



# Triangular arbitrage in the foreign exchange market

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## Abstract

We first review our previous work, showing what is the triangular arbitrage transaction and how to quantify the triangular arbitrage opportunity. Next we explain that the correlation of the foreign exchange rates can appear without actual triangular arbitrage transaction.

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## 1. Introduction

Many analyses of the foreign exchange market have been done in the field of econophysics in recent years [1–8]. Most studies investigate fluctuations of one exchange rate. In fact, the foreign exchange market consists of various currencies and the exchange rates are obviously correlated to each other. We suggested [6–8] that the triangular arbitrage causes an interaction among foreign exchange rates. We

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also showed [6–8] that the triangular arbitrage makes the auto-correlation negative in a short time scale. In the present paper, we claim that the foreign exchange rates tend to keep a certain relation even if the triangular arbitrage transaction is not actually carried out in the market.

In Section 2, we give a brief review of our previous work on the triangular arbitrage. Next, in Section 3, we show that the correlation among multiple exchange rates can occur even if the triangular arbitrage transaction is not carried out.

## 2. Triangular arbitrage and rate product

In this section, we review our previous work [6]. The triangular arbitrage is a financial activity that takes advantage of three exchange rates [9]. In order to quantify the triangular arbitrage opportunities, we define the quantity

$$\mu \equiv \prod_{i=1}^3 r_i(t), \quad (1)$$

where  $r_i(t)$  denotes each exchange rate at time  $t$ :

$$r_1(t) \equiv \frac{1}{\text{yen-dollar ask}(t)}, \quad (2)$$

$$r_2(t) \equiv \frac{1}{\text{dollar-euro ask}(t)}, \quad (3)$$

$$r_3(t) \equiv \text{yen-euro bid}(t). \quad (4)$$

We refer to this quantity as the rate product. There is a triangular arbitrage opportunity whenever the rate product is greater than unity [6]. In other words, the rate product  $\mu$  represents the profit of the transaction.

Once there is a triangular arbitrage opportunity, or the rate product is greater than unity, many traders will make the triangular arbitrage transaction. This makes  $\mu$  converge to a value less than unity, thereby eliminating the opportunity. On the other hand, each rate fluctuates strongly. As a result, the rate product fluctuates around its average, yielding a fat-tail distribution. Since the distribution of the rate product has fat tails, the triangular arbitrage opportunity can appear quite often; in fact, it appears more than five percent of the time [6].

## 3. What makes the rate product converge

The feasibility of the triangular arbitrage transaction is of much interest for financial-market practitioners and researchers. In our previous study, we discussed the feasibility of the transaction and concluded that the transaction is quite possible, by analyzing the high-frequency data [6]. Unfortunately, evidence for the actual occurrence of the transaction is not available to us. We nevertheless claim that the correlation can be generated even without actual triangular arbitrage transactions.

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