investors can pick specified currencies, recommended by the association rule with greater lift value. A greater lift value means that these currencies have been classified as better than the average for all feasible currencies. Second, investors can further construct efficient portfolios composed of the recommended currencies. In contrast to making arbitrary choices, investors can trust the scientific interior mechanism of data mining techniques to pick appropriate assets. Thus, the *ACP* is reasonably constructed by virtue of its reliance on better data classifications and an interior mining mechanism.

Developing the *ACP* portfolio can bring about two benefits. First, we can examine the weights of currencies in terms of association rule. That is, the *ACP* portfolio shows the relative weights of recommended currencies. Although previous studies of mining association rules have analyzed the co-movement between item sets or assets, they have not discussed the assets' weights (Liao, Lu, & Lai, 2012; Malliaris, 2012). Second, the *ACP* may offer an alternative approach to form efficient portfolios for investors, in which the association of assets allows investors to diversify assets risks and increase returns. That is, it offers a feasible alternative to constructing portfolios which differs from the correlation portfolio approach in the Markowitz mean-variance analysis. Thus, we employ a data mining technique from the fields of big data to explore the mean-variance efficiency.

To evaluate the efficiency of *ACP* portfolios, we implement the following steps. First, we divide the sample period into two

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periods: a mining period and an evaluating period. The mining period is for mining potential association rules of candidate currencies, while the evaluating period is for evaluating mean-variance efficiency of currency portfolios. Second, we pick the currencies from all available ones by reference to the levels of lift revealed by the mining association rules, using the sample in the mining period. Third, we then construct an *ACP* portfolio made up of currencies that are recommended by the mining association rules. Fourth, the Sharpe ratio is used to evaluate the mean-variance efficiency of the *ACP* portfolio and the correlation currency portfolio (*CCP*). The *CCP* is constructed by selecting candidate currencies based on the Pearson's product-moment correlation coefficients. Specifically, correlation coefficients can provide useful information in traditional portfolio analysis, in that asset correlation dominates the power of asset diversification in Markowitz's portfolio theory. We examine whether the *ACP* strengthens the mean-variance efficiency compared to the *CCP* portfolio.

In our empirical analysis, we examine a sample of currencies from a Taiwanese investor's perspective over the period 2011–2016. To evaluate the mean-variance efficiency of *ACPs*, we calculate the Sharpe ratios for each currency portfolio. The Sharpe ratio reflects the efficiency of specified portfolios, in terms of the expected return and risk. If the Sharpe ratios of *ACP* are greater than the ratios of *CCP*, we conclude that the *ACP* is useful to strengthen the mean-variance efficiency of international currency portfolios.

In sum, we propose a new currency portfolio based on the recommendations generated by the association rule mining, and evaluate the portfolios' mean-variance efficiency. Although numerous previous empirical studies have examined the efficiency of international currency portfolio selections, we offer an alternative method by which to construct currency portfolios, namely, by using the data mining technique. Specifically, the *ACP* is reasonably constructed because the currencies themselves have interior linkages that we can discover by mining these currencies. We expect that our empirical results offer useful new evidence for international investors about currency investments.

This study is organized in four main sections. The "Methodology" section describes association rule, methodology, and data. The "Empirical Analysis" section analyzes the empirical results. In "Conclusions", we summarize our key findings.

2. Methodology

This section describes the association rule of data mining, portfolio efficiency, evaluation method, and data.

2.1. Association rule

The association rule discovers the probability of the co-occurrence of items, assets, or objectives in a dataset. The results display relationships between co-occurring items, assets, objectives. Specifically, association rule mining, one of the most widely used methods of detecting and extracting useful information from large scale data, can reveal several association relationships. Agrawal, Imielinski, and Swami (1993) first introduced the rule and define it as follows.

An association rule is in the form of $A \Rightarrow B$, where A and B are two disjoint sets of items in large databases. We refer to item A as the left-hand side (Lhs) and item B as the right-hand side (Rhs) of the association rule. The three most widely-used measures for selecting interesting rules are support, confidence, and lift. The support is the percentage of specified cases in the data that contain both A and B. The confidence is the percentage of cases containing A that also contains B. The lift is the ratio of confidence to the percentage of cases containing B. The formulae used to calculate these measures are follows:

$$Support(A \Rightarrow B) = P(A \cup B) \tag{1}$$

$$Confidence(A \Rightarrow B) = \frac{P(A \cup B)}{P(A)} \tag{2}$$

$$Lift(A \Rightarrow B) = \frac{P(A \cup B)}{P(A)P(B)} \tag{3}$$

where $P(.)$ is the probability or percentage of cases.

In this study, we employ the lift value of an association rule to pick candidate assets to construct currency portfolios.[1] The lift value of an association rule is the ratio of the confidence of the rule and the expected confidence of the rule. A greater lift value associated with specified rules indicates that these rules are potentially useful for predicting the Rhs items in future data sets. In our study, the candidate assets under an association rule with greater lift values are considered for inclusion in the currency portfolio.

We employ a classic "*apriori*" algorithm for the analysis of the association rules of data mining.[2] It is a widely-used, first algorithm which can count transactions to find the percentages of items following various rules. We implement the *apriori* algorithm by a function, *apriori*(), in the packages called *arules* (Hahsler, Buchta, Grün, & Hornik, 2010) and *arulesViz* (Hahsler & Chelluboina, 2011). Both functions, available in the *R* program, provide convenient tools for big data analyzers.

Association rule mining often results in a very large number of interesting relationships. We pick one of them based on the lift. The *arulesVIz* package further displays the results of association rule mining in visual form. In this study, we display visual results in scatter plots, grouped plots, graph plots, and parallel coordinate plots for potential rules.

2.2. Portfolio efficiency

If a portfolio offers greater expected return for a given amount of risk, we say the portfolio is more efficient. Investors can form their asset portfolio so as to achieve greater expected returns or lower risks by appropriately allocating their capital on certain assets. Specifically, Markowitz (1952) proposed a portfolio theory which demonstrated a portfolio with the highest level of return at a given level of risk, and showed that investors holding such a portfolio could not further diversify to promote the expected rate of return without accepting a greater amount of risk. Markowitz employed a portfolio frontier to show the relationships between expected return and risk, such that an optimal portfolio lay on the efficient frontier and exhibited a higher level of mean-variance efficiency.

In this study, we form the *ACP*s from the recommendations of the association rule mining, and then plot the *ACP*'s efficient frontiers to show risk-return characteristics. The investors expect to minimize their portfolio risk and decide the optimal asset weights among each of the currency they might possibly hold. The mathematical representation of the mean-variance analysis problem is as follows:

[1] There are numerous studies that have analyzed financial issues by employing the association rules, for example, Paranjape-Voditel and Deshpande (2013), Malliaris (2012), Liao et al. (2012), Liao and Chou (2013), Liao, Ho, and Lin (2008), 2011), and Kumar and Ravi (2016).

[2] The apriori algorithm is developed by Agrawal and Strikant (1994).