FINANCIAL MANAGEMENT

CURRENCY ARBITRAGE AS A TOOL OF CORPORATE FINANCIAL MANAGEMENT

MAREK ZABOJ

Department of Economy and Management,
College of Business and Hotel Management,
Czech Republic

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Abstract: The paper is focused on using of currency (foreign exchange) arbitrage. Given the possibility of obtaining financial capital in different currencies, possible doing business with currency exchange office and other services for foreign tourists, the currency arbitrage seems to be one of the opportunities to increase economic efficiency of disposable capital in business subjects. The main goal of this paper is proposal of a new approach to foreign arbitration process with reference to the generally applicable rules in the relationship between exchange rates and places of purchase or sale of foreign currency. On the real example will be then proved this thesis. Partial aim is through mathematical derivation to determine the level of costs, from which the given operation will be profitable.

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Introduction

The importance of financial operations and their effectiveness is currently rising. It is caused mainly by applying new approaches and knowledge in international trade and the rapid development of information technology. This makes possible to improve and accelerate the forms of communication and cooperation between all subjects operating in the financial markets. This is especially, on the one hand, companies that are looking for opportunities to invest surplus funds as well as the institutions dealing with the intermediation of various financial transactions. Among the first group includes companies providing accommodation services. These entities have appropriate expectations to improve their financial situation through entering the forex market and using its potential, methods and instruments. Especially larger hotel chains that offer their services to clients from different countries can earn revenue in the form of funds in different currencies. Therefore it is necessary to consider and select the best alternative for their eventual appreciation, namely especially for portfolio managers in companies mentioned above.

Arbitrage in the broadest sense of the word means the purchase of a product in one market for immediate sale in another market to take advantage of the price differential between both markets. This technique was and still is very popular with traders and one of the most prominent arbitrage markets was between original shares traded on European exchanges and the American Depository Receipts or ADRs...
of the same company that traded in the US. This of course refers to the popular 1980s when multiple listings were still in its infantile stages and stock markets were not as integrated as they are today.

Global labour arbitrage occurs when manufacturing companies in one country or continent take advantage of lower labour costs in another to produce the same products thereby creating a higher profit margin. This technique, first named as such by Stephen Roach, PhD, Chairman of Morgan Stanley Asia and Yale University Professor, is very well described in his book “The New Asia”.

The trend of overseas production units is also commonly referred to as outsourcing but it entails more than just job displacements since it has profound long-term effects on how a global economy grows, expands and integrates. When we look around, we notice we have different types of economies, some that are largely driven by exports due to high manufacturing capabilities which are also weak in consumer demand and spending. On the other hand we have consumer spending driven economies with a lack of production and exports. This is an unnatural and unsustainable imbalance from a pure global perspective and one that will have to rectify itself over time. A rebalancing act will occur naturally over time as economies adjust to a globally integrated model and domestic economies balance their own activity between production and consumption.

The idea behind currency arbitrage is to take advantage of the price differential between spot or cash trades versus the pricing of future or forward value of the same currency. The technique can also become more complicated when several currency contracts are written or purchased among a multitude of currencies and with different execution and expiration times. As a global economy progresses over time and the exchange of goods and services expands, the currency markets start to play a more pivotal role in the underlying economic activity. Not only that, currencies become a tool all by itself that can actually influence the amounts of imports and exports purely based on value rather than economic activity.

In 1993 two US based hedge funds speculated so heavily on the value of the Pound Sterling and the Italian Lira that both currencies were temporarily forced out of the European Monetary Union, or EMU, because the respective governments were not able to defend their currencies to continue to trade within the agreed upon bandwidth. This was the first time that private capital could dethrone government capital and a sign of how currency markets and the value of currencies was no longer simply dictated by GDP growth, economic activity and reserve currencies. It was also the first time we coined the activity as “trade to carry” or what is now known as the “carry trade” among professional traders.

Since then, we have witnessed the Asian crisis in 1997-98, the Russian crisis in 1998, the US crisis in 2000 and the global crisis of 2008. Neither one of them was caused by trading activity in goods and services. On the contrary, all of them find their roots in the underpinning of it: currency trading and financial instruments. As the financial crisis continues to linger even though some Government experts deem the recession to be over and the economic growth disparity between West and East becomes more visible, the currency markets start to play a more crucial role. Instead of allowing currency values to be determined by economic activity and growth, we now witness governments artificially impacting their own currency and influencing others to simulate economic activity. By artificially devaluing or appreciating a currency, one can impact the trade balance sheet from a financial value perspective without ever
changing the volume of trade on either side of the equation. In both cases, the impact is theoretical and not representative of any increase or decrease of economic activity.

