St. Petersburg University
Graduate School of Management
Master in Corporate Finance

DEVELOPMENT OF A CURRENCY RISK HEDGING STRATEGY FOR NON-FINANCIAL COMPANIES

Master's Thesis by the 2nd year student
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АННОТАЦИЯ

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ABSTRACT

Master Student's Name	Margarita Bondar
Master Thesis Title	DEVELOPMENT OF A CURRENCY RISK HEDGING STRATEGY FOR NON-FINANCIAL COMPANIES
Educational Program	Management
Main field of study	Corporate Finance
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Description of the goal, tasks and main results	Goal: to identify the method for determining the best strategy, which would help company to make a decision about hedging. Research objectives: • To analyze existing hedging strategies • To model a company with a currency risk exposure • To model different hedging strategies to identify expenses • To propose a criterion for strategy comparison and choice • To compare expenses in different strategies and identify the optimal one • To test modelled strategies • To summarize the obtained results and provide recommendations
Keywords	Currency risk, risk management, hedging, strategy, derivatives, forward, hedging instruments

Content

Introduction

The role of risk management in the modern business world is crucial for any company. However, in this regard, there are a lot of questions related to risk management. How does risk management work? One of the tools in risk management is hedging. One of numerous hedging definitions says that hedging can be defined as either an insurance contract or an activity, directed to reduction of the correlation between the purchased derivative`s value and random variable, using derivative instruments. Nowadays with the wide range of derivatives financial managers are able to provide an incredible flexibility in structuring an individual risk management strategy for the company.

However, there is still debate about the value of hedging for the company. According to finance theory the process called “hedging” can offset some losses in company`s core business by using derivatives and gaining profit on them. On the other hand this profits can be easily offset by unexpected loses. According to Modigliani-Miller in an ideal world of perfect markets, if a company decides to hedge, such decision cannot alter the company's value. The idea is that if the markets are efficient, then it is possible to build a portfolio that copies the stock of a hedged company and conduct an arbitrage (Tufano, 1994). But even in a perfect world in an efficient market, the theorem is valid only for investors with a strictly defined investment horizon (Okulov, 2015). Indeed, in efficient markets, participants conducting arbitrage operations are risk-neutral and take into account only the expected return on a fixed investment horizon. For them risk doesn`t exist, so risk management has neither meaning nor value. In the real world, markets are not perfect and some researchers have defined various hypotheses that state that the reason of increase in company value with hedging is due to various imperfections of financial markets and features of the economic environment in which companies operate (Froot, Scharfstein, & Stein., 1993).

As the real world is imperfect, and consequently, hedging in the real markets is valuable, but costly, and there are transaction costs of hedging. This means that companies, by implementing

hedging, might focus on minimizing its transaction costs. In this work, the idea of moving from the generally accepted maximization of the company's value to minimizing costs through hedging is put forward.

For the proper implementation of the hedging strategy it is essential to obtain the detailed understanding of derivative instruments as well as their applicability and costs. If used correctly these instruments reduce risk and bring value to the company. Otherwise, such instruments can be destructive for a company. For instance, if company`s expectations and predictions will not be met the company may suffer great loses. Consequently, the benefit of corporate hedging still remains controversial.

Usually, the use of hedging is associated exclusively with leveling volatility and attempts to minimize losses that the company may incur in the future. While hedging can reduce the probability of unfavorable outcome, it can cause additional costs that may offset such benefit. Based on this, companies often have nothing to justify their decision to hedge. Apparently, the company needs something to start from when making a hedging decision. Hence, there is a research gap which reflects in the absence of a clear methodology for justification of the decision to hedge.

Based on the formulated problem the following research questions are derived.

Research Question:

What is the currency risk and how it can be levelled? What are the instruments to hedge the currency risk? What are the companies that face currency risk? What criteria should be used when making a hedging decision? Under what conditions can we assume that the benefits of hedging are predictable? How to derive the appropriate hedging strategy? How this hedging strategy can influence a company`s decision to hedge?

Research goal: to identify the method for determining the best strategy, which would help company to make a decision about hedging.

Research objectives:

- To analyze existing hedging strategies
- To model a company with a currency risk exposure
- To model different hedging strategies to identify expenses
- To propose a criterion for strategy comparison and choice
- To compare expenses in different strategies and identify the optimal one
- To test modelled strategies
- To summarize the obtained results and provide recommendations

Without knowing how to determine the value of hedging, we look at the market, perhaps it already has all the answers. There is an efficient market hypothesis, which assumes that the market is efficient with respect to any information if it is immediately and completely reflected in the price of an asset. Therefore, in an efficient market, it is possible to determine whether the use of hedging instruments will be profitable in the future or not. It is necessary to consider the possibility of hedging and look at the costs to determine the most appropriate strategy. The most suitable one will be the one where the expenses are minimum. The development of appropriate strategy can help companies to make the right decision whether to hedge or not.

In the classic sense of hedging, it is necessary to hedge certain obligations, this is also called hedging a firm obligation. However, there is also an uncertain hedging item, such as a currency deficit, for instance, which may occur or may not occur. Or there is a certain probability of its occurrence. This issue has is usually not considered, which means that it`s necessary to pay attention to it. In this paper exactly this aspect of hedging is considered, namely the hedging of currency deficits, which may vary depending on the period, on the predictions of managers and deviations in revenue.

Chapter 1. Theoretical and empirical studies of hedging strategies and currency risk management.

One of fastest developing areas of company`s activities is risk management. Its concept is constantly changing over time. Now more and more companies are moving away from perceiving risk management as an activity aimed at completely minimizing risk. In most cases, we perceive risk as something given like we can't do anything about it. However, this is not entirely true. To some extent, the manager can choose the risks that his business bears. But why he should hedge? For one reason: it makes financial planning easier and reduces the likelihood of a cash deficit. Sometimes a lack of money means just the need to go to the bank, but sometimes, in the worst case scenario, an unforeseen shortage of money can cause a financial crisis or even bankruptcy. (Brealey, Myers, & Allen, 2019). So what is risk anyway? Risk is always a situation of exchanging reliability for something unreliable, but it promises benefits. When we talk about risk, we always mean comparison, that is, there is an element of calculating the possible benefits and possible costs ("to risk something for something" as a willingness to sacrifice one for the opportunity to get another). If there is no alternative choice, it is rather a situation of danger rather than risk (Okulov V.L., 2019).

The risk is associated with the ambiguity of the future, the possibility of multiple outcomes at any given time. The unpredictability of the future, its randomness, the lack of complete confidence in what the future outcome will be, is the most important prerequisite for a risk situation.

1.1. Risk classification and types of risks

Company has to manage the risk and to determine what risk it`s willing to take on and to what extent. Risk classification refers to a system for allocating risks to specific groups in order to achieve goals. This classification is a specific system that allows to identify the relationship of various types of risk with currency risk, which is necessary for risk management. The classification of risks is proposed by Federal Service for Financial Markets:

- Risk of loss of the client's funds when the property of the broker serving it is seized.
- Credit risk associated with margin trading.
- Risk when combining brokerage activities with your own operations.
- The risk of using the client's funds without their knowledge in the interests of the broker.
- Risk of using proprietary information.
- The risk of insufficiency of own capital.
- Risk associated with certification of managers and specialists.
- Risk arising from the lack of hedging due to the underdevelopment of the derivatives market.

Risk assessment

Given the huge variety of risks present in the world, any company needs certain methods to protect and avoid the risks that it may face. However, to do this, it must be able to assess this risk.

There are several methods of risk assessment. The most used method is historical, which assumes that in the future what has already happened in the past will be repeated. However, this hypothesis is not based on anything. This means that price volatility persists. The second method – expert method, which assumes that based on the intuition and experience of experts, it is possible to predict the possible development of the market situation. (Okulov V.L., 2015) Given the variety of risks that a company may face, it should know how to manage these risks and what tools to use.

1.2. What does it mean to hedge and why do firms hedge?

Without the need to transfer certain risks, there would be no derivatives or derivatives market. The company's managers are constantly searching for the best way to manage risks. They can use various operational techniques for managing it or use derivative financial instruments. Using

derivatives to reduce the volatility of future cash flows actually means to hedge. But why actually firms need to hedge? Taking into consideration the fact that hedging still remains controversial and may cause as benefits as losses for the company, it is necessary to investigate why some companies choose to hedge and what drives them.

Due to poor attempts to explain the benefits of hedging, a number of researchers considered that the decision to hedge may be caused by temporary price inconsistencies in the spot market and the derivatives market. In other words, managers who try to profit from price misalignment are not much different from speculators or quasi-arbitragers (Stulz, 1996; Faulkender, 2005). The same idea of speculation was suggested by Geczy & Bernadette, who stated that to make speculation profitable in rational markets, either a firm must have an information advantage about the prices of the instruments underlying the derivatives, or it must have economies of scale in transactions costs making profitable arbitrage opportunities possible (Christopher Geczy, 1997). Another example of how hedging can be used for speculation is described by Abon Mozumdar, who writes about default risk in swap markets: the problem of incentive to increase cash flow variance by participating in speculative swaps arises due to the information asymmetry between the firm and the swap dealer about the firm's operating exposure to the underlying risk. (Mozumdar, 2001)

Another idea about purpose if hedging was suggested by Stulz, who states that managers hedge to maximize their wealth which is proportionally driven from the firm`s value as he assumes that hedging increases firm`s value (Stulz R. M., 1984). Also Clifford W. Smith and Rene M. Stulz stated that hedging can be beneficial if it allows a company to avoid unnecessary fluctuations in external investment spending or funds raised (Stulz, Clifford, & Smith, 1985).

A completely different unconventional view of hedging motives reveals Okulov, who describes the contradicting fact that managers make decisions to hedge or not to hedge risks based only on their own forecasts of the market situation development, not paying attention to the general expectations of other market participants. He considers the motivation for hedging as the demand of

marginal investors –managers are trying to predict the desires of marginal investors to own shares of hedged companies in their portfolios. These marginal investors are the investors managing large industry portfolios.

1.3. Existing hedging strategies

Taking into account that companies may have completely different motives for hedging, different hedging strategies may also be used. Also, it is important to note that there are many different works dedicated to finding the optimal hedging coefficient. There were several works that were devoted to the determination of the optimal hedging strategy. In his article Stulz (1984) describes the model for the firm`s optimal hedge coefficient in several cases: in intertemporal settings and for risk-averse agents. The generalized approach to estimation of optimal hedge ratios on futures markets was developed by Robert J. Myers and Stanley R. Thompson. The approach is not difficult to apply and provides a framework for evaluating the appropriateness of conventional simple regression approaches to optimal hedge ratio estimation. They state that conventional approaches for estimation of optimal hedging ratios for the companies are not valid without including certain specific circumstances like conditional information (conditionalheteroscedasticity of an asset) which reflects variation in time (Myers & Thompson, 1989). Kenneth A. Froot, David S. Scharfstein, Jeremy C. Stein (1993) also illustrated other mean of deriving optimal hedge coefficient and described that a firm's optimal hedging strategy - in terms of both the amount of hedging and the instruments used - depends on the nature of its investment. Another example of optimal hedge coefficient model is presented in the article of V. L. Okulov “Selective hedging of price risks by companies” which is also related to the model for hedging optimization in the company. The main principal of this model is the determination of optimal ratio of “risk – expected return” considering different forecasts of the future dynamics of the risk factor. Besides existing models of identifying optimal hedging ratios, there are generally accepted hedging strategies that are widely used by companies.

The strategy of a perfect hedge or full hedge

Let`s consider a future contract for this strategy explanation. Imagine there is a portfolio which includes an asset, futures, and a cash account on the exchange. If there is an underlying asset and the futures contract for this asset is sold, the investor completely eliminates the risks of changes in the value of such a portfolio, which consists of the underlying asset, futures, and a cash account on the exchange. If the price of this underlying asset decrease then the future quotation decreases as well, so the investor (who sold the future) receives the variation margin from the future buyer and the initial value of the portfolio doesn`t change. At the same time investor doesn`t receive profit when the asset value increases. If investor has a short position in the underlying asset then it`s necessary to buy future contract. Thus, by including in the portfolio a futures contract for the underlying asset available to the investor (by taking a position on the futures market that is opposite to the underlying asset), investor can completely eliminate the risk of changes in the price of the underlying asset. This is called *full hedge* or *perfect hedge*.

Also, it is possible to eliminate the risk partly, for instance, to sell one future for one unit of an asset, having two units of it. The degree of hedging can be changed gradually, while producing a *partial hedge*. It is also possible to set limits on changes in the asset price. If this limit is exceeded, the investor can make a partial hedge, for example, hedge a third of their positions on the underlying asset. After that, another limit can be set and another part of the positions on the same asset can be hedged, and so on until the full hedge is made. The continuous hedging with shifting limits based on price changes is called a *dynamic hedging.*

Perfect hedging of futures contracts eliminates both the specific and market risks of the underlying asset. However, a futures contract carries the risk of paying a variation margin, which may cause the investor to suffer significant losses. For example, an investor with a long position on an underlying asset and a short position on a futures contract must pay a daily variation margin if the price rises.

Cross-hedging and the optimal hedge

If there are no futures contracts on the market for an asset held by an investor, it is necessary to find an asset which price change correlates with the change in the price of the existing asset. This type of hedge is called a *cross hedge*. For example, if an investor has shares of several companies, it is possible to use stock index futures for hedging. It is also necessary to understand how many contracts to have in order to find the optimal ratio of the hedged and non-hedged part of the asset.

Using the CAPM model, it is possible to determine the necessary number of contracts to eliminate the uncertainty of future cash flows when investor has a differentiated portfolio and he sells k number of futures on stock index. If to require that at a certain point in time, the expected return on both the portfolio and the expected payment of the variation margin on k contracts are equal, then using the CAPM formula K optimal can be derived. If the risk-free rate is not taken into account, since it is insignificant in comparison with strong market fluctuations, then the optimal number of contracts can be calculated as

$$K\ optimal = \beta_p * (P_0/F_0)\ , \qquad (1)$$

Where K is the number of contracts required, β_p –beta coefficient of the given portfolio, P_0 - value of a diversified portfolio, F_0 - forward price of a futures contract. This hedging strategy eliminates the risks generated by common factors affecting the investor's portfolio and the underlying futures asset. However, if the investor's portfolio is subject to some other risks, then it is necessary to consider *the residual risk of the hedged portfolio*. Assuming that the investor's goal is to minimize this residual risk, the optimal number of contracts should be such as to minimize the variance in the value of the hedged portfolio. Thus, the transition to the classical model of optimal hedging is carried out, using standard deviations of portfolio yield and futures prices:

$$k\ opt = \frac{P_0}{F_0} * \frac{\sigma p}{\sigma f} * \rho_{P,F}\ , \qquad (2)$$

Given the definition of the beta coefficient, we can say that the two expressions above are equivalent to each other, which means that optimal hedging reduces risks over the entire hedging period. However, it should be noted that cross-hedging does not reduce all risks, but moreover, it can add new risks associated with the underlying futures asset. It is generally assumed that if the correlation coefficient ($\rho_{P,F}$) is significantly less than 1, then cross-hedging should not be used.

According to the given strategies a company may choose the level of risk to be managed and exercise hedging, however, there is no certainty and confidence that these strategies will take into account all factors that affect the hedging effect for the company. It should be noted that the works considered have been around for a long time and suggest a relatively similar approach. More attention is given to the value of hedging and how hedging affects the value of the company. Although the research on hedging described in these papers was done a long time ago, and the world is changing as the derivatives market does not stand still, these questions about the value of hedging and its relationship to the value of the company have always been and remain relevant. Despite this, a new look at hedging and its application is considered in this paper. The new concept is based on a completely different principle and consideration of hedging.

