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Minimizing the Maximum Risk of Currency Conversion for a Company Buying Abroad

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Abstract:

Purpose: *The relevance of the study is due to the fact that the task of determining the moment of transition from one currency to another arises for each organization, which is not limited to work in the domestic market. This article is aimed at solving the problem of performing the operation of required sale (exchange) of the available currency to pay for goods to a foreign supplier.*
Design/Methodology/Approach: *There are two days to complete the exchange, which must be completed in no more than two steps. In the literature, the leading approach to solving this problem is the prediction of the exchange rate.*
Findings: *The solution proposed in this article is based on Savage's criteria (regret metric). We minimize the maximum risk of unprofitable exchange. This allows you to prevent large deviations from the minimum possible amount of sale of the available currency necessary to purchase a given amount in another currency.*
Practical Implications: *The article presents the prerequisites for the emergence of the task of determining the moment of transition from one currency to another, reveals the specifics of this task in Russian companies, identifies the main tools for solving problems of this type, justifies the use of the proposed approach to solve this problem.*
Originality/Value: *Article submissions are of practical value for managers of companies trading with constant foreign partners, especially under the condition that the operations of converting a significant sum fulfil often, but not daily.*

Keywords: *Currency exchange, regret metric, decision support.*

JEL codes: *G23, G12.*

Paper type : *Research article.*

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1. Introduction

Let's consider a company which must pay for goods to a foreign partner in local currency, having on the account currency of the country, other than the necessary currency for payment. In this case, the company – the buyer has to sell (to change), the currency which is available for it, in quantity sufficient for obtaining the required sum of the currency of the seller's country. If the cross rate of these currencies has the considerable volatility, then there is a problem for the choice of optimum strategy for converting the currencies on the given time $T \epsilon [t_b;t_f]$ (Anderson and Faff, 2008).

A required strategy can be a single-step or a multistep. In the case of the former, the buyer carries out the sale of the available currency once in some instant $t \epsilon T$. The sum which he sells completely is defined by a cross rate, operating on an instant t, and that sum in foreign currency which it has to get. The task consists in the right choice of an instant t. In the multistep strategy the particular sums, of the available currency, are on sale in particular instants; t_0, 1, 2,…,t, k from the given piece of T. The task consists in how to choose these moments and what sums to sell in each of them (Bettman, Sault and Welch, 2006). In this work the important practical case when the cross rate is defined on the basis of the official rate established by the Central Bank of the buyer's country, and the buyer has an opportunity to carry out operation of money changing no more, than in two steps. That is, the buyer change the particular sum on the known today's cross rate, and tomorrow the buyer buys in addition necessary quantity of foreign currency at tomorrow's course which is not known today.

The problem of the definition of the moment of the transition from one currency to another is classical for players of the foreign exchange market (Groenewald and Pretorius, 2011; Chronopoulos, De Reyck and Siddiqui, 2011; Gaspars-Wieloch, 2012). It is a special case of a task about the moment of change of instruments of investment (Jiang Tao, 2007) which in turn is a special case of a task about formation of the optimal investment portfolio (Dominiak, 2006). These tasks are solved in relation to instruments of the stock market (Weller, Friesen and Dunham, 2007).

The feature of the situation considered in this work is the following: converting is obligatory; the sum which is required to be received in foreign currency is specified. Besides, strategy cannot have more than two steps. The new result is received – the formula defining how many it is necessary to change today to minimize the maximum risk. The risk is determined by regret metrics of Savage (Wenzel, 2018).