In financial crisis, as in any other previous crisis, traders and institutional investors have used the carry trade as a hedging tool rather than a trading tool, which has distorted the true exchange values of currencies in the marketplace. Besides the carry trades, which may consist of simple term contracts, swaps, reversed repos or more complex financial instruments, several Governments have also resorted to currency arbitrage but on a very different scale and with a different motive. By implementing a specific monetary policy, geared towards and focused on domestic activity, the related currency can either weaken or strengthen, thereby impacting not only a domestic economic engine but also influencing the international currency markets and other economies as well.

What may seem good policy for one does not always translate in what is good for others and certainly not in light of a global economy with such high inter-dependence. The financial crisis has also given rise to direct or indirect currency arbitrage by multiple Governments which can only exacerbate the global situation. While the currency interventions may seem justifiable from a domestic economic perspective, it certainly does not contribute positively to the health of a global economy, which begs the question whether such policies would not be better placed in light of a global economic recovery rather than being viewed as a form of protectionism.

The currency arbitrage is really playing the tipping point of the seesaw game that can abruptly tilt one of the two sides to the extreme. In essence, our global economy has become far more vulnerable because of the creation of arbitrage and while economies have and will continue to be cyclical by nature, we have increased both the frequency and amplitude of the regular cycles without noticing. Hoping that the currency arbitrage or waging a trade war will result in new employment in countries that have lost a portion of their production capacity in favour of cheaper labour is wishful thinking. That will only result in shifting production from what once was the cheapest production country to the ones standing in line to take over that role.

The continued integration of the global economy will ultimately result in a natural rebalancing of domestic economies. Economies that are currently driven by consumer spending rather than production and who are also plagued by low savings rates will have to adjust to a model that supports both exports and domestic spending. The abolishment of import tariffs through the expansion of free-trade agreements across global trading partners, combined with currency pegs will lead to an increase in trading activity. The associated currency pegs will diminish any currency risks and will also increase the free flow of capital and currencies that in turn will have a more balanced effect on currency reserves. (Doms, 2010)

The conclusion for portfolio managers is apparent - no matter that some sectors are still relatively independent of country risk factors, nowadays the country-diversification paradigm should dominate the portfolio choices. The further studies should investigate if this holds true not only in Eurozone case, but also in worldwide scale (Kurach, 2011).

Brandt and Diebold (2003) are considering foreign exchange. In foreign exchange markets, absence of triangular arbitrage implies a deterministic relationship between any pair of dollar rates and the corresponding cross rate. Consider two dollar exchange rates, denoted A/$ and B/$. Then, in the absence of triangular arbitrage, they are determining the cross-rate through using the changes of logarithms.
This paper focuses on the use of foreign exchange rate differences at different locations (e.g. at various banks), which is discussed in the scientific literature as currency or foreign exchange arbitrage. According to Rejnuš (2014), it is in practice most often called "spatial arbitrage" or balancing observed exchange rate differences on particular (territorially distinct) spot foreign exchange markets. However, we must define and distinguish another concept, namely commodity arbitrage. These issues are addressed e.g. Machková (2014), who states that if foreign exchange reasons are the motive for the use of re-export, this transaction is referred to as a switch. It's a special kind of indirect trades, which involves the conversion of foreign currencies, which are not mutually convertible. Switch trade can change inconvertible currencies to be convertible, convertible to be inconvertible or non-convertible currencies each other. Switch can be characterised as foreign exchange arbitrage made by form of trade with goods. Given that there is purchase of a specific product in one market and simultaneously those goods are sold in another market, the switches contain even elements from commodity arbitrage.

During currency arbitrage so called quotation of exchange rates is often used. Polouček (2006) is confirming this fact and states that is necessary to understand in detail the principle of exchange rates quotation. Generally, exchange rate can be defined as price of currency expressed in units of another currency. In the financial practice, however, the two conventions of exchange rates quotation are used, which in some cases may look very confusing and cause difficulties in assessing the evolution of exchange rates. The most of currencies in the world are quoted through direct quotation, which means how many units of domestic currency are equal to one unit of foreign currency (according to conventions the one hundred or one thousand units of foreign currency may be used). Only several currencies, mainly British Pound, Euro and also Australian Dollar, are quoted through indirect quotation, which says how many units of foreign currency are equal to one unit of domestic currency (respectively 100 or 1,000 units). Mutual relationship between both conventions is simple because indirect quotation is the reciprocal value of direct quotation and vice versa.

Further to this Polouček (2006) adds that the use of direct quotation conceals a nuisance in the evaluation of the changes and development of exchange rates, which is necessary to keep in mind. As a direct quotation is a unit price of foreign currency expressed in units of domestic currency, the growth of the exchange rate means depreciation of the domestic currency and the decline in the exchange rate expresses appreciation of the domestic currency.