1.4. Examples of poor risk management and unsuccessful hedging

Based on the analysis of the previous studies of hedging and existing hedging strategies it can be concluded that the benefit of using hedging by companies remains doubtful and depends on many factors, that gives a subject to further investigation. When considering the question of hedging it would be interesting to see real cases of how hedging affected various companies. Hence, let`s take a look at several examples of how wrong hedging strategy negatively affected companies.

In 1993, the German conglomerate Metallgesellschaft lost $ 1.3 billion after suffering from an incorrect long-term hedging strategy. By entering into short-term futures contracts, the company wanted to protect itself from future possible losses in sales. However, falling spot prices forced the company to margin calls and all contracts were closed at a loss. But that wasn't all. Since the spot

price subsequently increased, the company suffered even greater losses, covering its obligations to customers. The subsidiary (together with MG Refining & Marketing) has committed to supply hundreds of customers with fuel at a fixed price for 5-10 years. This price at the time of signing the contract was slightly higher than the current oil exchange rate. If oil prices fall, the business will be extremely profitable. If they start to grow, losses are inevitable. Therefore, MG resorted to so — called hedging-it bought short-term oil futures on the new York exchange, which give the right to buy oil at a certain price. If prices started to rise, these futures would be profitable. However, prices fell, and this brought MG large losses (margin calls). On the other hand, the current situation was theoretically very profitable for MG — in the long term, since if the downtrend continued, IT could hope for huge profits due to fixed supply prices for gasoline.

However, the MG control Board considered that the risk was too high. By the time oil prices fell as low as possible, the control Board ordered to immediately get rid of futures. Thus, MG suffered losses of $1.3 billion.

Another example of a poorly chosen hedging strategy is a case of Russian company Polymetal, which is a major gold producer and the world's largest silver producer. Exchange prices for silver after price shocks in the late seventies and early eighties for many years were weakly volatile and showed a slight downward trend. This is probably why the company used large-scale hedging, concluding long-term forward contracts for the sale of silver in 2004-2005. However, in 2006, a sharp increase in silver prices began, but Polymetal could not take advantage of the favorable market conditions, since almost all of the extracted metal had to be sold at the contract execution price, which is actually half the market price. According to analysts estimates, the company lost about $ 100 million in 2006-2007 alone.

Having analyzed existing hedging strategies and real cases of hedging, we can conclude that the benefit of hedging for companies remains uncertain. If hedging is used incorrectly, it can cause serious financial damage to the company, as evidenced by real cases. There is no specific criterion on which the company made a decision to hedge. In most studies, the main value of hedging is

represented by an increase in the value of the company. The main part of the research is aimed at identifying the impact of hedging on changes in the company's value, as well as finding the optimal hedging coefficient.

However, these strategies are more suitable for managing an investment portfolio, while in real business, other factors are taken into account to make a decision about hedging. Therefore, these strategies can be used in specific situations. It should also be taken into account that when making a decision on hedging in a company, the interests of the company as a whole and its stakeholder are taken into account, not the sole investor. Thus, the decision to hedge is no longer an investment decision but a financial one.

In this work the new hedging approach is presented on the basis of the market efficiency hypothesis. The most appropriate hedging strategy is defined and the new criterion is chosen for the determination of the appropriate strategy. The criterion for the appropriateness is minimization of transaction hedging costs. The main assumption in deriving the new hedging strategy is to rely on the market and assume that it`s efficient, so that we can build a model for predicting the future hedging costs. The developed strategy is aimed at hedging currency risks, therefore, it is necessary to study the features of this type of risk and consider the tools and techniques for hedging currency risk.

1.5. Currency risk management: operational techniques and use of derivatives

Currency risk exposure is a probability of adverse changes in a company's profitability, net cash flows and market value due to changes in the exchange value of currencies. The exchange rate is one of the most important sources of risk for non-financial organizations. Not only it can affect company`s financial performance, but in the long term, it affects the company's sales in foreign markets, the costs associated with purchasing foreign goods, and therefore changes the company's competitive position in home and foreign markets. It is the price of one country's currency in terms of another, and, as such, it converts prices denominated in one currency into prices denominated in

another currency. Changes in exchange rates should therefore have a significant effect on the performance of firms involved in international activities (M.Bodnar & Bartov, 1994).

Hence, companies operating internationally are exposed to currency risk, so only they are faced with the need to manage it. However, changes in the exchange rate may also affect companies that are fully focused on the domestic market, since even in this case, companies may be exposed to indirect currency risk factors.

Direct factors of exposure to currency risk:

1. Companies export and import in foreign currency.

2. Companies buy and sell goods and services in the domestic currency, but the contract provides for the possibility of changing the currency of the counterparty under certain conditions.

3. Companies have debt obligations and / or assets in foreign currency.

4. Companies have foreign investments/branches abroad.

Indirect factors of currency risk exposure:

1. Companies buy and sell goods and services in the domestic currency, but the price depends on currency fluctuations.

2. Companies operate in domestic and foreign markets, competing with domestic companies whose cost structure is subject to currency risk.

3. Companies operate on domestic and international markets, competing with foreign companies that have an excellent capital structure.

Operational techniques for managing currency risk are used by companies that want to minimize the risk of currency exchange rate changes within themselves. They are based on the characteristics of the company and its relationships with counterparties, that is, they do not require access to the markets of currency or derivative financial instruments, which makes them quite easy to apply.

1. Netting (direct borrowing)

This technique involves offsetting intra-company cash flows between the company and its foreign subsidiaries at the end of each period. Thus, only the difference between these flows remains exposed to currency risk and requires hedging. In addition, netting allows you to reduce transaction costs (Commission when transferring funds), but you can only use the advantages of this strategy if there is a two-way cash flow.

2. Matching

Mapping is quite similar to netting, but it includes interaction with a third party, not a foreign subsidiary. Using this operating technique, the company aims to compare projected outflows and inflows of currency by amount and time. For example, a company that is involved in export operations and expects to settle accounts receivable in a foreign currency in a certain period may plan to pay its obligations in the same currency in the same period (for example, by entering into a contract for the import of goods). In this case, the match will be called natural matching.

3. Lead & lag - managing the timing of payments and receipts

An additional operating technique that companies can use is managing the timing of payments and receipts – leading and lagging. Leading means paying bills earlier or collecting receivables, while lagging is the transfer of outflows and inflows to later points in time. By changing the terms of contracts, companies can ensure that there is a minimum time interval between inflows and outflows in the same currency, thus reducing the effect of currency exchange rate changes or reducing the scale of exposure to currency risk. Companies usually seek to negotiate earlier payment of accounts receivable in an unstable currency that is difficult to predict due to economic and political turbulence (soft currency) and defer payment of accounts receivable in a hard currency that is relatively stable in the short term (hard currency) in order to avoid the depreciation of the unstable currency and benefit from the appreciation of hard currency. Following the same logic, companies should try to include in their contracts with suppliers conditions for early payment of accounts payable denominated in hard currency, and later payment of obligations in an unstable currency.

4. The choice of invoice currency

By choosing this currency risk management option, the company can transfer or share its currency risk. For example, if a company issues an invoice in its domestic currency, it does not face the risk of an adverse change in the exchange value of the currency. In this case, the risk is not minimized, it is simply transferred from the company to the buyer. In addition to fully transferring currency risk, the company can split it, for example, by issuing half of the account in its own currency and the other half in a foreign currency. Obviously, the company's exposure to currency risk is reduced by half in this case. To achieve this useful effect, the payment currency must be agreed upon at the time of the sale or be included in the terms of the contract. In real life, companies are wary of resorting to this operating technique, because they are afraid of losing customers in a highly competitive environment. Only companies with significant market power in negotiations can use it without fear.

In addition to internal ways of currency risk management within the company, there are external management methods that are most often associated with derivative financial instruments. Using these tools, the company can reduce the volatility of its cash flows.

1.6. Derivative definition

A derivative financial instrument - is a contract that fixes the rights and obligations of the parties to this contract in relation to a specific underlying asset (Hull, 2018).

Main types of derivatives:

- Forward and futures contracts
- Option swaps
- Swap contracts
- CDS contracts

The main underlying assets for which derivatives are traded are:

- Commodities
- Currency
- Capital market instruments
- Financial market indicators (interest rates)
- Other derivatives

Based on the concept of market efficiency, the value of a derivative is closely related to the current price of the underlying asset, but if the underlying asset of a derivative is non - tradable, the value of such a derivative is tied to some quantitative characteristic. Also derivative contracts are divided into delivery and cash-settled contracts. When a delivery contact is made, the underlying asset is physically delivered. During the settlement contact, mutual monetary settlement is made according to the terms specified in the specification of this contract.

1.7. World derivatives usage – general statistics

During recent years there has been an enormous growth in the use of derivative instruments. This is caused by the unique feature of derivative instrument – risk is separated from the underlying asset, as it affords transferring risk from one investor to another without transferring the underlying asset itself. It should be noted that in general there is a growing trend in the use of derivatives, both OTC and exchange-traded derivatives. Over the last 3 years the global tendency for increase in derivatives usage can be seen in the OTC market.

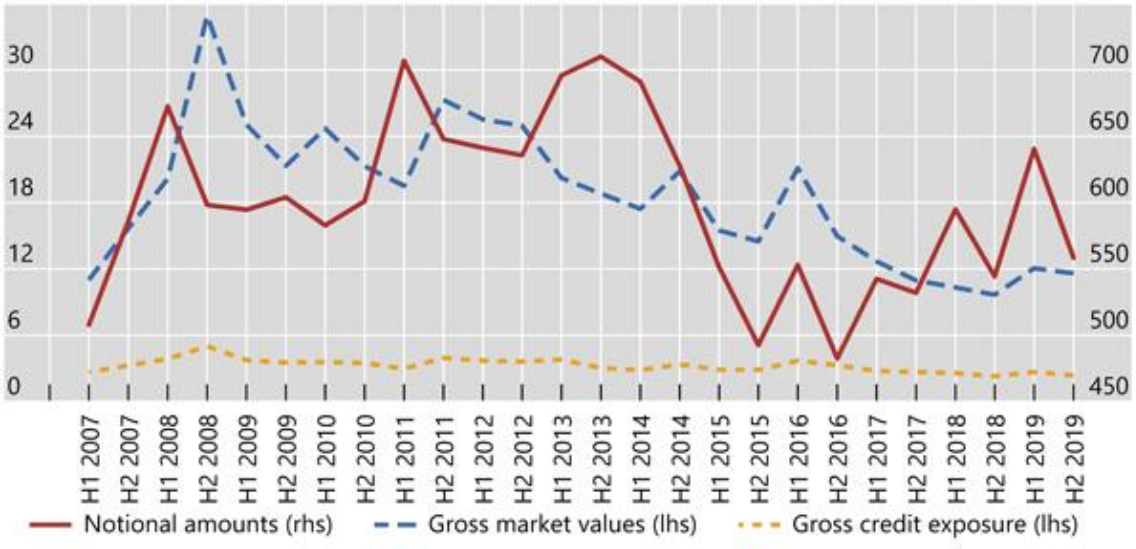


Figure 1. Notional amounts of OTC derivatives

Statistical release: OTC derivatives statistics at end December 2019 (Source: https://www.isda.org)

According to Bank of International Settlement report, notional amounts of OTC derivatives rose from $544 trillion at end-December 2018 to $559 trillion at end-December 2019. Regarding foreign exchange market instruments, there is a constant trend of growing of derivative`s use.

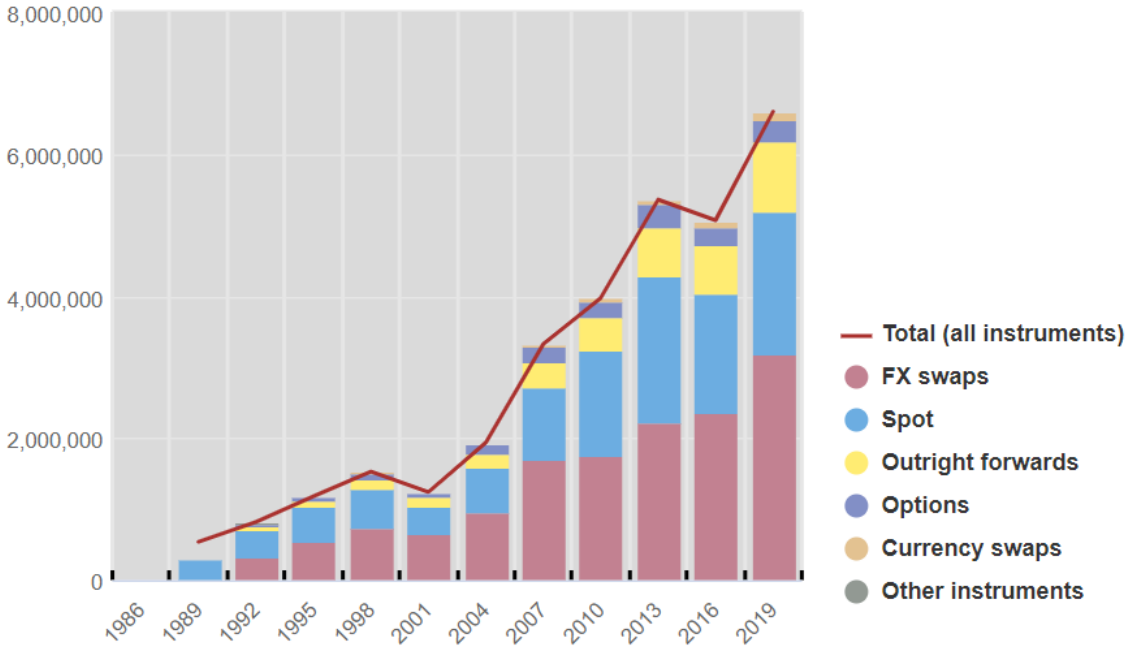


Figure 2. Global foreign exchange market turnover .Daily averages, in millions of US dollars

Statistical release: OTC derivatives statistics at end December 2019 (Source: https://www.isda.org)

Moreover, Based on the ISDA Future of Derivatives Survey 56% of the experts expect the overall future derivatives volumes in the market to increase.

1.8. Hedging instruments

1. Forward contract

Forward - is an agreement between the parties on the future delivery of the underlying asset, which is concluded outside of the exchange. All terms of the transaction are negotiated at the time of conclusion of the contract. The contract is executed in accordance with these terms and conditions at the appointed time. A forward contract is traded in the over-the-counter market-usually between two financial institutions or between a financial institution and one of its clients (Hull, 2018). One of the parties to a forward contract assumes a long position and agrees to buy the underlying asset on a certain specified future date for a certain specified price. The other party assumes a short position and agrees to sell the asset on the same date for the same price.

2. Future contract

Using futures contracts is an alternative to using forward contracts to buy or sell a certain amount of currency at a fixed time at a fixed price. However, futures are exchange-traded instruments. This means that their main parameters are determined by the exchange.

Future is a unified exchange-traded forward contract, all parameters of which are set by the exchange (the underlying asset and its characteristics, the date of contract execution, the method of delivery and settlement). The only available parameter is the price, which is set by the decision of the buyer and seller at the time of conclusion of the contract.