2. Methodological Framework

2.1 Substantial Statement of the Problem

In Russia the official exchange value of dollar and euro are determined based on the results of exchange trading of the current day. The auction begins in the morning, is held each working day, and after 12:00 Central Bank announces the official rates of these and other currencies received. Banks establish the exchange rates (based on purchases and sales) for all currencies being guided by an official rate. Let's consider the following real situation. The organization has to make, until the end of the next working day, a payment in rubles for S sum. The organization has no rubles, but it has euro. The manager knows the result of today's trading and, respectively, knows an official euro exchange rate to ruble at which it is possible to sell euro and receive rubles in his account. He has to decide on a more favorable scenario for him until the end of day from the following:

- ✓ to sell euro today for the whole amount;
- ✓ to sell euro tomorrow after another auction and after the new announcement of the official rate being guided by the bank which will establish the tomorrow's buying rate of euro for rubles;
- ✓ to sell a part today, and a part tomorrow.

The rate of national currency in relation to reserve depends on a large number of factors. Possible range of daily changes depends on the stability of national economy, but even the strongest national currencies are sometimes subject to sharp jumps, as towards increases, and decreases. At a large sum S adoption of the correct decision by the manager allows to receive a significant gain (Basili, Chateauneuf and Fontini, 2008).

In Russia as it was told above, the official rate is determined by results of the auction and can be predicted by analyzing big data (Polyakova *et al.,* 2019). Participants of the exchange auction are commercial banks and the Central Bank of the Russian Federation. Commercial banks execute applications of their clients and own applications. The Central bank represents the interests of the state. Major customers of commercial banks are: enterprises, investment funds, ownerships. Importers buy foreign currency. They are interested in the strong rate of national currency. Exporters sell foreign currency. They are interested in weakening the rate of the national currency. In Russia exports exceed imports. Not to allow sharp fluctuations of ruble Central bank carries out purchases or sales of reserve currencies to keep the rate in a certain level.

Banks and physical entities buy or sell foreign currency depending on demand. Investment funds buy or sell local currency depending on the relation to its stock market (Cohen, Polk and Vuolteenaho, 2009). During the repayment some percent of the credits from foreign banks the enterprise buy foreign currency. During the payment of taxes the enterprise buy additional local currency. When leaving from the local stock market investment funds buy foreign currency. In these conditions the manager in essence cannot specify tomorrow's euro exchange rate to ruble. At the same time, it can on the basis of the available information, provide by the serious

analytical agencies a determination of the range of the possible rate change. Furthermore it will be shown as, knowing today's course and range of its possible change, to define the best option of convertion. For the concreteness of the statement the task will be formulated in relation to converting euro in rubles. It is apparent that it won't reduce community of result which in a simulated condition will be applicable to a problem of converting of one currency in another, for example, euro in dollars or the opposite.

2.2 Mathematical Problem Definition

Today (in t_0 instant) the company has money in euro. Today's selling rate of euro for rubles is equal to E_0 [RUB/EUR]. Tomorrow (in t_1 instant) the company needs to pay S sum in rubles. Tomorrow's course is unknown. However, there are bases to assume that it will change ranging from E_{min} to E_{max} and

$$E_0 \in [E_{min};\ E_{max}]. \quad (1)$$

It is required to define what part of tools in euro to sell today, and what tomorrow for obtaining the required sum of money in rubles.

2.3 Decision's Prerequisites

Let's consider a situation when the need of exchange arises not daily, and incidentally, though is frequent. In this case it is expedient to apply game theory methods, namely decision making methods in the conditions of indeterminacy which cannot be estimated by means of probability theory methods to the solution of a task (Dominiak, 2009). There are two main criteria of a decision making in such situations: the criterion of the Wald (Sniedovich, 2008) and the criterion of Savage (Somasundaram and Diecidue, 2016) although other criteria are sometimes used (Achelis, 2000) as for example, the criterion of Hurwitz.

According to criterion of the Wald strategy at which the minimum prize is maximum is optimum. It is a criterion of "the poor pessimist" who considers that conditions of carrying out operation will be the inferior for it, and at the same time it is necessary to receive the small, but the guaranteed prize.