According to Kennedy (2014) the foreign exchange market consists of different markets and institutions. Yet, at a given point of time, all markets tend to generate the same exchange rate, for a given currency regardless of its geographical location. The uniqueness of the foreign exchange rate regardless of geographical location occurs because of arbitrage. The factor underlying the consistency of the exchange rate is called exchange arbitrage. Exchange arbitrage refers to the simultaneous purchase and sale of a currency in different foreign exchange markets in order to profit from exchange rate differentials in two locations. This process brings about an identical price for the same currency in different locations and thus results in one market. Arbitragers make gains by discovering price discrepancies that allow them to buy cheap and sell dear. Because one in buying and selling currency simultaneously, there is no risk in this activity. In addition, because of the speed of communication and the efficiency of transactions in foreign exchange, the spot market quotations for a given currency are remarkably similar worldwide, and any profit spread on a given
currency in quickly arbitraged away. In a free and open market, the scope for currency arbitrage tends to the low and it is, by and large, accessible only to dealer banks. In a world of many currencies, there is also a possibility for arbitrage if exchange rates are not consistent between currencies. This point can be easily seen in a three-point arbitrage or triangular arbitrage. Three-point arbitrage involves switching funds among three currencies in order to profit from exchange rate inconsistencies.

Teall (2013) indicates that currency arbitrage can exist when currency prices are not consistent with respect to other currencies or with respect to goods or financial instruments in different countries. Thus, there exist many potential types of currency (foreign exchange or FX) arbitrage opportunities. Triangular arbitrage exploits the relative price difference between one currency and two other currencies.

According to Somanath (2011) the term arbitrage is the practice of taking advantage of a price difference between two or more markets and striking a combination of matching deals that capitalize upon such imbalances. The profit being the difference between the market prices. Arbitrage does not require funds to be tied up for a long tenor and can also be termed as a possibility of a risk-free profit. The act of arbitrage will causes the prices to realign. Despite tremendous advances in their information and communication technology, inconsistency in currency rates do takes place across the nations and of course at all times. The arbitrageurs take advantage of the inconsistency and make a quick profit by buying and selling the currencies. They buy a particular currency at lower price and sell it at a higher price. This is called as currency arbitrage. Locational arbitrage can occur when the spot rate of a given currency varies among locations. Specifically, the ask rate at one location may be lower than the bid rate at another location. The disparity in rates can occur since information is not always immediately available to all banks. If a disparity does exist, locational arbitrage is possible, as it occurs, the spot rates among locations become realigned. When three currencies and three markets are involved, it is referred to as three point arbitrage or triangular arbitrage. The cross exchange rate represents the currency exchange rate between two currencies, where neither of the currencies are of the country in which the exchange rate is given. Like the locational arbitrage, triangular arbitrage does not tie up funds. The three point arbitrage is risk free because the uncertainty about the prices at which you will buy and sell currencies does not exist. We have to understand that the arbitrageur will not get a continuous benefit. The realignment of currencies will take place quickly and the arbitrage position will disappear in a fraction of a second. This is the reason why the exchange rate quotes among different banks at different locations normally does not differ. Moreover, discrepancy in currency exchange rates cannot happen with only one single bank. Discrepancies to take place require transactions involving a consortium of banks. With the advent of high speed computers and networks integrating the technology, the scope of arbitrageurs to make a gain on account of discrepancies in the currency exchange rates is very remote. Any misalignments in the cross currency rates can be detected very quickly and very easily leaving very little space for arbitrage.

Reasons for taking this topic:
- to improve and simplify methodology of currency arbitrage
- to find general issues and principles for direct (two-point) and indirect (three-point) currency arbitrage
- to show differences between using of direct and indirect quotations in currency arbitrage
- to form procedure and equation supporting the calculation of breakeven point (i.e. level of transactional costs, in which the effect of currency arbitrage is zero - neither profit, nor loss)

- universal method and symbols for currency arbitrage do not exist in professional literature

**Alternative ways to solve the problem of purchase and sale of assets**

Arbitrage is the simultaneous purchase and sale of equivalent assets at prices which guarantee a fixed profit at the time of the transactions, although the life of the assets and, hence, the consummation of the profit may be delayed until some future date. The key element in the definition is that the amount of profit be determined with certainty. It specifically excludes transactions which guarantee a minimum rate of return but which also offer an option for increased profits.

Hedging is the simultaneous purchase and sale of two assets in the expectation of a gain from different subsequent movements in the price of those assets. Usually the two assets are equivalent in all respects except maturity. Individuals will hold inventories of assets only in the expectation of increases in the value of those assets by at least enough to cover the costs of carrying the assets. In the case of financial assets, these carrying costs are largely the costs of the money tied up. In the case of physical inventories, there will also be costs of storage and spoilage or deterioration. Set against these costs will be certain benefits from the inventory: for merchants, for example, the inventory may be the means to increased sales or commissions. In the usual case, hedging is undertaken in the hope or expectation that the gain on the hedge transaction will be greater than the current difference between the price of the futures contract and the price of the corresponding physical commodity. Hedging provides the economic rationale for the speculator. When the merchant hedges to reduce his personal risk, he does not change the total risk faced in the market. The risk of price fluctuation is merely transferred from the merchant to the futures speculator. The speculator accepts that risk voluntarily, in expectation of making money from the futures price changes.