Specific characteristics of currency futures are:

- A futures position may be closed before its execution date.
- Futures are quite inflexible: available only for a limited number of currencies and for standardized execution dates (usually 15^{th} day of the month)
- Lots of the contact are standardized
- Futures require a guarantee which is costly.

3. Swap contracts

Swap contracts are an agreement between companies to exchange cash flows in the future. The company's motivation for using a swap is a desire to replace a monetary payment in an undesirable currency with a payment in a more profitable currency for the company, which is usually the currency of receipt of revenue. Companies often attract loans in currencies in which they do not receive revenue. The reason for this is the lower interest rate. However, after raising such a loan, the company, fearing an adverse change in the exchange rate of the currency, may exchange the currency payment for a payment in the currency that it receives inflows of.

4. Options

A currency option is a contract that gives the buyer the right, but not the obligation, to buy or sell a certain amount of currency at a fixed price per unit over a certain period of time. There are two types of options: call and put. A call option is an option to buy a currency, while a put option is an option to sell a currency.

In this work forward contracts are going to be considered and analyzed for deriving the potential hedging strategy, so it was decided to concentrate of on explanation of the peculiarities of this type of contract.

Forward specifications

A forward contract is usually used for making a real sale or purchase of the relevant asset and insuring the supplier or buyer against possible adverse price changes.

By entering into a forward contract, both the buyer and the seller destroy the uncertainty of their future. The buyer knows exactly how much money they will pay for the underlying asset when the contract is due, and the seller knows exactly how much money they will receive. A forward contract usually specifies not only the term of execution and the price of execution of the contract,

but also the terms of delivery and settlement, special characteristics of the underlying asset, and so on.

This contract is very specific, it is tailored to the interests of the parties who signed it. Because of this, it is difficult to sell a forward to anyone if one of the parties decides to get rid of it; the circle of participants interested in such a contract is very narrow. This is a tool for companies that have close production ties with each other and will not lose their reputation by renouncing their obligations. But a forward contract can be an interesting, flexible tool for managing the risks associated with the underlying asset: first, because its value is directly related to the change in the value of the underlying asset, and secondly, because entering into a transaction with this instrument does not require the movement of funds (Okulov, 2019).

The hedging mechanism using a forward contract is as follows: let the investor have an underlying asset and sell a forward contract for this asset, thus setting a future price for the sale of this asset. The main question is to correctly determine what price (forward price) should be fixed for the future sale of the hedged asset.

From the point of view of theory, in the issue of determining the forward price two concepts can be distinguished. The first is that the forward price arises as a consequence of the future expectations of the futures market participants regarding the future spot price. The second concept is based on the arbitration approach. The arbitrage approach is based on the technical relationship between the forward and current spot prices, which is determined by the existing risk-free rate on the market. It is based on the provision that the investor, from the point of view of a financial decision, should be indifferent to the issue of purchasing the underlying asset on the spot market now or on a forward contract in the future.

The forward price of the currency is based on the so-called interest rate parity, which says: the investor should receive the same income from placing funds at interest without risk in both national and foreign currencies. Let's assume that the spot exchange rate of the ruble to the dollar (direct quote) is equal to $ 1. = S rubles, the risk-free rate for a ruble deposit is rr, and for a dollar deposit is

rd. The investor plans to place funds on deposit for the duration of the transaction. There are two options before it.

First, place the amount S on a ruble deposit and receive funds at the end of period t in the amount of:

$$S\ (1+ rr\ \frac{1}{360})\ rub\ , \qquad (3)$$

Second, convert the amount of S to $ 1, place it with the rate rd for period t, and at the end of it, convert in rubles at a certain forward rate F the funds received in the amount of:

$$(1+ rd\ \frac{1}{360})\ doll\ , \qquad (4)$$

Both options should bring the same result to the investor. Otherwise, it will be possible to perform an arbitration operation. Therefore, we can write that:

$$S\ (1+ rr\ \frac{1}{360}) = F\ (1+ rd\ \frac{1}{360}\ )\ , \qquad (5)$$

From this we derive that:

$$F=S\ \frac{1+rr(\frac{t}{360})}{1+rd(\frac{t}{360})}\ , \qquad (6)$$

In professional language, the formula name is “forward outright” (Hull, 2018).

In this work it is necessary to estimate foreign currency exchange rate and for this purpose the given formula above was used. Based on this formula it is possible to identify the forward currency rate and therefore derive future hedging and non-hedging costs. It is important to note that for identifying these costs and then deriving a strategy for costs minimization all information is available as this strategy relies on effective market hypothesis.

It is known that the price movement in a competitive market is a random walk. If past price changes could be used to predict future price changes, investors could easily make a lot of money. However, as soon as investors make an attempt to profit from information about past prices, a price

correction immediately occurs, eliminating the possible benefits of knowing their past dynamics. In a competitive market, the current share price already contains all the information about past prices. This means that in a competitive market, today's asset price should reflect all the information available to investors. These securities are priced fairly and their returns are unpredictable, no matter what information is analyzed (Brealey, Myers, & Allen, 2019).

Based on the hypothesis of market performance, it is impossible to build a strategy that would outperform the market in the long term. However, accepting this hypothesis raises an internal logical problem, which is that the market cannot become fully effective for a long time. This is due to the fact that in order to achieve efficiency in the market, active participants must act, which by their transactions bring the market to an effective state. However, if the market is effective, then active participants will not be able to profit from their actions and will leave, after which the market will again become ineffective. Thus, in the long term, the market may either remain permanently inefficient to some extent, or fluctuate relative to a certain level. This means that the potential strategy will be applicable only in a short run.

Chapter 2. Research methodology and model construction

2.1. Methodology description

The goal of this work is to identify the method for determining the best strategy, which would help company to make a decision about hedging. It can be assumed that in order to make a decision about hedging, the company's decision may be based on minimizing costs. So in order to facilitate this decision a company can develop several strategies based on non-hedging and hedging expenses comparison, and choose one which is the most appropriate one. The chosen criterion is cost minimization – which means such hedging strategy helps to reduce transactions costs to the minimum level and allows company to spend as little as possible. It is also assumed that all information is available and market is efficient, so it is possible to build a model for hedging cost calculation.

This research is purely methodological in nature. In order to derive the model for making a test and comparison of hedging and non-hedging costs the proposed **"sample"** company was created. All financial data was constructed manually in order to create a "sample company" for which the results of the best hedging strategy would be relevant. This sample company is a kind of collective model that combines the typical features and structure of many other real existing companies.

The revenue of the company and its liabilities were constructed manually and possible currency revenue inflows were simulated using the chosen simulation technique. The main methods used for constructing possible revenue inflows exposed to currency risk - Monte-Carlo simulation.

Data sources

- Thomson Reuters Eikon – forward EUR/RUB bid ask spread was taken (6M-3Y)
- The Central Bank of Russian Federation database
- MOEX Moscow Exchange
- Sberbank Brokerage service rates – commissions for transactions on the currency market of the Moscow exchange: percentage of turnover for the trading day (0,2%)

Hedging instrument

In this analysis the forward contact is considered as the hedging instrument of uneven and uncertain currency inflows. A forward contract is very specific and it is most suitable for this currency purchase operation since it includes the price of execution of the contract and the terms of delivery and settlement and other special characteristics. Forward is easy to settle and have clear description and is aimed at actual transaction execution.

For identifying the forward rate averages for one last year of LIBOR Euro and MIBOR rates were used, the spot rate was calculated as the average of values for the last two years given by Central Bank.

Table 1. Forward calculation components

72,37996	Spot
1%	LIBOR Euro
6%	MIBOR

(Source: compiled by the author)

Then 36 forward rates were calculated for each future month of the 3-year period. It should be assumed that regardless of whether the company will be hedged or not, and regardless of the chosen hedging strategy, it will always buy the currency at the **calculated forward exchange rate** in the future. This is a very important assumption on which subsequent calculations are based.

In order to identify hedging costs, bid-ask spread of the euro/ruble forward contract was calculated for 6M, 9M, 1Y, 1,8Y, 2Y, 3Y. The data was taken from Thomson Reuters Eikon database. Non-hedging costs equal the commissions for transactions on the currency market of the Moscow exchange which equals to 0,2% of a turnover.

The formula for estimation of the hedging expenses (H) for the entire hedging period includes the following components:

$$H = \sum (D_1 * S_1 + (D_2 - d_1) * S_2 + \cdots + (D_n - d_{n-1}) * Sn), \quad (7)$$

For estimation of average expenses per month:

$$\text{H per month} = \frac{\sum(D_1 * S_1 + (D_2 - d_1) * S_2 + \cdots + (D_n - d_{n-1}) * Sn)}{N},$$

(8)

Where

D_n – deficit of the certain month,

D_r – real deficit of the month (modelled values),

d_n – difference between Dn and Dr, if Dn>Dr,

S – bid ask spread of the currency to be purchased in the future,

N – number of months in the hedging period.

Non-hedging expenses (NH) for the entire period under review contain the following components:

$$NH = \sum(Dr1 + Dr2 + \cdots Drn) * C,$$

(9)

$$\text{NH per month} = \frac{\sum(Dr1 + Dr2 + \cdots Drn) * C}{N},$$

(10)

Where

D_r – real deficit of the month (modelled values),

C – commission costs for urgent purchase of the currency in the bank,

N – number of months in the hedging period.

In order to estimate whether hedging is beneficial it is necessary to compare hedging and non-hedging expenses. For simplifying the method used, the following formula for calculation and comparison of hedging and non-hedging expenses can be used:

$$\sum_{n=1}^{N}(D_n - d_{n-1}) * S_n - \sum_{n=1}^{N} Dr_n * C,$$

(11)

Where

D_n – predicted deficit of the certain month,

D_r – real deficit of the month (modelled values),

d_n – difference between Dn and Dr, if Dn>Dr,

S – bid ask spread of the currency to be purchased in the future,

C – commission costs for urgent purchase of the currency in the bank,

N – number of months in the hedging period.

The hedge will be considered relevant in the case of a negative difference, when the non-hedging costs will exceed the hedging costs.

This formula assumes adjustment for the difference between sum hedged and real deficit of the previous month. The "real deficit" value is not the deficit value predicted by the Manager, which is subject to hedging, but one of 1000 simulated values of real revenue receipts, which was obtained by simulation with specified parameters.

The main goal of the method is to find the most appropriate strategy. The criterion for the choice of such a strategy is minimization of expenses. So, after estimation of hedging expenses (H) and non-hedging expenses (NH), we compare them and if

$$H < NH,$$

Then after estimating expenses for every strategy we chose the one where

$$H \rightarrow \min$$

2.2. Description of the modeled company

In this analysis a company with the currency risk exposure in a form of foreign liabilities and revenues is considered. The sample company, or a Company 1, receives revenue in two currencies: rubles and euros. Thus, the Company faces currency risk associated with cash inflows in a foreign currency.

In addition to exposure to currency risk from inflows, another factor of currency risk in the Company is the presence of debt liability denominated in a foreign currency – euros.

Today is the 1st of January. In July Company 1 takes a 3-year loan in euros provided by commercial bank.

The revenue of Company 1 during 3 years starting from July stands for:

Table 2. Revenue

	Revenue, thousand euros
Year 1	170 000
Year 2	180 000
Year 3	190 000

(Source: compiled by the author)

The revenue distribution in months is predicted by the Company managers based on their knowledge of the company specification and insights. The revenue inflows distribution in the 1st, 2nd and 3rd year respectively is shown on the graphs:

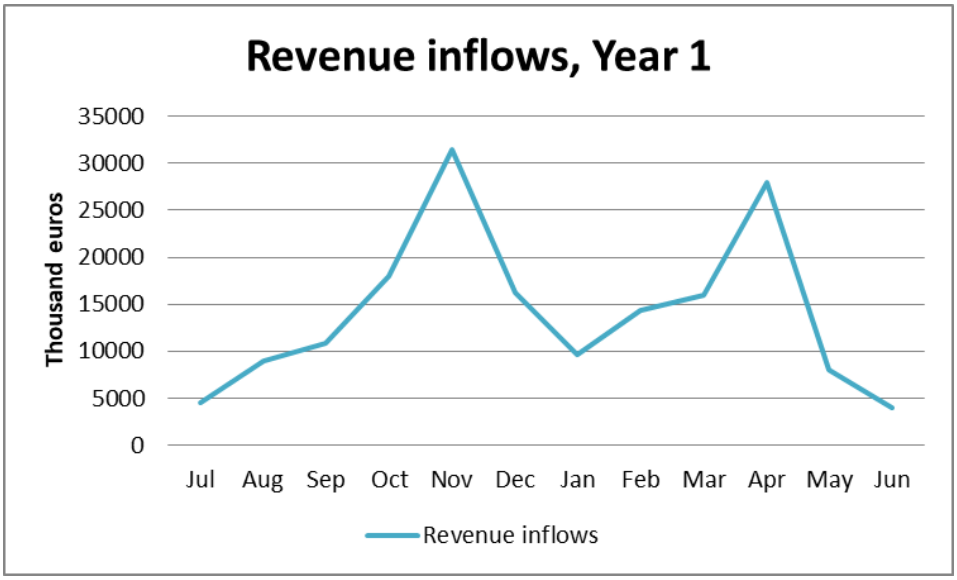


Figure 3. Revenue inflows, thousand euros

(Source: compiled by the author)

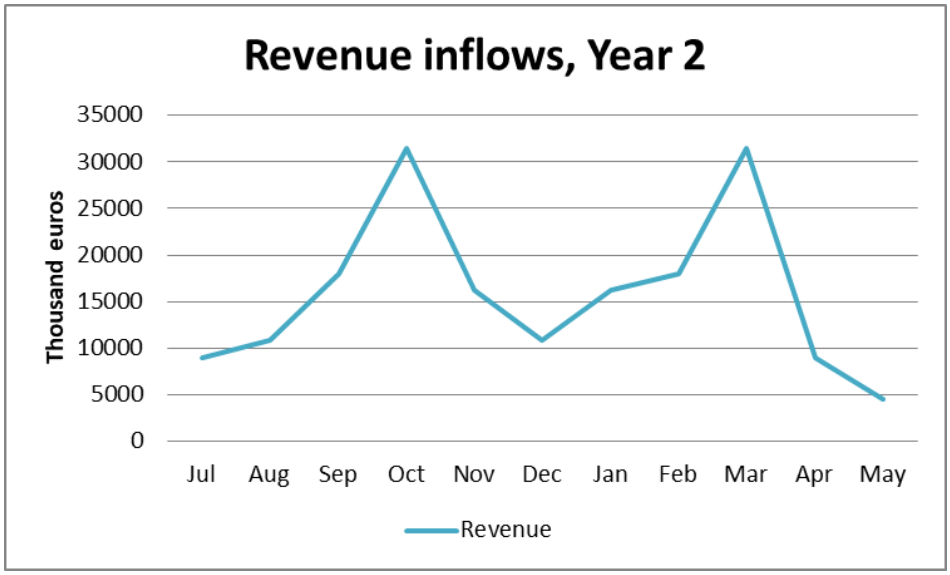


Figure 4. Revenue inflows, thousand euros

(Source: compiled by the author)

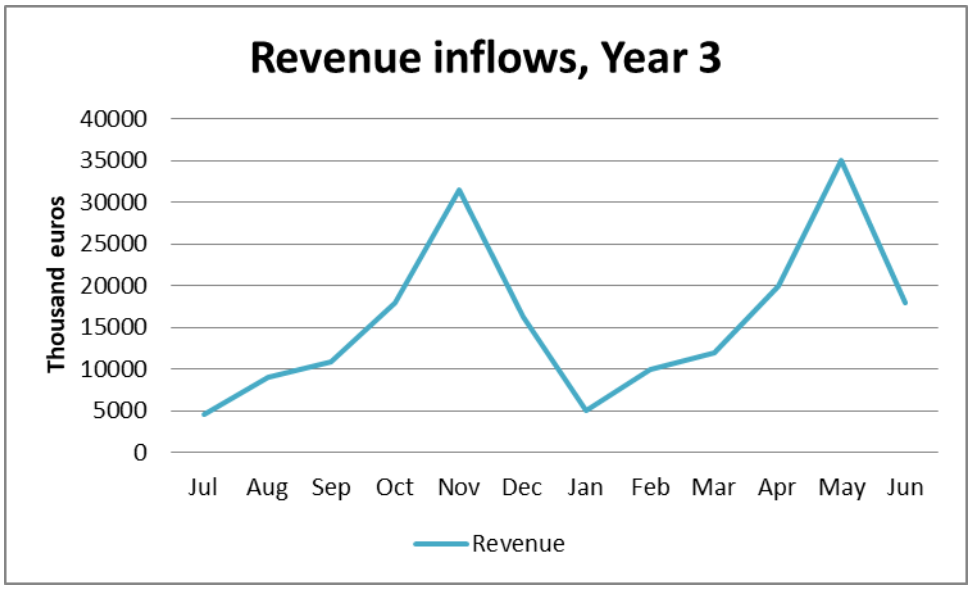


Figure 5. Revenue inflows, thousand euros

(Source: compiled by the author)

Starting from July there is a permanent loan debt, equals to 720 million euro that must be repaid in a monthly fixed payment during 3 years.

