

Chapter I

Introduction

1.1 Background

Arbitrage is the most important concept in finance and is a fundamental mechanism for achieving efficiency in the financial markets (Ross, 1976). An arbitrage opportunity occurs when a price discrepancy exists between two or more highly related assets. It is commonly assumed that state variables of financial instruments will disallow the existence of investment strategies with riskless profit. Active investors who have rapid identification, fast transactions, and low transaction costs will exploit any arbitrage opportunity in a financial market by buying the underpriced asset and selling the overpriced asset without any risk. Therefore, mispricing is rapidly corrected in highly competitive markets (Frenkel and Levich, 1975, 1977).

Foreign exchange market is an important part of the financial market. In the global foreign market, there will be the arbitrage opportunity due to the geographically separated market, difference of operation time and information. Exchange rate arbitrage is the practice of taking advantage of inconsistent exchange rates in different markets by selling in one market and simultaneously buying in another. Examination of data from ten markets over a 12-day period by Mavrides (1992) revealed that a significant arbitrage opportunity exists. Some opportunities were observed to be persistent for a long time. There are two types of arbitrage to the forex markets: Exchange rate arbitrage and Interest rate arbitrage. Exchange rate arbitrage involved two-point and three-point arbitrage. Two-point arbitrage concerns two currencies in two different markets. Three-point arbitrage is commonly called triangular arbitrage, that is, exchange rates among different currencies may be mutually inconsistent. Arbitrageurs will then attempt to profit from these inconsistencies and in the process will eliminate discrepancies and establish mutually consistent cross-exchange rates. One can choose any currency to

start. A successful arbitrage depends on whether the currency one starts with is the same as the end currency.

In most financial markets there are always two prices for a particular financial instrument at any one time which are known as the bid and the ask price. The bid price is the price at which the market maker (the actual entity that is on the other side of the trade) will buy and therefore the rate at which you the client can sell. The ask price is the price at which a market maker will sell and therefore the rate at which you, the client, can buy. The difference between the rate at which you can sell (the bid) and the rate at which you can buy (the ask) is referred to as "the spread". For example, the current bid price for the EUR/USD currency pair is 1.5760 and the current ask price is 1.5763. This means that currently you can sell the EUR/USD at 1.5760 and buy at 1.5763. The difference between those prices is the spread. The bid-ask spreads exist in the real market. They represent an important component of the transaction costs.

1.2 Objective

This article tries to find the arbitrage opportunity with an efficient way in the international foreign exchange market. Because of the difficulty of the position, operating time and information, one needs an efficient algorithm to search for a multiple-currency arbitrage path.

Ma (2004) has developed the matrix method that efficiently searches for an arbitrage path in an N-currency market. Ma also derives a simple sufficient condition that will guarantee the presence of arbitrage opportunities. When $\lambda \max \neq n$ there exists the arbitrage opportunity. Because the assumption of Ma's work bases on the zero bid-ask spread and the bid-ask spread is an important component of the transaction cost, we try to test whether $\lambda \max \neq n$ still hold for the case with bid-ask spread, therefore, we need to modify method of Ma to get a new conclusion.

In this article, the author modifies the matrix method to accommodate the case where the bid-ask spread are nonzero. We gather three month data to illustrate the use of the

modified method and find that the sufficient condition derived from Ma's work still holds for the case of the bid-ask spread.