For speculators as a group actually to earn a profit requires that merchants be willing to sell for future delivery at prices lower than those they expect in the future. One reason why they might do so is that by hedging, they eliminate risk; and the difference between the price at which they sell and the price they expect in the future is the risk premium - somewhat analogous to the premium one pays for insurance (over and above the actuarial value of the risk). Speculators, like insurance companies, would not furnish their services without being paid the premium. In this view, the speculator receives what the merchant is willing to pay for his services.

Speculation is the purchase or sale of an asset in the expectation of a gain from changes in the price of that asset. In a world characterized by uncertainty, speculation is essential to the allocation of economic resources over time. There is no question of whether or not speculation should be permitted; the only economic issue is who will perform the service most effectively. The sometimes-heard charge of “overspeculation” is incorrectly framed: The issue is not one of amount but, rather, whether it is done well or poorly. The role of speculation is to allocate resources among periods. If one expects, as did Joseph and the Pharaoh in the Old Testament, seven lean years to follow the seven fat, economic theory tells us that social welfare
can be increased by refraining from some present consumption and storing the unconsumed goods until the lean years are upon us, so long as the price expected in the lean years is greater than today’s price by at least the costs of storage (including capital costs). If the future is certain, there is no need for speculation, but with uncertainty, whoever carries the inventories is exposed to the risk that the expected lean years will not materialize. Unless that risk is taken, resources will be used wastefully today and unnecessary hardship will be induced tomorrow, relative to intertemporal distribution under certainty.

The terminology of capital markets is less precise, but the suppliers of capital for investment projects play a similar role in determining whether resources should be “non-consumed” today so as to permit greater production of goods in the future. In futures markets, the influence of the speculator is easier to see. If the speculator anticipates higher prices in the future, he buys futures contracts, tending to force up their price. This gives a larger prospective profit to the hedger for carrying inventory and causes him to increase his holdings. Thus, if speculators as a group make correct judgments, their self-interest results in correct intertemporal decisions.

Even among those who recognize that futures markets may reduce the range of price variation, there are some who believe that speculative activity may cause prices to move more frequently between the narrower boundaries. According to this view, alternate waves of buying and selling may cause excessive fluctuations: price changes over successive periods would be positively correlated. On the other hand, in a perfect market, future price changes would be completely independent of past history. The price at the end of the previous day would discount all factors of importance known at that time - a price change would result only from new information. To a very close approximation, if we correct for the seasonality of risk premiums, speculative markets seem to be perfect (Cootner, 1963)

**Methodical recommendations and implementation in direct (two-point) currency arbitrage**

With using direct (or two-point) currency arbitrage as one of opportunities to invest disposable financial resources, first it is necessary to recognize the existence of so called “space” for this transaction. It is possible by two ways assuming that we have information about ratios of two different currencies in a two different places. First variant means multiplying of direct quotations of exchange rates, which is indicate in formula (1a) or multiplying of indirect quotations of exchange rates, which is indicate in formula (1b).

\[ CA = \left( \frac{CA}{CB} \right)_A \times \left( \frac{CB}{CA} \right)_B, \]  

(1a)

Where CA - space for currency arbitrage; A - country, place A; B - country, place B; C\textsubscript{A} - currency in country, place A; C\textsubscript{B} - currency in country, place B.
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\[ CA = \left( \frac{C_B}{C_A} \right)_A \times \left( \frac{C_A}{C_B} \right)_B, \quad (1b) \]

Where all symbols are the same like in previous formula (1a).

If result of this multiplying is equal to one, space for currency arbitrage does not exist. On the contrary it is effective to make given transaction assuming no transaction costs. For arbitrage realization it is then necessary to select right place to purchase of the second currency. It means other currency than we have useful funds. Thus, if we have financial sources in currency \( C_A \) and indicator \( CA \) (in case of direct quotations) is higher than one or lower than one in case of indirect quotations, it is possible to calculate final effect (return) through formula (2). In this case it is necessary to purchase the currency \( C_B \) in country (place) B and then to sell it in country (place) A for the currency \( C_A \).

\[ K_n = K_0 \times \left[ \left( \frac{C_A}{C_B} \right)_A \times \left( \frac{C_B}{C_A} \right)_B \right]^n, \quad (2) \]

Where \( K_n \) - final value (return) of capital after arbitrage; \( K_0 \) - nominal value of capital before arbitrage; \( n \) - number of transactions (rounds) in multiple and repeated purchase and sell of currencies; other symbols see formula (1a).