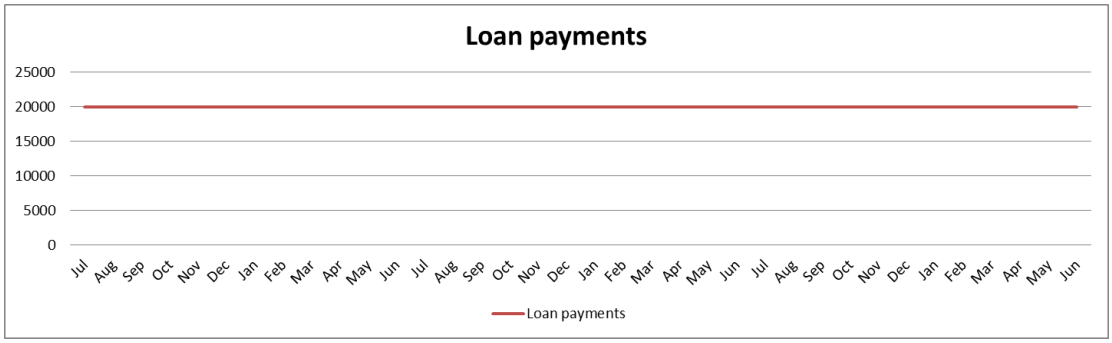


Figure 6. Loan payments during 3 years, thousand euros

(Source: compiled by the author)

The modeled company has part of its revenue in foreign currency and meanwhile has long-term liabilities in the same foreign currency, so there is a need for proper distribution of cash flows for even repayment of debt in a foreign currency. In Company #1 cash inflows are received unevenly, resulting in a negative difference between the foreign currency inflows and the obligation, so Company 1 will not have enough foreign currency to repay its regular fixed obligations.

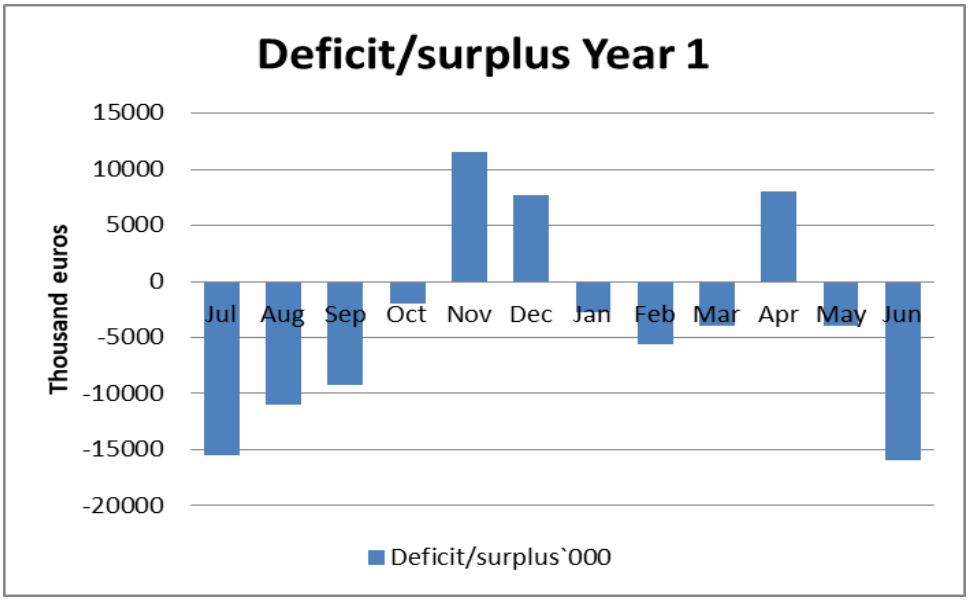


Figure 7. Deficit/surplus, thousand euros

(Source: compiled by the author)

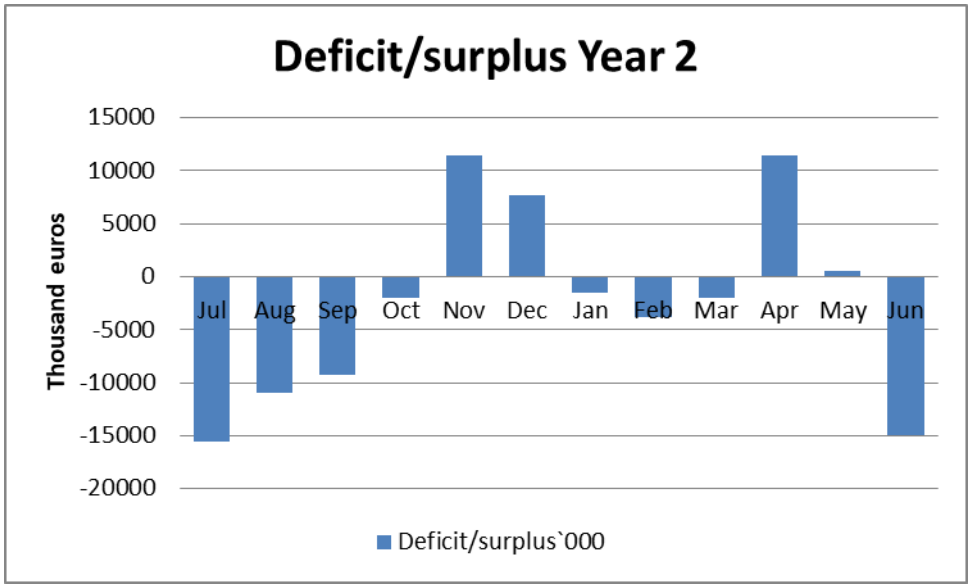


Figure 8. Deficit/surplus, thousand euros

(Source: compiled by the author)

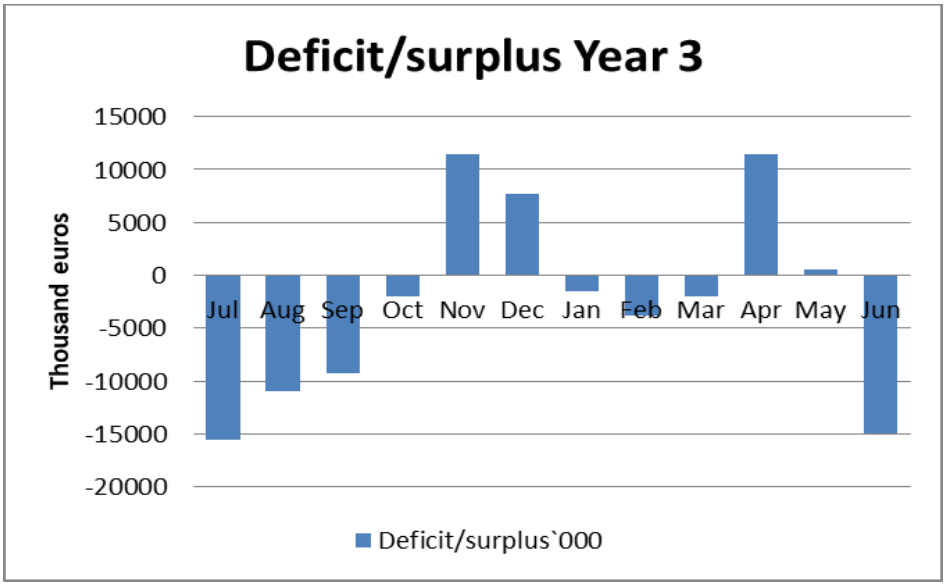


Figure 9. Deficit/surplus, thousand euros

(Source: compiled by the author)

It is important to pay attention to the uncertainty of the currency deficit. Despite the fact that many studies are aimed at hedging a fixed deficit and identifying the resulting value of hedging, in practice, very often companies do not know what the actual deficit is waiting for them and often can only predict it. This is why it is necessary to estimate as many possible predictions of the deficit as possible to produce a coherent and reliable analysis.

Despite managers' forecasts, it should be taken into account that the company's foreign exchange earnings can vary greatly each month. As a result, 1000 revenue values were simulated for each month for 3 years with the following parameters:

- managers ' forecasts were taken as the average value (the distribution of currency inflows above),
- the standard deviation of currency inflows is 15%,
- normal distribution was taken.

As a result of 1000 new revenue values for each month, new 1000 deficit values appear. As it is seen in the charts above, managers predict a surplus in some months, but there may be a deficit in the predicted values in these months. Therefore, it is necessary to calculate the probability of occurrence of such a deficit and calculate its average value.

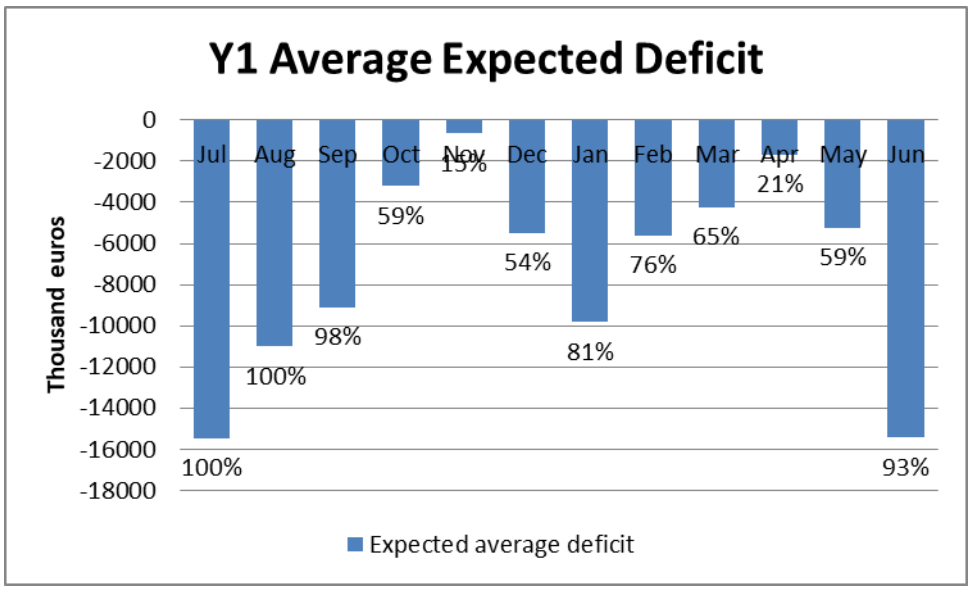


Figure 10. Average expected deficit, thousand euros

(Source: compiled by the author)

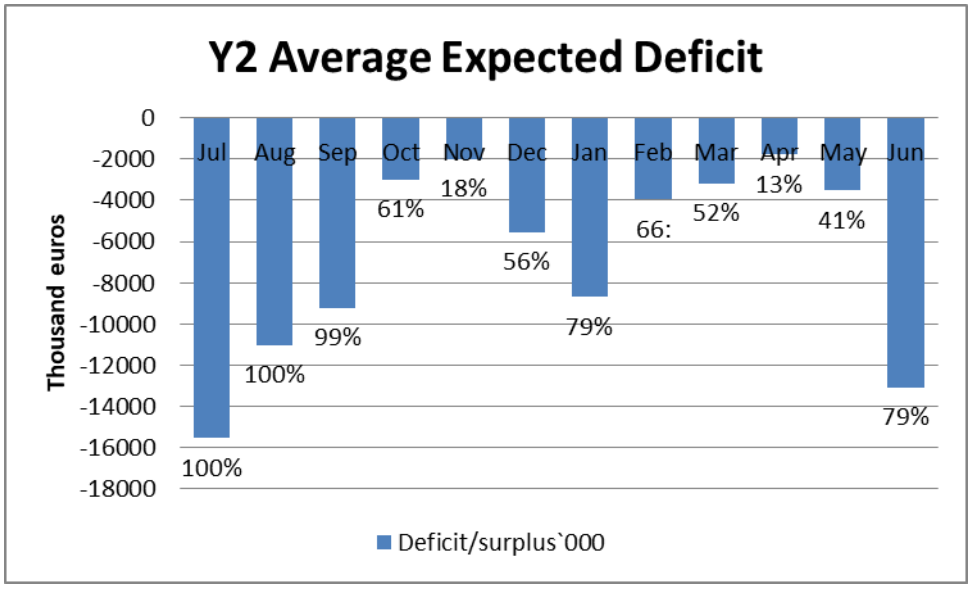


Figure 11. Average expected deficit, thousand euros

(Source: compiled by the author)

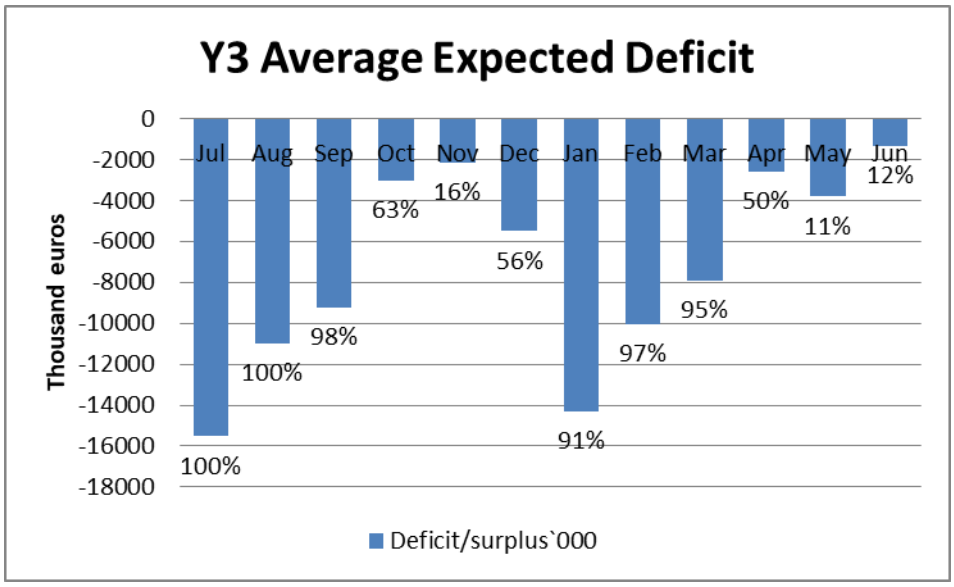


Figure 12. Average expected deficit, thousand euros

(Source: compiled by the author)

The expected deficit is calculated as the average of only negative values among 1000 simulated deficit values obtained.