The criterion of Savage is based on a concept of risk. The risk, by the definition of Savage, is the difference between that prize which we could receive if we foreknew with what there will be conditions of carrying out operation, and the prize which will be received from the application of the chosen strategy. According to the criterion of Savage, the optimum strategy at which the maximum risk is minimum. It is a criterion of the pessimist, but pessimist is too rich considering that the most terrible outcome is to miss a prize. In our case the decision based on Savage criterion, will not allow the considerable deviations from the minimum possible sum necessary for

the purchase of the given sum in the currency different from that the company has (Bettman, Salut and Schultz, 2009).

3. Results

Let's find an optimal solution on the criterion of a minimum of the maximum risk. The sum of euro which should be spent to buy S rubles is equal to

$$L(x,E) = x + \frac{S - xE_0}{E} = x\left(1 - \frac{E_0}{E}\right) + \frac{S}{E}, \tag{2}$$

where: x – quantity of euro sold today at course E_0;
E – tomorrow's euro exchange rate to ruble.

The choice of value x is our strategy. The choice of strategy happens in the conditions of indeterminacy. It is bound to the fact that the value E is unknown. Let's determine risk by Savage. If we knew that euro exchange rate to ruble will be tomorrow no more, than today, that is $E \le E_0$, then we would make purchase of rubles today and spent,

$$L_1 = \frac{S}{E_0}. \tag{3}$$

The difference between what we could spend if foreknew tomorrow's course and what we will spend, having sold today x euro, represents risk across Savage who is equal at $E \le E_0$,

$$R_1(x,E) = x + \frac{S - xE_0}{E} - \frac{S}{E_0} = x\left(1 - \frac{E_0}{E}\right) + S\left(\frac{1}{E} - \frac{1}{E_0}\right). \tag{4}$$

If we knew that euro exchange rate to ruble will be tomorrow more, than today, that is $E > E_0$, then we would make purchase of rubles tomorrow and spent

$$L_2 = \frac{S}{E}. \tag{5}$$

The difference between what we could spend if foreknew tomorrow's course and what we will spend, having sold today x euro, at $E > E_0$,

$$R_2(x,E) = x\left(1 - \frac{E_0}{E}\right) + \frac{S}{E} - \frac{S}{E} = x\left(1 - \frac{E_0}{E}\right). \tag{6}$$

On the basis of it we have that, to sale today x – euro, there corresponds the risk across Savage equal to:

$$R(x,E) = \begin{cases} R_1(x,E)\ when\ E \le E_0 \\ R_2(x,E) when\ E > E_0 \end{cases}. \tag{7}$$

At the same time, independent parameter E can change from $E_{min} < E_0$ to $E_{max} > E_0$, and the value x can be chosen ranging from 0 to L_1. It is possible to show that the minimum of the maximum risk is reached in a point x, where

$$x\left(1-\frac{E_0}{E}\right)+S\left(\frac{1}{E_{min}}-\frac{1}{E_0}\right)=x\left(1-\frac{E_0}{E_{max}}\right). \quad (8)$$

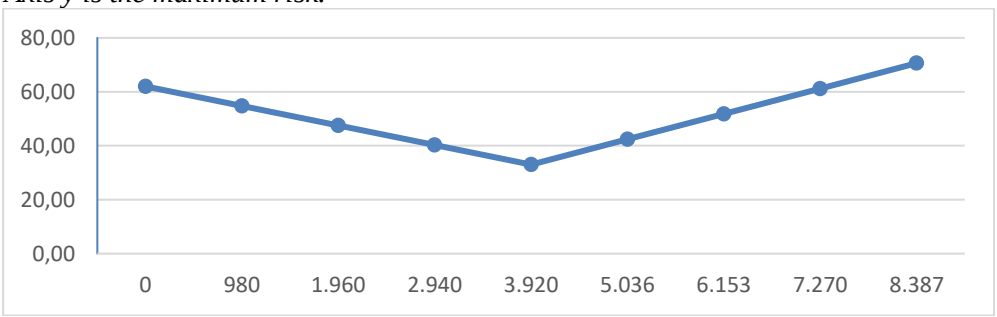
From where follows that optimum strategy which allows to minimize the maximum risk consists in the following:

- at today's course E_0 is on sale
$$x^*=\frac{E_{max}(E_0-E_{min})}{E_0^2(E_{max}-E_{min})}S; \quad (9)$$
- at tomorrow's course is on sale, that quantity of euro which still is necessary for obtaining all sum of S in rubles.