In situation, when disposable funds are again in currency \( C_A \) but indicator \( CA \) (in case of direct quotations) is lower than one or higher than one in case of indirect quotations, it is necessary to purchase currency \( C_B \) in country (place) A and then sell it in country (place) B for currency \( C_B \). In this case the return on investment is calculated due to formula (3).

\[ K_n = K_0 \div \left[ \left( \frac{C_A}{C_B} \right)_A \times \left( \frac{C_B}{C_A} \right)_B \right]^n, \quad (3) \]

Where all symbols are the same like in previous formula (2).

In situation, disposable financial resources are in currency \( C_B \), it is possible to use an analogous procedure in reverse.

The second variant to determine space for currency arbitrage and location of the first transaction means calculation of the difference between exchange rate with direct quotation in country (place) A and exchange rate with indirect quotation in country (place) B or vice versa. In this case we can use formula (4).

\[ CA = \left( \frac{C_A}{C_B} \right)_A - \left( \frac{C_A}{C_B} \right)_B, \quad (4) \]

Where all symbols are the same like in previous formula (1a).
If the result of formula (4) is equal to zero, space for currency arbitrage does not exist. On the contrary it is effective to make given transaction assuming no transaction costs.

In hypothetic example let us assume disposable funds 750,000 USD and these exchange rates: 1.6375 USD/GBP in New York (USA) and 0.6112 GBP/USD in London (GB).

Through multiplying direct quotations (see formula 1a) we can firstly recognize if the space for currency arbitrage exist or not:

\[ CA = 1.6375 \times 0.6112 = 1.00084 \quad > \quad 1 \]

Indicator CA is higher than one, therefore arbitrage could be effective and final return can be calculated through formula (2). Let us suppose one and ten rounds:

\[ K_1 = 750,000 \times 1.6375 \times 0.6112 = 750,630 \text{ USD} \]
\[ K_{10} = 750,000 \times (1.6375 \times 0.6112)^{10} = 756,323.87 \text{ USD} \]

In case of one transaction the final profit could be 630 USD and in case of ten rounds it could be 6,323.87 USD. This example was used without any transaction costs. Besides the very important information is also place for the first transaction. We have USD and CA for direct quotations is higher than one. It means according the method above to purchase the second currency (GBP) in its domestic country (GB - London) and then again buy the first currency (USD) in its domestic country (USA - New York):

1. \( 750,000 \text{ USD} \times 0.6112 \text{ GBP/USD} = 458,400 \text{ GBP} \);
2. \( 458,400 \text{ GBP} \times 1.6375 \text{ USD/GBP} = 750,630 \text{ USD} \).

If the reverse procedure would be used, then the result will be a loss:

1. \( 750,000 \text{ USD} / 1.6375 \text{ USD/GBP} = 458,015.27 \text{ GBP} \);
2. \( 458,015.27 \text{ GBP} / 0.6112 \text{ GBP/USD} = 749,370.53 \text{ USD} \).

This non effective transaction would mean loss 629.47 USD.

**Importance of differences in exchange rates**

Differences in exchange rates have a strong relationship with the cost of capital estimated on the spot market and futures market. Exchange rates are very difficult to forecast due to a multitude of factors. Forecasts are, therefore, a continuation of economic analysis and judgement. In forecasting foreign exchange rates it is important to take account of purchasing power parity (PPP), that is, one unit of currency should buy the same amount of goods and services as it bought in an equilibrium period, despite differential rates of inflation. The lower the level of inflation, the greater will be the PPP effect. If prices in local currency rise faster or more slowly than prices in the rest of the world, an equal adjustment of the exchange value of the currency in the opposite direction will restore equilibrium to relative price levels. The formula to calculate the PPP impact and exchange rate is:
\[ S_t = 1 = (S_1) \times \frac{1 + i_n}{1 + i_f}, \]

Where:
- \( S \) - spot rate of exchange in the number of units of the home currency equal to one unit of the foreign currency
- \( i_n \) - inflation rate in the home country
- \( i_f \) - inflation rate in the foreign country
- \( t \) - base period or the present time
- \( t+1 \) - future time period as defined.

Unfortunately as levels of inflation are difficult to predict and foreign exchange transactions are other than solely for purchasing goods and services, the PPP is not a very reliable forecasting technique. Other factors affect the foreign rate of exchange other than just PPP. These are:
- economic factors - balance of payments, monetary and fiscal policy, inflation, real and nominal interest rates, government controls and incentives, etc.;
- political factors - philosophy of leaders, elections;
- psychological factors - expectations, forward market prices, traders' attitudes.

One of the issues in analysing a country's competitive position is the critical adjustment of the exchange value of a country's currency. The index is a trade weighted index (based on world trade share). Indices are issued by various bodies like the IMF. (Keegan, W., 1989)

Exchange rates between currencies vary over time, reflecting supply and demand considerations for each currency. For example, the demand for British Pound comes from a number of sources, including foreign buyers of British exports who must pay for their purchases in pounds, foreign investors who desire to make investments in physical or financial assets in Britain, and speculators who expect British pounds to increase in value relative to other currencies. The British government also may be a source of demand if it attempts to keep the value of the pound (relative to other currencies) from falling by using its supply of foreign currencies or gold to purchase pounds in the market. Sources of supply include British importers who need to convert their pounds into foreign currency to pay for purchases. British investors who desire to make investments in foreign countries, and speculators who expect British pounds to decrease in value relative to other currencies.