Consequently, the resulting deficit is inevitable and Company 1 has two options:

- to hedge deficit using the forward contract (6 different strategies can be considered),
- to buy the missing amount of currency at the price set by the Bank that serves this company.

Chapter 3. Hedging strategies and their verification

3.1. Hedging strategies

In order to derive the hedging strategy it`s necessary to know exact cost of hedging and non-hedging for each month of the analyzed period. The bid ask spread of the forward contact was taken as the cost of using this contract – the spread represents the price to be paid for each euro in cents. The cost of non-hedging is 0,2% of the sum to be hedged, what is translated into euros equals to 0,002 euro or 0,2 cents.

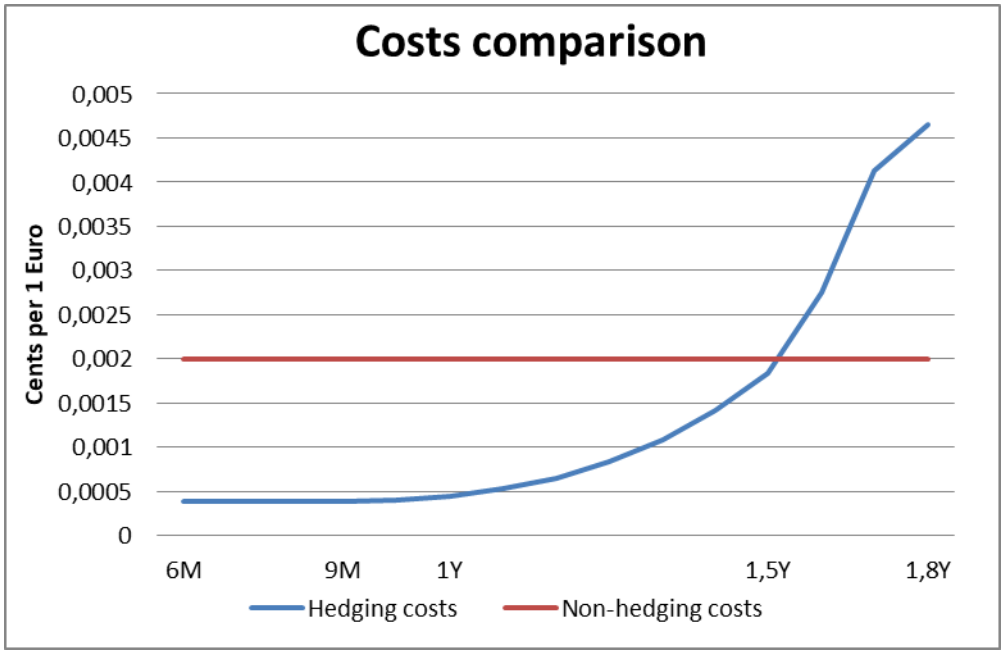


Figure 23. Cost comparison, cents per 1 euro

(Source: compiled by the author)

It is important to mark that starting from July of the next year, in 12 months, hedging costs start exceeding cost of paying commission to the Bank for purchasing euros. This is reflected further in the difference between hedging and non-hedging costs as it can be seen on the graphs.

For non-hedging expenses calculation the simulated sum of deficit was multiplied by the price of commission for transaction (0,002 cents).

For identifying hedging and non-hedging expenses the average values of 1000 costs values are taken. Hedging and non-hedging expenses are calculated for each simulated value of the deficit for each month.

Based on these prices the following strategies can be used:

Strategy 1:

Every month Company 1 hedges only deficit predicted by managers with adjustment based on the real deficit in the previous month. If surplus is predicted then company switches to non-hedging and buys currency from the bank.

Since currency revenue inflows can vary significantly, so can the deficit values. The 1000 simulated deficit values have deviations from the Manager's forecast values. Therefore, Strategy 1 involves hedging only the deficit of July and then adjust the next sum to hedge based on the amount that actually was received in July. This is necessary in order not to accumulate "extra" currency, but to reduce the subsequent deficit amount predicted by the Manager by the positive difference between the hedged amount in the previous month and the actual amount of the received deficit/surplus, if there is one. For instance, the predicted sum of deficit in July is 15,5 million euro and the simulated deficit equals 14,4 million, which means that 1,1 million will be kept for the next month and the next sum of deficit predicted by Manager (11 million in August) will be decreased by 1,1 million and so on. If Manager predicts surplus, no forward contract is used, and if there is still a deficit (in 1000 simulations), then the costs are calculated as non-hedging expenses. The amount of each month is hedged until the hedging costs exceed the non-hedging costs, which can be seen on the graph when comparing.

The comparison of hedging and non-hedging expenses can be seen on the graph:

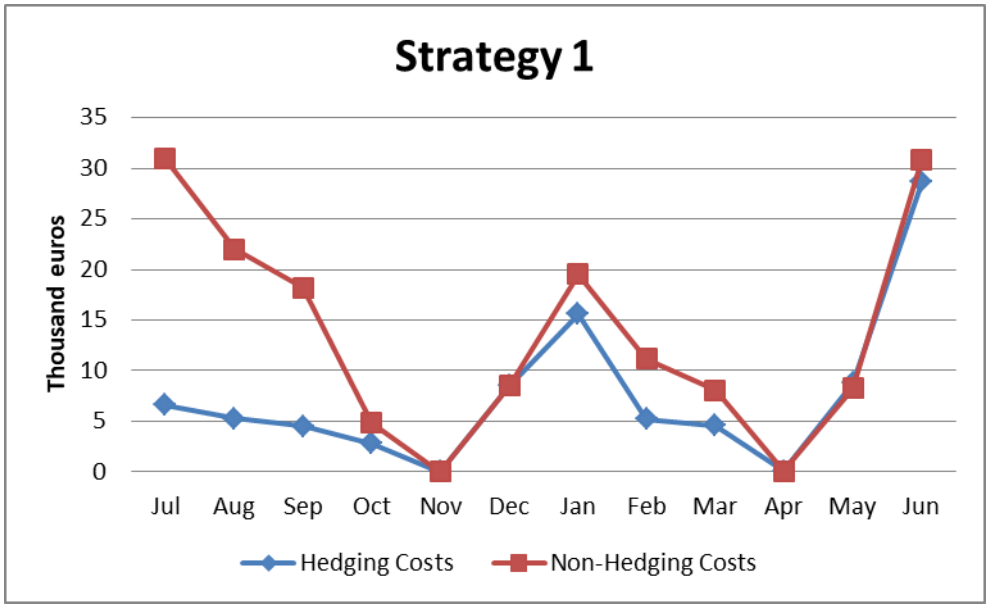


Figure 14. Expenses in Strategy 1, thousand euros

(Source: compiled by the author)

Strategy 2:

Hedging with certain number of contracts now and no changes in the hedging sum can be made. This means that company 1 buys certain number of contracts right now (in our case 7 as hedging remains beneficial till March inclusively). No flexibility and adjustments are provided, but the exact amount of hedging sum and the exact costs are already known.

If Manager predicts deficit, this is the amount that will be hedged, if there is a surplus, then in the case of a deficit in simulations, non-hedging expenses will be calculated. The number of contracts corresponds to the number of months when the deficit is forecast. The amount of each month is hedged until the hedging expenses exceed the non-hedging expenses, which can be seen on the graph when comparing.

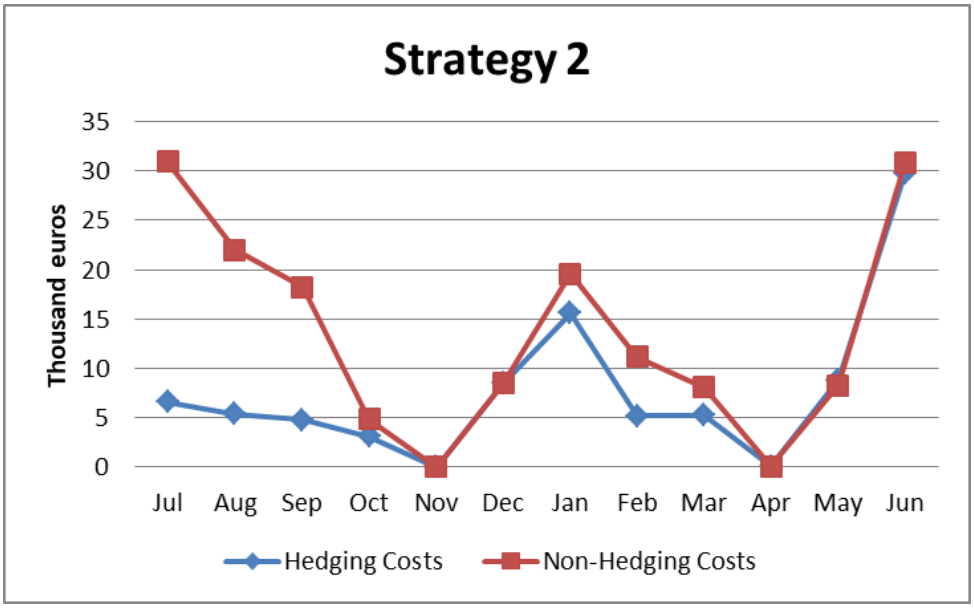


Figure 15. Expenses in Strategy 2

(Source: compiled by the author)

Strategy 3and 4:

Hedging of the negative expected deficit calculated in the bases of simulated values of deficit, not the values predicted by Manager. Contracts for all months are not pre-purchased, only July is hedged, and subsequent hedging amounts are adjusted depending on the actual situation. The sum of expected deficit is adjusted every month on the positive difference between sum hedged in the previous month and the real deficit received, if there is such difference. Nevertheless, in some months despite the expected deficit, the probability of getting it is low and the cost of non-hedging is lower than the cost of hedging this unlikely deficit. Here there are 2 options and two strategies can be derived:

- to hedge the deficit of each months with adjustments and switch to non-hedging if the expenses of hedging exceed non-hedging in certain month,

Figure 16. Expenses in Strategy 3

(Source: compiled by the author)

- or hedge the deficit of each month where this deficit can occur despite the difference in expenses if there is one in a certain months.

It can be seen on the graph that the hedging expenses in November are slightly higher than non-hedging:

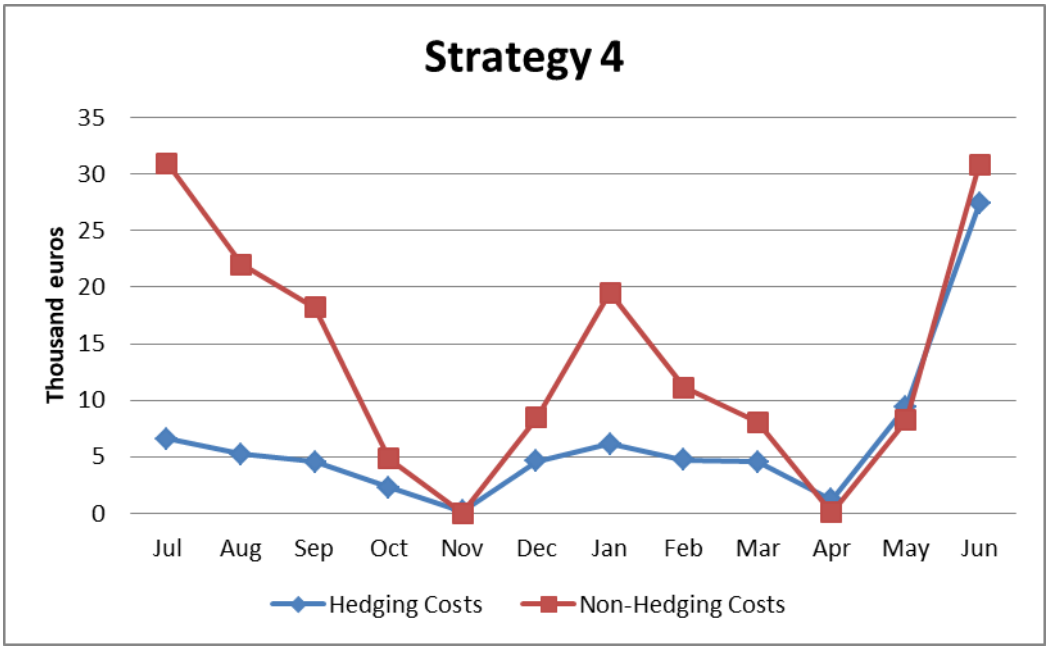


Figure 17. Expenses in Strategy 4

(Source: compiled by the author)

Strategy 5 and 6:

All contracts are purchased in advance, now, meaning the sum of hedging can no longer be adjusted. The expected deficit is hedged, and again in some months the probability of getting the deficit is relatively low, so the non-hedging expenses are lower than the hedging ones. Therefore, again there are 2 option and 2 hedging strategies can be exercised.

Strategy 5 allows to hedge the expected deficit each month without an adjustment but to switch to non-hedging when hedging expenses exceed non-hedging. Thus, when entering into contracts in advance, it`s necessary to take into account in which months the forward will not be needed, and in this month the currency will be purchased from the Bank at a fixed price.

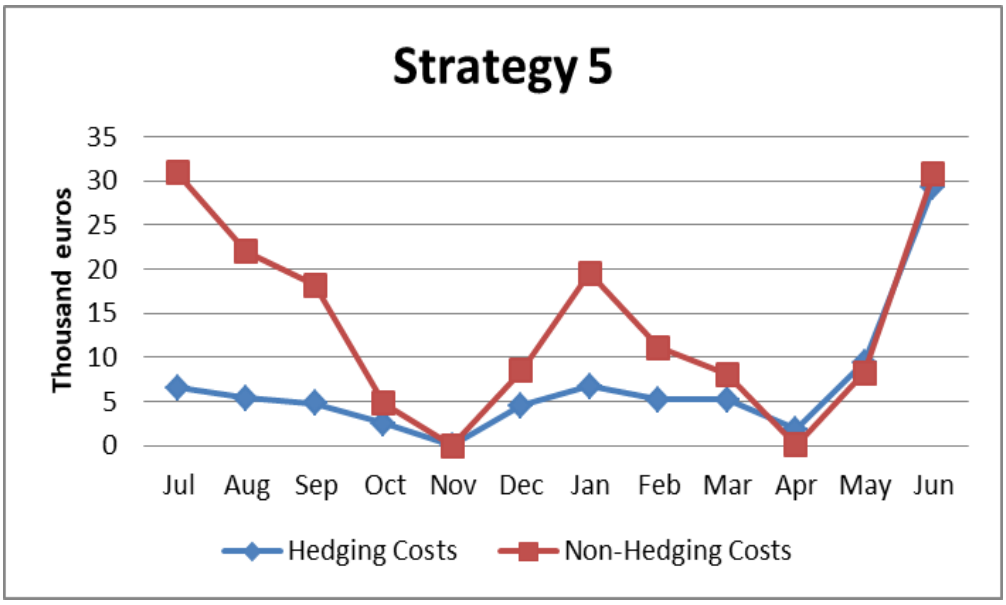


Figure 18. Expenses in Strategy 5

(Source: compiled by the author)

Strategy 6 allows to hedge the expected deficit every month during the whole hedging period and fix the sum of hedging in advance but without switching to non-hedging even when the hedging expenses exceed hedging, so that the probability of getting deficit and the need to buy this missing currency from the Bank in such months is leveled.