Let's notice that at increase x from 0 to x^* the maximum risk decreases on a straight line which equation is written down in the left-hand part of equality (4), and then increases on a straight line which equation is written down in a right member of equality (6). It becomes especially visual if to tabulate values of risk of a line which correspond the value x increasing with a particular step from 0 up to L_1, and columns to the values E increasing with a particular step from E_{min} to E_{max}.

So, for example, rate today 77.74 RUB/EUR; for tomorrow's value of the rate limits are predicted: E_{min} = 77.17 RUB/EUR; E_{max} = 78.40 RUB/EUR. Tomorrow it is necessary to have 652,000 RUB. In this case, today it is necessary to sell x^* = 3919.62 EUR and to receive the sum of 304,711.26 RUB, and to buy the missing sum of 347,288.74 RUB at tomorrow's rate. At such strategy the maximum risk will be minimum and will be 33 EUR. Let's notice that in this case the absolute maximum of risk is equal to 70.60 EUR. It corresponds to the strategy of purchase of all necessary sum at today's rate. The schedule of change of the maximum risk is provided in Figure 1.

Figure 1. *Schedule of change of the maximum risk. Axis x is euro sum sold today. Axis y is the maximum risk.*



4. Discussion

A huge number of works in the field of investment is devoted to pass from one tool into another (Lewellen, 2004; Lo, Mamaysky and Wang, 2000). In most of them need of a transition based on prediction of change of cost of tools is required (Dichev and Tang, 2009). Others refer to financial crises and how the market reacts (Thalassinos and Thalassinos, 2018). Usually we apply the technical analysis, the fundamental analysis or their combination to prediction (Fabozzi and Peterson, 2003). The technical analysis is an attempt to predict future on the basis of the past taking into account mass behavior of players in the market (Marshall, Young and Rose, 2007).

The apparatus of the technical analysis is very diverse. In it both a simple visual method, and the most difficult numerical method of successive approximations used is neural networks (Swanson, Rees and Juarez-Valdes, 2003; Haykin, 2008). First of all the technical analysis is applied at a game of share and the foreign exchange markets where there are larger arrays of historical data. There are a lot of researchers skeptically fall into technical analysis (Fama and French, 2006). They call into question a possibility of prediction of the future from the past without explanation of the structure of this phenomenon. The fundamental analysis is based on the economic theory and explains the reasons of changes of cost of tools, but accuracy of these predictions is not always sufficient for the adoption of the justified decisions (Beneish, Lee and Tarpley, 2001). Game theory methods are also applied first of all in the theory of formation of an optimal portfolio of investments. The classical approach here is Markovits's theory.

The difference of the considered task from the tasks solved earlier consists that currency exchange on the given short price is obligatory. Respectively it is necessary to execute it in the best way.

5. Conclusion

It is considered as one of the best strategies at which the minimum of the maximum risk across Savage is reached. It is established that by this criterion the strategy of sale, the available currency for purchase of the given sum in the required currency consisting of two steps is optimum. On the first step the quantity of the available currency determined by formula (9) is on sale at today's rate. On the second step is on sale, the quantity of the available currency, which lacks for obtaining the necessary sum, in the required currency. On the second step sale is carried out at tomorrow's rate.

6. Recommendation

The result is useful, first of all, to persons responsible for currency conversion in the companies which are carrying out trade operations with permanent foreign partners.

The method especially well works when it is frequent, but not as daily operations, and is bounded to converting of considerable sums. A case when converting is carried out almost daily, according to the authors it is necessary to be guided by criterion of a minimum of average risk. The authors works on the solution of such task for a possible research article in the future.

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