Exchange rates also are affected by economic and political conditions that influence the supply of, or demand for a country’s currency. Some of these conditions include differential inflation and interest rates among countries, the government’s trade policies, and the government’s political stability. A high rate of inflation within a country tends to a lower the value of its currency with respect to the currencies of other countries that are experiencing lower rates of inflation. The exchange rate will tend to decline as holders sell or exchange the country’s currency for other currencies whose purchasing power is not declining at as high a rate. In contrast, relatively high interest rates within a country tend to increase the exchange rate as foreign investors seek to convert their currencies and purchase these higher yielding securities.
Government trade policies that limit imports - such as the imposition of tariffs, import quotas, and restrictions on foreign exchange transactions - reduce the supply of the country’s currency in the foreign exchange market. This, in turn, tends to increase the value of the country’s currency with respect to other currencies and thus increase exchange rates.

Finally, the political stability of the government affects the risks perceived by foreign investors and companies doing business in the country. These risks include the possible expropriation of investments or restrictions on the amount of funds (such as returns from investments) that may be taken out of the country. (Moyer, McGuigan, and Kretlow, 1992)

**Methodical recommendations and implementation in indirect (three-point) currency arbitrage**

In case of indirect (three-point, triangular) currency arbitrage the only multiplying direct or indirect quotations can be used to determine space for this transaction. It is possible when we have information about ratios of three different currencies in a three different places. This calculation is based on multiplying of direct quotations of exchange rates, which is indicate in formula (5a) or multiplying of indirect quotations of exchange rates, which is indicate in formula (5b).

\[
CA = \left( \frac{C_A}{C_B} \right)_A \times \left( \frac{C_B}{C_C} \right)_B \times \left( \frac{C_C}{C_A} \right)_C, \tag{5a}
\]

Where all symbols are the same like in previous formula (1a).

\[
CA = \left( \frac{C_B}{C_A} \right)_A \times \left( \frac{C_C}{C_B} \right)_B \times \left( \frac{C_A}{C_C} \right)_C, \tag{5b}
\]

If result of this multiplying is equal to one, space for currency arbitrage does not exist. On the contrary it is effective to make given transaction assuming no transaction costs. For arbitrage realization it is then necessary to select right place to purchase of the second or the third currency. It means other currency than we have useful funds. Thus, if we have financial sources in currency C_A and indicator CA (in case of direct quotations) is higher than one or lower than one in case of indirect quotations, it is possible to calculate final effect (return) through formula (6). In this case it is necessary to purchase the currency C_C in country (place) C and then to sell it in country (place) B for the currency C_B and then to sell it in country (place) A for again the currency C_A.

\[
K_n = K_0 \times \left[ \left( \frac{C_A}{C_B} \right)_A \times \left( \frac{C_B}{C_C} \right)_B \times \left( \frac{C_C}{C_A} \right)_C \right]^n, \tag{6}
\]
Where all symbols are the same like in previous formulas (2) and (5a).
In situation, when disposable funds are again in currency $C_A$ but indicator $CA$ (in case of direct quotations) is lower than one or higher than one in case of indirect quotations, it is necessary to purchase currency $C_B$ in country (place) A and then sell it in country (place) B for currency $C_C$ and then to sell it in country (place) C for again the currency $C_A$. In this case the return on investment is calculated due to formula (7).

$$K_n = K_0 \div \left[ \left( \frac{C_A}{C_B} \right)_A \times \left( \frac{C_B}{C_C} \right)_B \times \left( \frac{C_C}{C_A} \right)_C \right]^n,$$

(7)

Where all symbols are the same like in previous formulas (2) and (5a).

In situation, disposable financial resources are in currency $C_B$ or $C_C$, it is possible to use an analogous procedure in reverse.

In hypothetic example let us assume again disposable funds 750,000 USD and these exchange rates: 1.6375 USD/GBP in New York (USA), 163.32 JPY/GBP in London (GB) and 99.435 JPY/USD in Tokyo (J). Beforehand, the exchange rate in London must be changed into direct quotation: $1/163.32 = 0.0061229$ GBP/JPY. Through multiplying direct quotations (see formula 6) we can then recognize if the space for currency arbitrage exist or not:

$$CA = 1.6375 \times 0.0061229 \times 99.435 = 0.99696004445625 < 1$$

Indicator $CA$ is lower than one, therefore arbitrage could be effective and final return can be calculated through formula (7). Let us suppose one and ten rounds:

$$K_1 = 750,000 / (1.6375 \times 0.0061229 \times 99.435) = 752,286.92 \text{ USD}$$

$$K_{10} = 750,000 / (1.6375 \times 0.0061229 \times 99.435)^{10} = 773,195.88 \text{ USD}$$