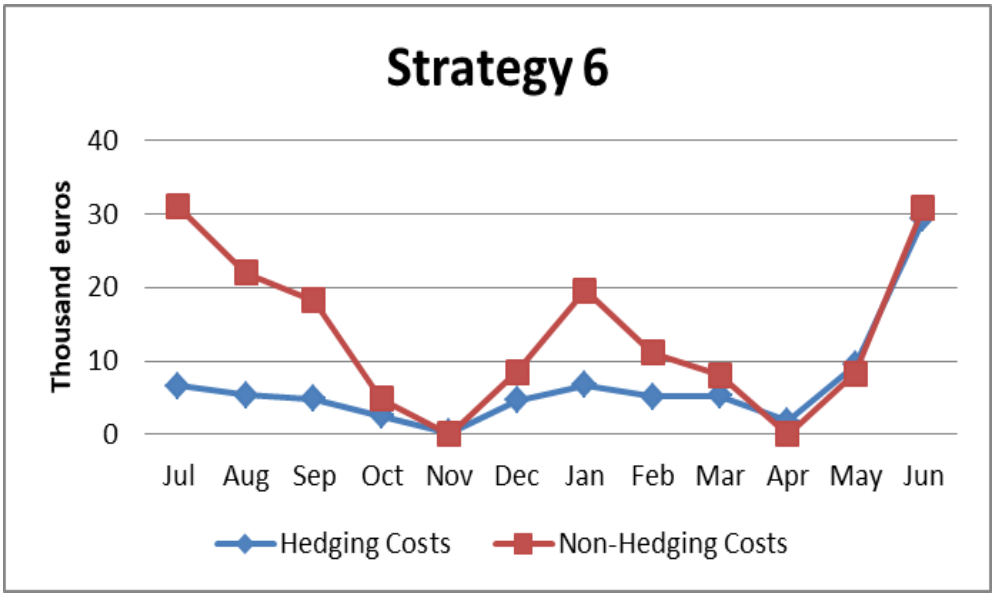


Figure 19. Expenses in Strategy 6

(Source: compiled by the author)

By implementing 6 different hedging strategies and comparing resulting hedging expenses with alternative non-hedging expenses, it is clearly seen that in April in all 6 cases hedging expenses start exceeding non-hedging and hedging becomes inefficient. Therefore, it should be noted that for further comparison and analyses hedging should be considered until March of the next year, which is total of 9 months starting from July of this year.

3.2. Comparing the strategies

To sum up, there are 6 different hedging strategies, each of which has its own specifics:

Strategy 1 – hedging of predicted deficit every month with adjustments and switching to non-hedging

Strategy 2 – hedging of predicted deficit by 7 different contracts and switching to non-hedging in November and December

Strategy 3 – hedging of the expected average deficit with adjustment and switching to non-hedging in November

Strategy 4 – hedging of the expected average deficit with adjustment without switching to non-hedging

Strategy 5 – hedging of the expected average deficit by 8 contracts and switching to non-hedging in November

Strategy 6 – hedging of the expected average deficit by 9 contracts without switching to non-hedging

In order to make a conclusion, which strategy is the most profitable for Company 1, if it wants to minimize its costs for purchasing currency, it`s necessary to calculate the overall costs for 9 months from July till March and average hedging costs per month for each strategy. Here are the results of these calculations:

Table 3. Summery of expenses

	Sum`000 €	Average`000 €
Strategy 1	53,09	5,8989
Strategy 2	54,294	6,0327
Strategy 3	38,758	4,3064
Strategy 4	38,922	4,3246
Strategy 5	40,993	4,5548
Strategy 6	41,257	4,5841

(Source: compiled by the author)

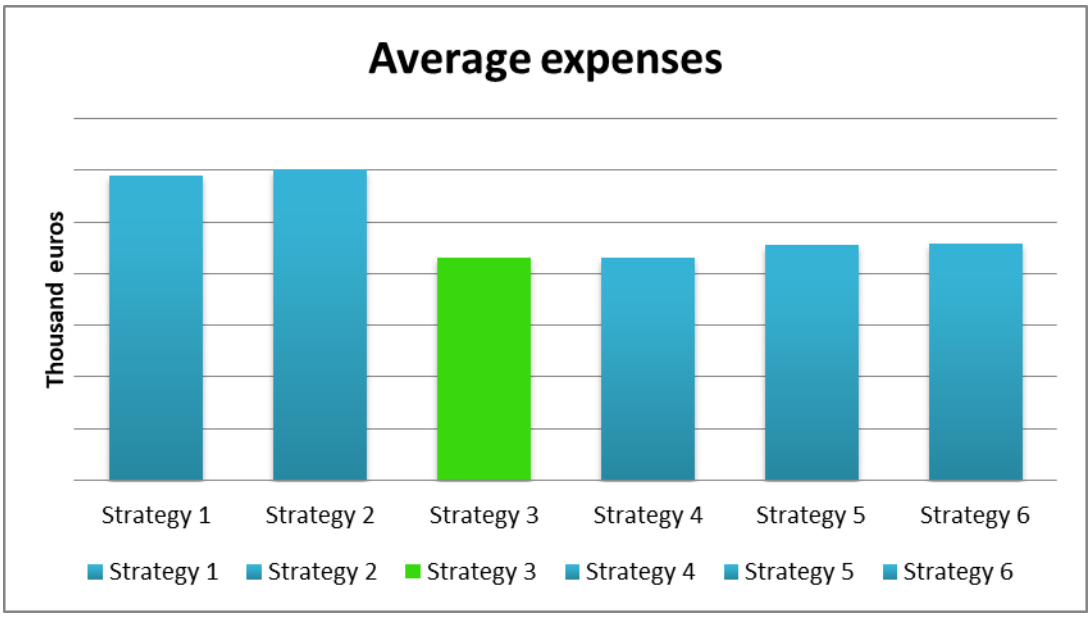


Figure 20. Average expenses, thousand euros

(Source: compiled by the author)

As it can be seen the sum of overall expenses and the average expenses is minimal when using the Strategy 3

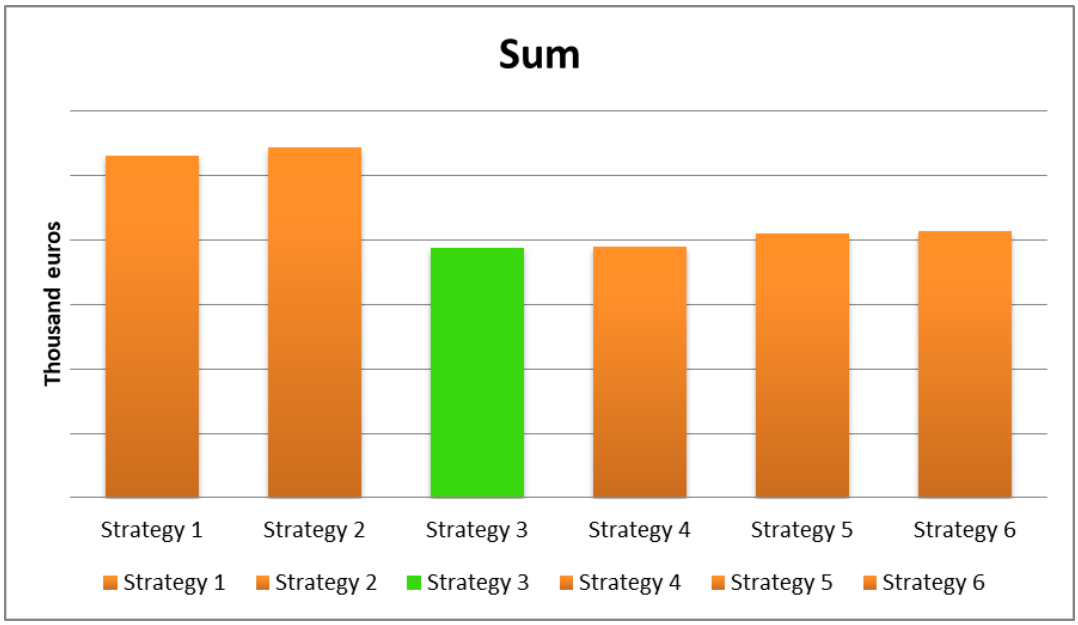


Figure 21- Overall expenses, thousand euros

(Source: compiled by the author)

When comparing derived strategies according to the minimum expenditure criterion, it can be concluded that the strategy which minimizes the cost of purchasing the required amount of currency is Strategy 3 that suggests hedging of the expected average deficit with adjustment and switching to non-hedging in November.

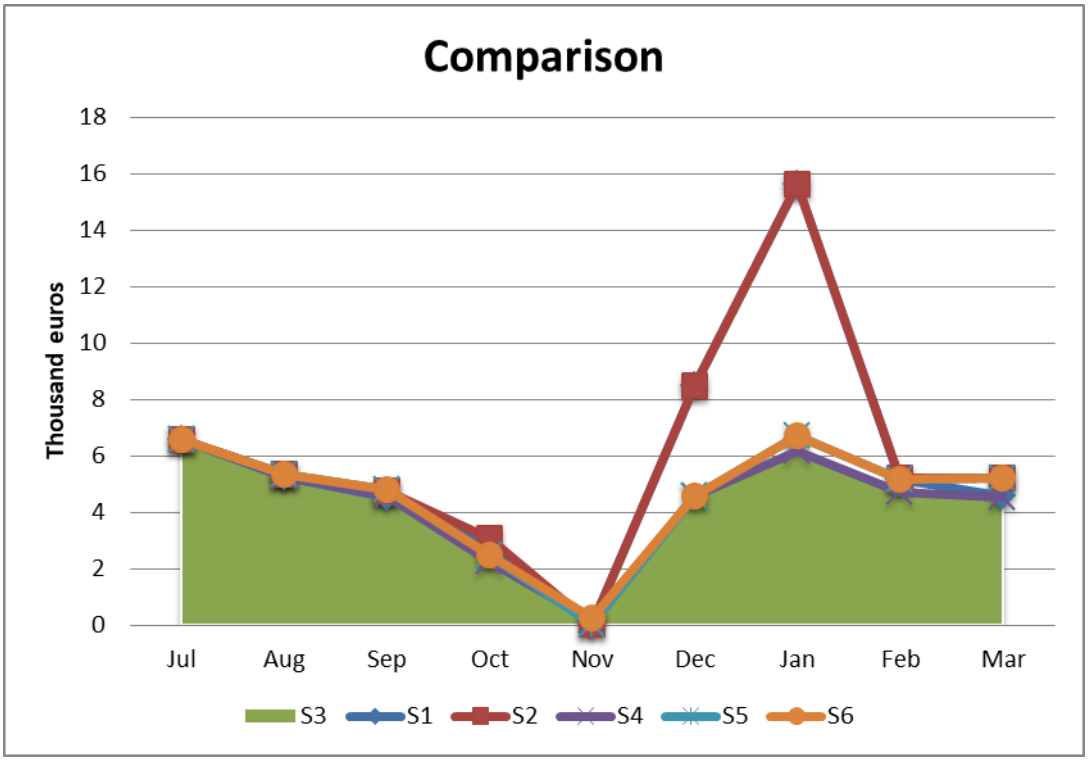


Figure 22. Comparison of hedging strategies, thousand euros

(Source: compiled by the author)

3.3. Switching between strategies

It is also important to note that there is a possibility of switching between strategies if there is a need. It is impossible to switch in strategies 2, 5 and 6, because with these strategies no adjustment is made and forward contacts are bought in advance so that the deficit of the entire hedged period has already been hedged. However, in Strategies 1,3 and 4 we hedge every month and adjust the sum of the deficit to be hedged in next month, so there is a possibility to switch from strategy to strategy if there is a sense of it. For instance, if we choose Strategy 3 but in a certain we see that the expenses of hedging are lower if we hedge the sum of deficit predicted by the Manager (as in Strategy 1), for this certain month we can switch to Strategy 1.

In the given case, despite the fact that Strategy 3 is optimal, in July, August and September, the average hedging costs are lower for Strategy 1, which means that in the first 3 months of the hedged period, you can use Strategy 1, and then switch to Strategy 3.

Table 4. Hedging expenses in each month for every strategy, thousand euros

	Jul	Aug	Sep	Oct
S1	6,5787	5,2479	4,5336	2,8318
S2	6,5787	5,3596	4,7412	3,0587
S3	6,5929	5,2537	4,5844	2,2699
S4	6,5929	5,2537	4,5844	2,2699
S5	6,5929	5,3605	4,7917	2,5024
S6	6,5929	5,3605	4,7917	2,5024

(Source: compiled by the author)

It can be seen that hedging expenses in Strategy 1 are lower so there is a sense to start hedging by Strategy 1 and in October to switch to Strategy 3, so that the overall hedging expenses will equal 38,68 thousand euros and average per month – 4,29 thousand euros which is even lower than by using the optimal Strategy 3.

This means that in case of such possibility a company may compare not only the overall expenses of given strategies, but may look at comparison of hedging expenses in each month and decide whether there is a reason to switch hedging strategy. Although the difference in expenditure may seem small, it should be taken into account that when using real data, the amount of the currency deficit can be significantly larger and the difference between expenses can also be significant.