In case of one transaction the final profit could be 2,286.92 USD and in case of ten rounds it could be 23,195.88 USD. This example was used without any transaction costs. Besides the very important information is also place for the first transaction. We have USD and CA for direct quotations is lower than one. It means according the method above to purchase the second currency (GBP) in its foreign country (USA - New York), then to buy the third currency (JPY) in its foreign country (GB - London) and then to buy again USD in its foreign country (J - Tokyo):

1. $750,000 \text{ USD} / 1.6375 \text{ USD/GBP} = 458,015.27 \text{ GBP};$
2. $458,015.27 \text{ GBP} / 0.0061229 \text{ GBP/JPY} = 74,803,650.23 \text{ JPY};$
3. $74,803,650.23 \text{ JPY} / 99.435 \text{ JPY/USD} = 752,286.92 \text{ USD}.$

If the reverse procedure would be used, then the result will be a loss:

1. $750,000 \text{ USD} \times 99.435 \text{ JPY/USD} = 74,576,250 \text{ JPY};$
2. $74,576,250 \text{ JPY} \times 0.0061229 \text{ GBP/JPY} = 456,622.92 \text{ GBP};$
3. $456,622.92 \text{ GBP} \times 1.6375 \text{ USD/GBP} = 747,720.03 \text{ USD}.$
This non effective transaction would mean loss 2,279.97 USD.

**Determination of the transaction costs in indirect (three-point) currency arbitrage**

In practice, if some company wants to invest and use disposable financial resources there is usually, except potential profit, so called transaction costs to realize this idea. In case of financial transactions especially in international markets it is necessary to cooperate with financial institutions (e.g. banks, brokers, intermediaries, bank agents) because of their competency or authorization, knowledge and access into financial markets. Of course, these subjects must also cover their operating costs and profit. Therefore they are calculating some fees for their clients, for which it means transactional costs. Then these costs could significantly decrease the required profit or cause loss after the whole transaction. The following method should reduce or eliminate the risk resulting from these costs namely in case of indirect currency arbitrage. If this charge will be implemented into arbitrage it is possible to correct formulas (6) and (7) and create equations (8) and (9).

$$K_n = K_0 \times \left[ \left( \frac{c_A}{c_B} \right)_A \times \left( \frac{c_B}{c_C} \right)_B \times \left( \frac{c_C}{c_A} \right)_C \times (1 - TC)^3 \right]^n, \quad (8)$$

Where TC - transactional costs (fee requiring from financial institutions); other symbols are the same like in previous formulas (2) and (5a).

$$K_n = K_0 \times \left[ \left( \frac{c_A}{c_B} \right)_A \times \left( \frac{c_B}{c_C} \right)_B \times \left( \frac{c_C}{c_A} \right)_C \times \frac{1}{(1 - TC)^3} \right]^n, \quad (9)$$

Where all symbols are the same like in previous formulas (2), (5a) and (8).

One round of indirect currency arbitrage includes three partial transactions - three exchanges of three different currencies in three different countries (places). That is why there is exponent 3 in formulas (8) and (9).

Now, it is better to introduce the following substitution (10) for direct quotations to simplify general method of TC\(_0\) determination:

$$\left( \frac{c_A}{c_B} \right)_A = X, \left( \frac{c_B}{c_C} \right)_B = Y, \left( \frac{c_C}{c_A} \right)_C = Z, \quad (10)$$

Then it is possible to determine TC\(_0\) due to mathematical derivation from formulas (8) and (9) and construct the formulas (11) and (12). The aim is to calculate TC\(_0\) like certain breakeven point, at which the final result after currency arbitrage will not be profit nor loss. It means that nominal value of capital before arbitrage is equal to value of capital after this transaction (K\(_0\) = K\(_n\)) and the previous substitution is used.

$$TC_0 = 1 - \frac{3}{\sqrt[3]{X \times Y \times Z}}, \quad (11)$$
Where \( TC_0 \) - level of transactional costs, in which the effect of currency arbitrage is zero (neither profit, nor loss), other symbols are implemented from substitution (10).

\[
TC_0 = 1 - \frac{3}{X \times Y \times Z} ,
\]

(12)

Where all symbols are the same like in previous formula (11) and substitution (10).

To apply this method we can use the same data like in previous hypothetic example. The space for indirect currency arbitrage was lower than one, so that it is necessary to use formula (12) to calculate potential breakeven point \( TC_0 \):

\[
TC_0 = 1 - \frac{3}{1.6375 \times 0.0061229 \times 99.435} = 0.0010143471
\]

Generally, fees or charges for financial transactions are declared in percentage form like portion of amount of capital in the given transaction. Therefore the previous result is multiplied by 100 %:

\[
TC_0 = 0.0010143471 \times 100 = 0.10143471 \%
\]

If the real transaction costs will be lower than this calculated figure we can recommend to realize currency arbitrage and profit could be expected. On the contrary, if the real transaction costs will be the same or even higher than indicator \( TC_0 \) the given financial transaction will be ineffective.

**Conclusion**

The paper was focused on contribution to method of currency arbitrage. There are theoretic principles and general formulas to be effective in this financial transaction. Firstly, the variants how it is possible to determine space for currency arbitrage both direct (two-point) and indirect (three-point) arbitrage. It means procedures confirming the effectiveness of this transaction. Then there are equations suggested to calculate return on investment, which is final capital in the end of arbitrage. The attention was concentrated also to differences between direct and indirect quotation. One of the main result is exploring the mutual relationship between currency of the nominal capital and country (place) of the first partial transaction (first exchange of currencies. The most important finding is:

If space for currency arbitrage is higher than one in case of multiplying the direct quotations of different exchange rates in different locations, then the first partial transaction, i.e. purchase of the other currency, must be done in country (place) where the currency of disposable funds is domestic currency and vice versa.

The benefit of this suggestion is faster and simpler decision making in the frame of arbitrage, namely for investors from subjects providing an accommodation services in international markets because of their access to foreign currencies. Another fact is that one of the assumption for currency arbitrage is relatively big quantity of disposable funds. The last methodical contribution is general derivation of transaction costs determination, which is the certain breakeven point, at which the nominal value of invested capital is equal to final capital revenue in the end of currency arbitrage.
These general rules, relations and principles were then implemented and proved in hypothetical examples with real numbers.

We can categorize arbitrage in the real world into three groups:

- Pure arbitrage, where, in fact, you risk nothing and earn more than the riskless rate.

- Near arbitrage, where you have assets that have identical or almost identical cash flows, trading at different prices, but there is no guarantee that the prices will converge and there exist significant constraints on the investors forcing convergence.

- Speculative arbitrage, which may not really be arbitrage in the first place. Here, investors take advantage of what they see as mispriced and similar (though not identical) assets, buying the cheaper one and selling the more expensive one.

For pure arbitrage, you have two assets with identical cash flows and different market prices makes pure arbitrage difficult to find in financial markets. There are two reasons why pure arbitrage will be rare:

- Identical assets are not common in the real world, especially if you are an equity investor.

- Assuming two identical assets exist, you have to wonder why financial markets would allow pricing differences to persist.

If in addition, we add the constraint that there is a point in time where the market prices converge, it is not surprising that pure arbitrage is most likely to occur with derivative assets - options and futures and in fixed income markets, especially with default-free government bonds. A futures contract is a contract to buy (and sell) a specified asset at a fixed price in a future time period. The basic arbitrage relationship can be derived fairly easily for futures contracts on any asset, by estimating the cash flows on two strategies that deliver the same end result - the ownership of the asset at a fixed price in the future. In the first strategy, you buy the futures contract, wait until the end of the contract period and buy the underlying asset at the futures price.

In near arbitrage, you either have two assets that are very similar but not identical, which are priced differently, or identical assets that are mispriced, but with no guaranteed price convergence. No matter how sophisticated your trading strategies may be in these scenarios, your positions will no longer be riskless.

There are a large number of strategies that are characterized as arbitrage, but actually expose investors to significant risk. We will categorize these as pseudo or speculative arbitrage. The use of financial leverage has to be scaled to reflect the riskiness of the strategy. With pure arbitrage, you can borrow 100 % of what you need to put the strategy into play. In futures arbitrage, for instance, you borrow 100 % of the spot price and borrow the commodity. Since there is no risk, the leverage does not create any damage. As you move to near and speculative arbitrage, this leverage has to be reduced. How much it has to be reduced will depend upon both the degree of risk in the strategy and the speed with which you think prices will converge. The more risky a strategy and the less certain you are about convergence, the less debt you should
take on. These strategies work best if you can operate without a market impact. As you get more funds to invest and your strategy becomes more visible to others, you run the risk of driving out the very mispricing that attracted you to the market in the first place.

In pure arbitrage, two exactly identical assets trade at different prices and price convergence is guaranteed at a point in time in the future. Pure arbitrage yields riskless profits but is difficult to find in markets and if found, difficult to sustain. Near arbitrage is more common but there is risk, either arising from the fact that assets are not identical or because there is no guaranteed convergence. Pseudo arbitrage is really not arbitrage. Similar assets are mispriced, either relative to their fundamentals or relative to their historical pricing. You buy the cheaper asset and sell the more expensive one and hope to make money on convergence.

Of course, there are more invest opportunities to use disposable financial funds in practice. Therefore the evaluation of economic efficiency of investment is very important. For this purpose the methods like time of return on investment, net present value and IRR internal revenue rate could be used. Moreover, it is necessary to consider and compare a currency arbitrage transaction with opportunity costs. This area is however outside the scope of this work.

References