3.4. Strategies verification

In order to make sure that the strategy found is actually optimal for companies, it`s important to test this method with other characteristics in the company. To make sure that this method will work for different companies, it`s necessary to change these characteristics. Let's assume that the distribution of currency inflows, as well as the standard deviation of these currency inflows, may vary. In Company 1, it is assumed that currency revenue inflows are distributed unevenly and vary (st.dev. is 15%) without certain dependence. It is proposed to consider several options for when the distribution of currency revenue inflows and their standard deviation will differ. Let us assume that there may be several distributions of currency inflows:

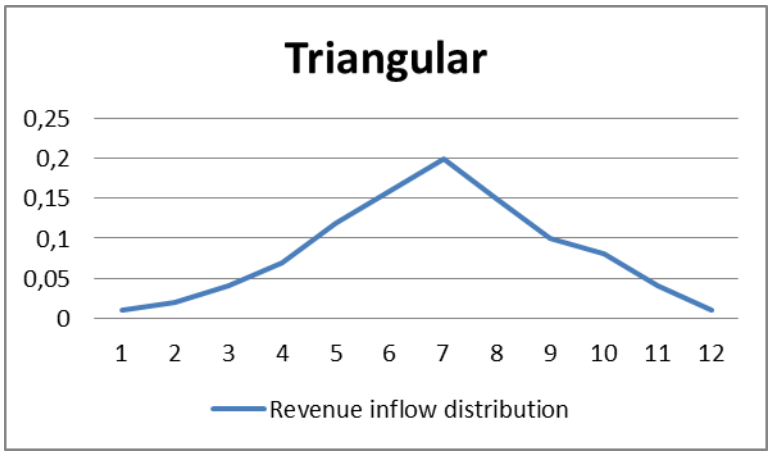


Figure 24 – Revenue distribution

(Source: compiled by the author)

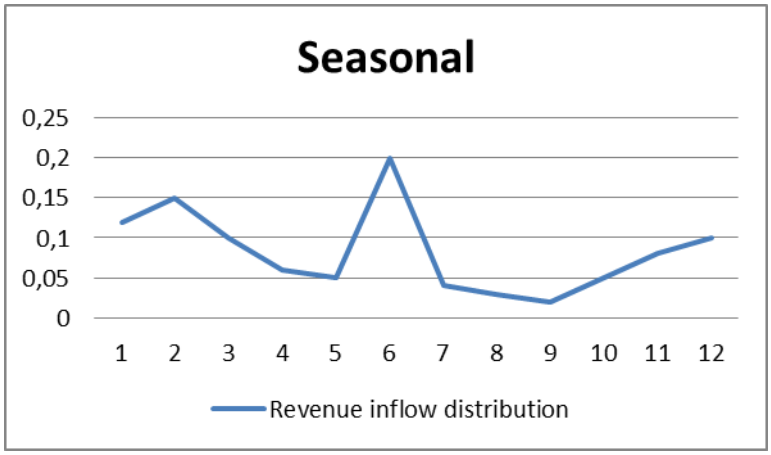


Figure 25 – Revenue distribution

(Source: compiled by the author)

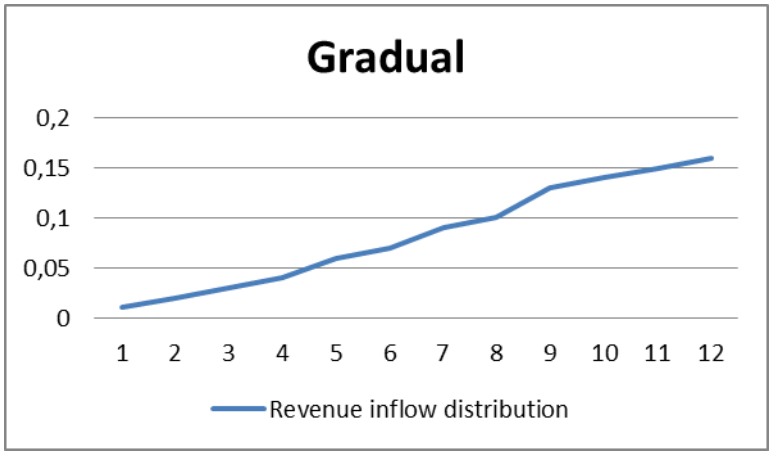


Figure 26 – Revenue distribution

(Source: compiled by the author)

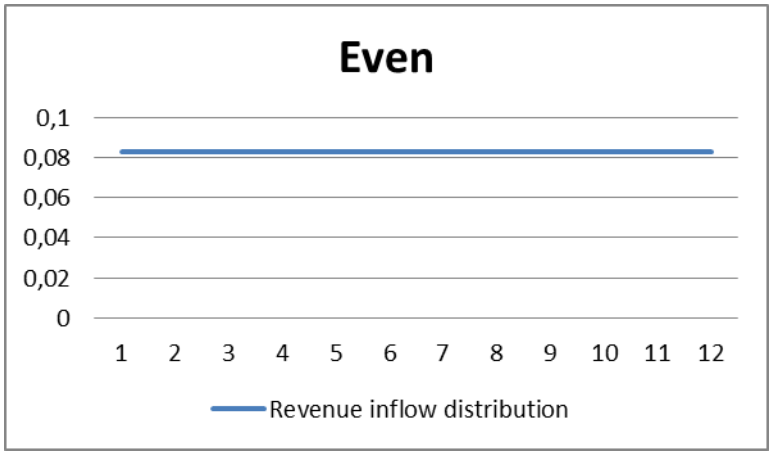


Figure 27 – Revenue distribution

(Source: compiled by the author)

Also, let us suggest that the standard deviation can be in the range from 5% to 30% (a larger deviation will not be considered due to the low probability). Let's change the characteristics and see which of the proposed strategies will be most suitable for the company with the changed characteristics. The test results are shown in the table below. The table shows that for different distributions of currency revenue inflows and at different levels of standard deviation, the most optimal strategy is Strategy 4. The table below shows that strategy 4 is the most suitable for almost all tests. Only in 4 cases with even distribution is strategy 1 the most optimal, but this is only 15% of 26 tests with only even distribution.

This test proves the correctness of the previously developed method. As it was previously verified, the most optimal strategy is Strategy 3, however, Strategy 4 completely repeats Strategy 3, only adjusted for the absence of switching to non-hedging. This is because for all four types of distribution, there will be no need for this switch, which means that Strategies 3 and 4 will duplicate each other and have the same costs.

Table 5. Strategy with minimal expenses

Strategy #				
Standard deviation of inflows	Structure of currency inflows			
%	Triangular	Seasonal	Gradual	Even
5%	4	4	4	4
6%	4	4	4	4
7%	4	4	4	4
8%	4	4	4	4
9%	4	4	4	1
10%	4	4	4	1
11%	4	4	4	1
12%	4	4	4	4
13%	4	4	4	4
14%	4	4	4	4
15%	4	4	4	1
16%	4	4	4	4
17%	4	4	4	4
18%	4	4	4	4
19%	4	4	4	4
20%	4	4	4	4
21%	4	4	4	4
22%	4	4	4	4
23%	4	4	4	4
24%	4	4	4	4
25%	4	4	4	4
26%	4	4	4	4
27%	4	4	4	4
28%	4	4	4	4
29%	4	4	4	4
30%	4	4	4	4

(Source: compiled by the author)

As volatility increases (i.e., the standard deviation of foreign exchange earnings increases), so do the costs of hedging, but Strategy 4 maintains its superiority over other strategies, despite the gradual increase in costs.

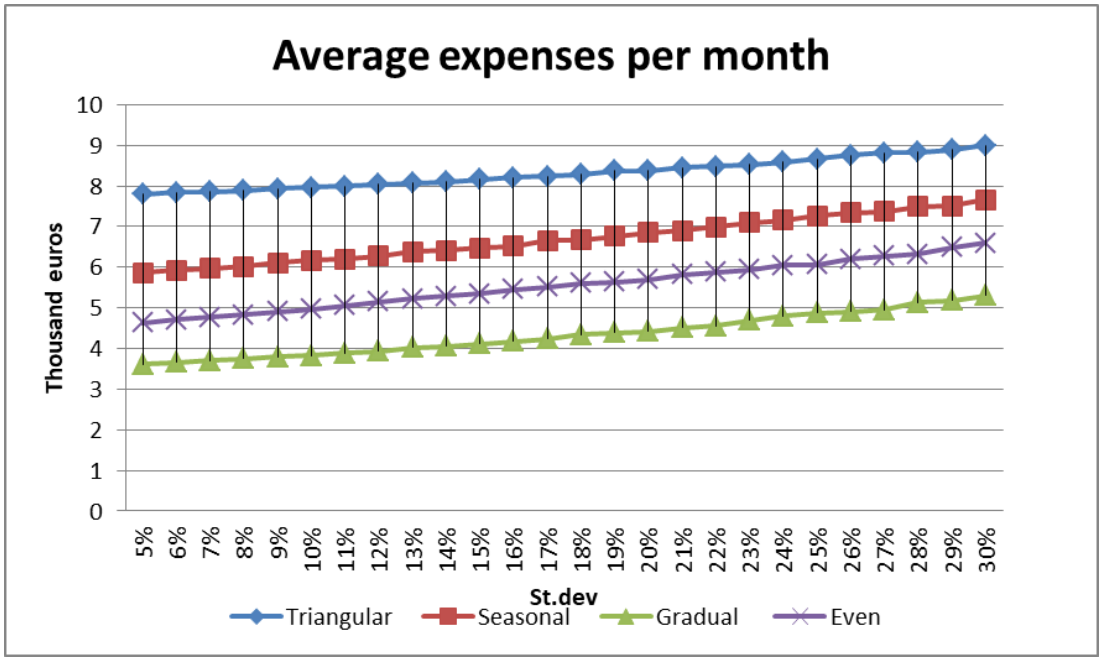


Figure 28 - Average expenses, thousand euros

(Source: compiled by the author)

By combining all the received information about costs and testing the proposed 6 strategies on several examples of companies, it can be concluded that the best solution is to hedge the company's expected average deficit and adjust it for the difference between the hedged amount of the previous month and real income. However, if there is a need to switch to a non-hedging strategy, you must do so. If the increase in hedging costs occurs gradually without differences and intersections with non-hedging costs, then there is no need to switch to non-hedging and you should hedge the amount of the expected average deficit each month. This difference is due to the fact that in the case of non-hedging, the company risks incurring large costs if a deficit appears in this month, and the probability of its occurrence is, although it is small.

Managerial application

Based on the research conducted, the methodology of hedging strategy determination was deduced. When applying the methodology, hedging and non-hedging expenses are calculated and compared. Based on the costs minimization criterion the most appropriate strategy can be chosen and applied. After developing the resulting methodology, it is necessary to check how it works on the real data of a company that is exposed to currency risk.

In order to make sure that the proposed method works, it is suggested to check the comparison of six strategies on the example of real data of LLC “Air Gates of the Northern Capital”.

Checking the method using the example of real data of LLC “Air Gates of the Northern Capital”

The LLC “Air Gates of the Northern Capital” receives revenue that is expressed in rubles, but in fact, revenue is received in two currencies: rubles and euros. The counterparties that receive payments in euros are international airlines and a company that organizes Duty Free trade on the territory of the airport. As of 2015, 68 airlines cooperate with Pulkovo airport, of which 42 are foreign airlines. Thus, the operator company faces currency risk associated with cash inflows in a foreign currency.

However, in addition to exposure to currency risk from inflows, another factor of currency risk in the company is the presence of debt liability denominated in a foreign currency – euros. The company attracted a long-term syndicated loan of 1,2 milliard euros provided by development institutions, as well as a number of commercial banks. In the case of LLC “Air Gates of the Northern Capital”, debt exposures generally represent a single or small number of transactions with multiple subsequent payments for which the timing is known.

Therefore, foreign-debt exposure over the life of the debt contract is known at the inception of the contract – company has to pay 10 million euros every month and has a currency deficit in the first and in the second half of the year.

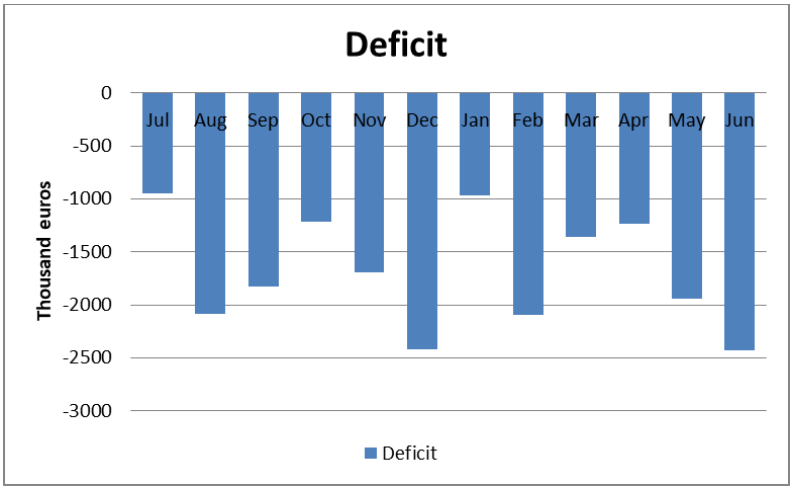


Figure 29. Currency deficit in LLC "Air Gates of the Northern Capital", thousand euros

(Source: compiled by the author)

The distribution of currency revenue can be described as relatively even and currency inflows has a standard deviation of 23% every month based on the data of LLC "Air Gates of the Northern Capital" Management predictions and insights.

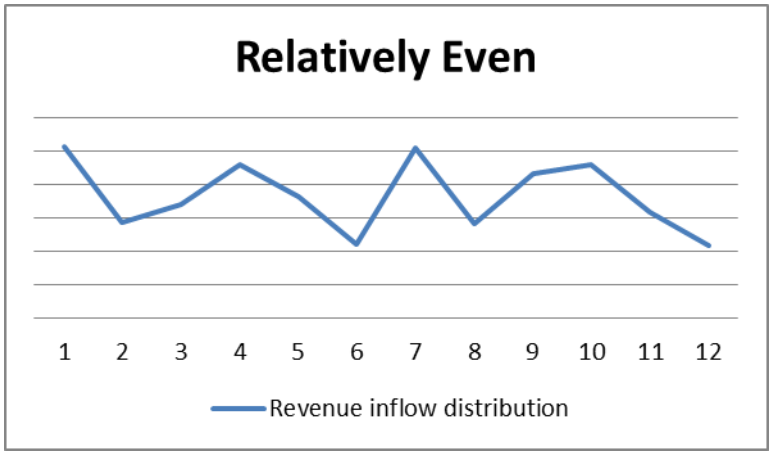


Figure 30. Revenue distribution in LLC "Air Gates of the Northern Capital"

(Source: compiled by the author)

Based on the given data the overall and average hedging and non-hedging expenses were calculated and compared:

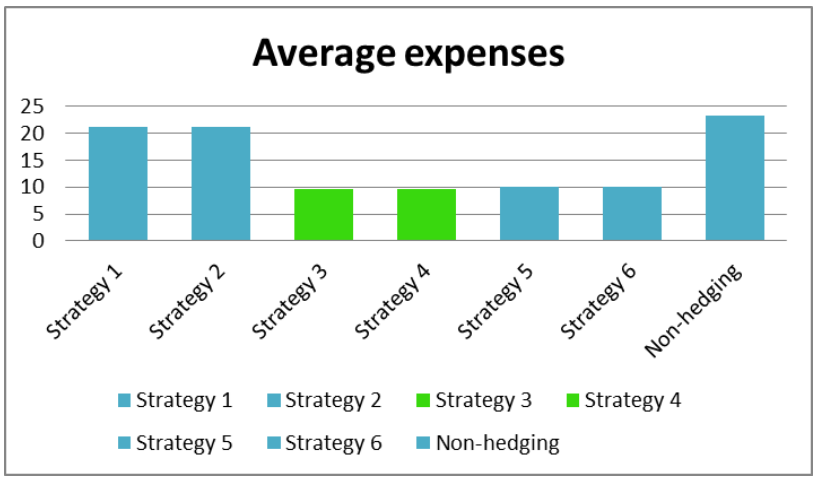


Figure 31. Average expenses in LLC "Air Gates of the Northern Capital"

(Source: compiled by the author)

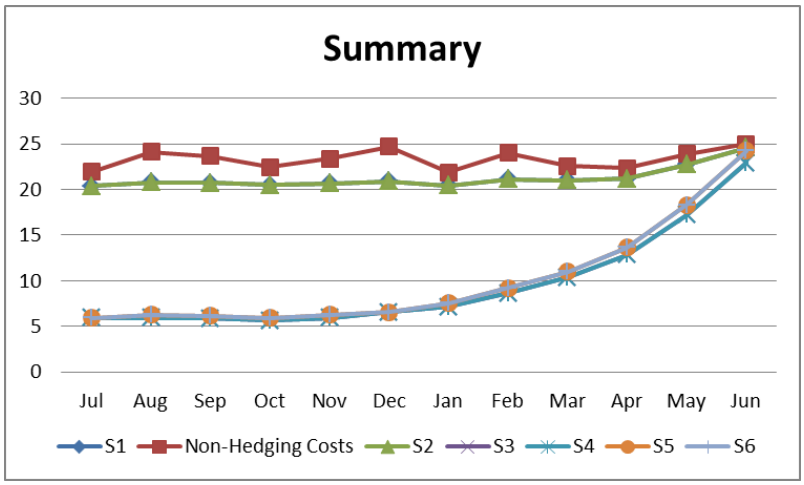


Figure 32. Average expenses in LLC "Air Gates of the Northern Capital"

(Source: compiled by the author)

Again it can be seen that Strategy 3 and 4 duplicate each other so Strategy 4 remains the most appropriate one as it minimizes expenses. When testing this methodology on real data, it can be concluded that the proposed method works and proves the correctness of the earlier analysis and the optimality of Strategy 4 (in some cases, 3, taking into account the amendments). With relatively equal revenues and a fairly large standard deviation of foreign exchange earnings in LLC "Air Gates

of the Northern Capital", it is more profitable for the company to hedge the sum of expected deficit adjusted to the positive difference (if it presents) of the previous month.

When verified on the real data of LLC "Air Gates of the Northern Capital", the results show that the methodology suggested works and proves it consistency. There is no information available in the public sources about the implementation of hedging strategies in this company. However, based on the results of the proposed method, it can be concluded that LLC "Air Gates of the Northern Capital" needs to apply the strategy of hedging of the expected average deficit with adjustment without switching to non-hedging, what corresponds to the proposed Strategy 4, so that the company can minimize its expenses.

Conclusion

Based on an analysis of existing hedging strategies, it can be concluded that there is still no specific reference point that can be referred to in question of hedging, since hedging value for the company is relatively controversial. If used correctly, hedging can help offset the risks associated with uncertainty in the future and reduce undesirable costs, but if used incorrectly, hedging can also entail large costs. Determining the most appropriate hedging strategy is necessary for making decision about hedging in general. At the moment hedging still raises many questions, its value for the company is still unclear and remains controversial. The motives for using hedging instruments can vary significantly. When making a decision about hedging, the company must have a certain basis for choosing whether to hedge or not. By the proposed methodology application a company with the currency risk exposure can estimate whether hedging can be potentially beneficial and applicable or it will incur additional losses.

The developed methodology suggests that when companies try to find a criterion that gives a certain answer to the question whether to hedge or not, they can pay attention to the criterion of minimizing costs. It can be assumed that based on the available data in the market, it is possible to predict the future expenses and model several options for hedging strategies. This is the assumption that is put forward in this work. Based on the conducted methodological research, it can be concluded that if refer to the current market data based on the market efficiency hypothesis and model a hypothetical company with the currency risk exposure, it is possible to calculate hedging and non-hedging costs and deduce several possible strategies that the company could follow in the future. After analyzing the modelled strategies and comparing their costs, best option can be identified, and this exact strategy, the most appropriate one, could become a guide for a company that is hesitant to make a decision about hedging.

It is necessary to take into account the uncertainty of the currency deficit. Despite the fact that many studies are aimed at hedging a fixed deficit and identifying the resulting value of hedging,

in practice, very often companies do not know what the actual deficit is waiting for them and often can only predict it. This is why in this methodology many various values of the potential deficit are estimated. Based on the strategies suggested the company is able to choose the one that fits the most to the selected criterion – cost minimization.

It should be noted that no one can say with certainty that the costs given in this paper will be exactly the same in the future, since the market may be volatile and has a tendency to constant changes. But if refer to the market efficiency concept it is possible to estimate potential future expenses. Undoubtedly, the difference in costs may seem insignificant; however, these calculations are given only to show that the selected criterion for minimizing costs can work and be used in the future for hedging currency risks by companies.

List of References

Adam, T., & Fernando, C. (2006). Hedging, speculation, and shareholder value. *Journal of Financial Economics*, 283–30.

Bessembinder, H. (1991). Forward Contracts and Firm Value: Investment Incentive and Contracting Effects. *Source: The Journal of Financial and Quantitative Analysis*, 519-532.

Brealey, R., Myers, S., & Allen, F. (2019). *Principles of corporate Finance.* McGraw-Hill Education; 13 edition .

Burenin, A. (1996,). Markets of derivative financial instruments. In A. Burenin.

Christopher Geczy, B. A. (1997). Why Firms Use Currency Derivatives. *The Journal of Finance*, 1323-1354.

Damodaran, A. (2008). *Strategic Risk Taking: A Framework for Risk Management.* (chapters 9,10). – Wharton.

Eiteman, D. (2013). *Multinational Business Finance.* 13th ed. – Pearson.

Faulkender, M. (2005). Hedging or Market Timing? Selecting the Interest Rate Exposure of Corporate Debt. *The Journal of Finance*, 931-962.

Froot, K. A., Scharfstein, D. S., & Stein., J. C. (1993). Risk Management: Coordinating Corporate Investment and Financing Policies. *The Journal of Finance*, 1629-1658.

Glaum, M. (2002). The Determinants of Selective Exchange Risk Management: Evidence from German Non-Financial Firms. *Journal of Applied Corporate Finance*, 108-121.

Hull, J. C. (2018). *Options, Futures, and Other Derivatives.* 10th Edition. University of Toronto.

M.Bodnar, G., & Bartov, E. (1994). Firm Valuation, Earnings Expectations, and the Exchange-Rate Exposure Effect. *The Journal of Finance*, 1755-1785.

Mian, S. (1996). Evidence on corporate hedging policy. *Journal of Financial and Quantitative Analysis*, 419-439.

Mozumdar, A. (2001). Corporate Hedging and Speculative Incentives: Implications for Swap Market Default Risk. *The Journal of Financial and Quantitative Analysis*, 221-250.

Myers, R. J., & Thompson, S. R. (1989). Generalized Optimal Hedge Ratio Estimation. *American Journal of Agricultural Economics*, 858- 868.

Nance, D., Smith, S., & Smithson, C. (1993). On the determinants of corporate hedging. *Journal of Finance*, 267-284.

Okulov, V. L. (2010). The value of hedging for the Corporation and market expectations. *Scientific report no. 17 (R) Saint Petersburg: GSOM SPBU.*

Okulov, V. L. (2015). *Financial institutions and markets: textbook.* Saint Petersburg: SPBU: SPBU — - ISBN 978-5-9924-0091-5.

Okulov, V. L. (2015). Selective hedging of price risks by companies. *Vestnik of St. Petersburg State University: Management Series* .

Okulov, V. L. (2019). *Risk management: fundamentals of theory and practice of application: textbook.* Saint Petersburg: Publishing house of St. Petersburg State University. UN-TA.

Sang, L. T., Zatul Karamah, A., & Osman, Z. (2013). The Determinants of Corporate Hedging. *Journal of Asian Academic Applied of Business*, 57-69 .

Semenkova, E. V. (1997). *Operations with securities.* Moscow: ISBN: 978-5-7749-0536-2.

Smith, C., & Stulz, R. (1985). The determinants of firms' hedging policies. *Journal of Financial and Quantitative Analysis*, 391-405.

Söhnke M. Bartram, G. W. (2009). International Evidence on Financial Derivatives Usage. *Financial Management*, 185-206.

Struchenkova, T. V. (2009). *Currency risks: Textbook.* Moscow: Finakademiya, ISBN 978-5-7942-0606-7.

Stulz, R. (1996). Rethinking Risk Management. *Journal of Applied Corporate Finance*, 8-25.

Stulz, R. M. (1984). Optimal Hedging Policies. *The Journal of Financial and Quantitative Analysis*, 127-140.

Stulz, R., Clifford, W., & Smith, M. (1985). The Determinants of Firms' Hedging Policies. *The Journal of Financial and Quantitative Analysis*, 391-405.

Titman, S. (1992). Interest Rate Swaps and Corporate Financing Choices. *The Journal of Finance*, 1503-1516.

Tufano, P. (1994). Why Manage Risk? . *Harvard Business School Note 9* , 294–107.

Electronic sources

International Swaps and Derivatives Association. https://www.isda.org

Source for international interest rates and economic indicators. https://www.global-rates.com

Moscow Exchange website. https://www.moex.com

Bank of Russia: Central Bank of the Russian Federation. https://www.cbr.ru

Commissions for transactions on the currency market. https://www.sberbank.ru/ru/person/investments/broker_service/tarifs

The classification of risks is proposed by Federal Service for Financial Markets. http://www.consultant.ru

Thomson Reuters Eikon. Forward EUR/RUB bid ask spread. http:// eikon.thomsonreuters.com

The operator of the Airport. http://www.pulkovoairport.ru/about/operator/

Public-private partnership agreement. http://www.pulkovoairport.ru/about/agreement/

Appendix

Appendix 1. Euro/Rub forward bid-ask spread

Figure 1. Euro/Rub forward bid-ask spread 6M.

(Source: Thomson Reuters Eikon)

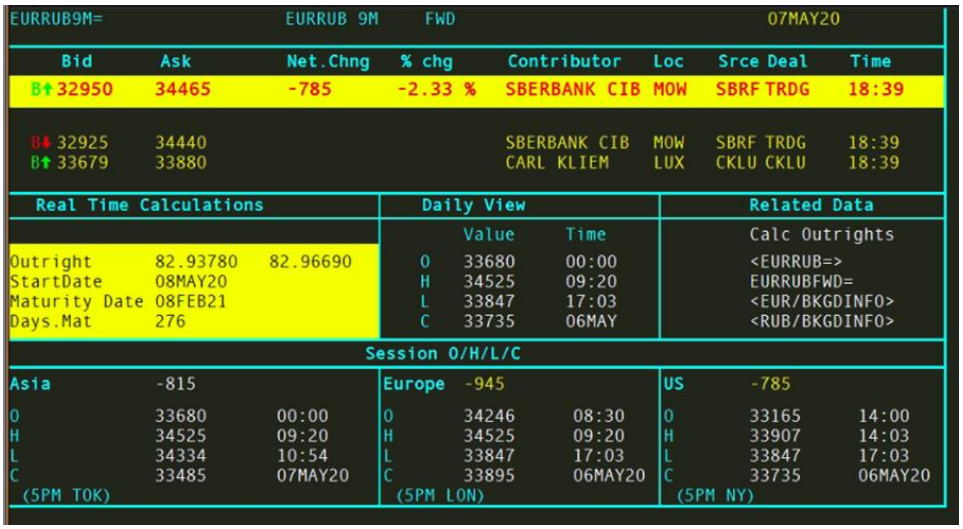
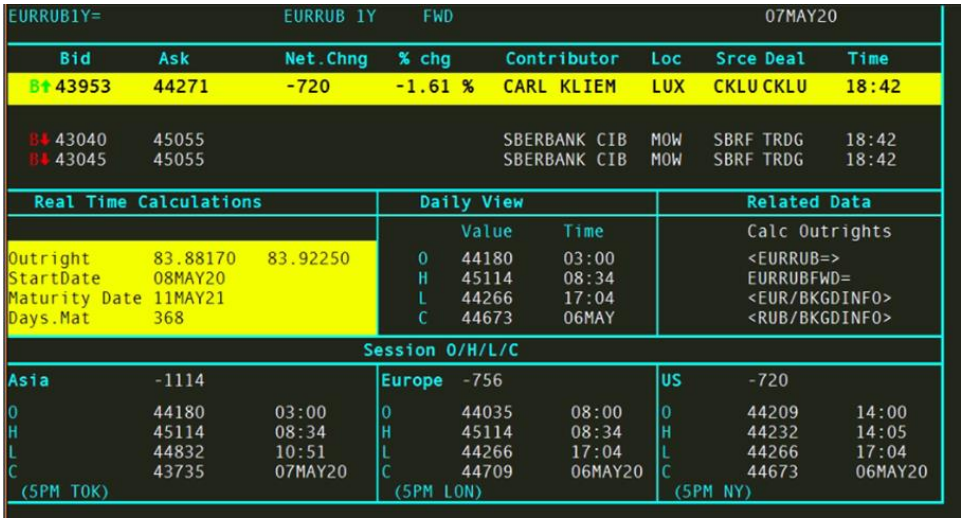


Figure 2. Euro/Rub forward bid-ask spread 9M.

(Source: Thomson Reuters Eikon)



EURRUB1Y= EURRUB 1Y FWD 07MAY20

Bid	Ask	Net.Chng	% chg	Contributor	Loc	Srce	Deal	Time
B↑ 43953	44271	-720	-1.61 %	CARL KLIEM	LUX	CKLU	CKLU	18:42
B↓ 43040	45055			SBERBANK CIB	MOW	SBRF	TRDG	18:42
B↓ 43045	45055			SBERBANK CIB	MOW	SBRF	TRDG	18:42

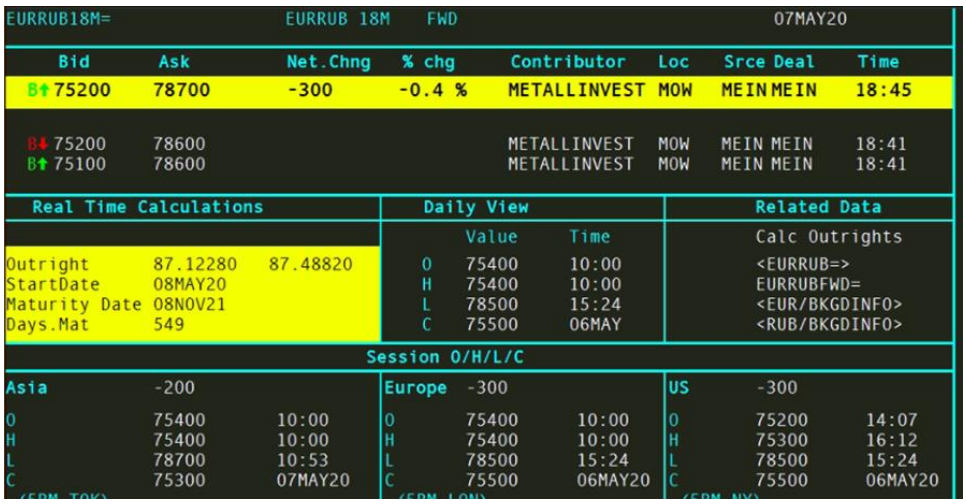
Real Time Calculations			Daily View	Value	Time	Related Data	Calc Outrights
Outright	83.88170	83.92250	O	44180	03:00		<EURRUB=>
StartDate	08MAY20		H	45114	08:34		EURRUBFWD=
Maturity Date	11MAY21		L	44266	17:04		<EUR/BKGDINFO>
Days.Mat	368		C	44673	06MAY		<RUB/BKGDINFO>

Session O/H/L/C

Asia	-1114		Europe	-756		US	-720	
O	44180	03:00	O	44035	08:00	O	44209	14:00
H	45114	08:34	H	45114	08:34	H	44232	14:05
L	44832	10:51	L	44266	17:04	L	44266	17:04
C	43735	07MAY20	C	44709	06MAY20	C	44673	06MAY20
(5PM TOK)			(5PM LON)			(5PM NY)		

Figure 3. Euro/Rub forward bid-ask spread 1Y.

(Source: Thomson Reuters Eikon)



EURRUB18M= EURRUB 18M FWD 07MAY20

Bid	Ask	Net.Chng	% chg	Contributor	Loc	Srce	Deal	Time
B↑ 75200	78700	-300	-0.4 %	METALLINVEST	MOW	MEIN	MEIN	18:45
B↓ 75200	78600			METALLINVEST	MOW	MEIN	MEIN	18:41
B↑ 75100	78600			METALLINVEST	MOW	MEIN	MEIN	18:41

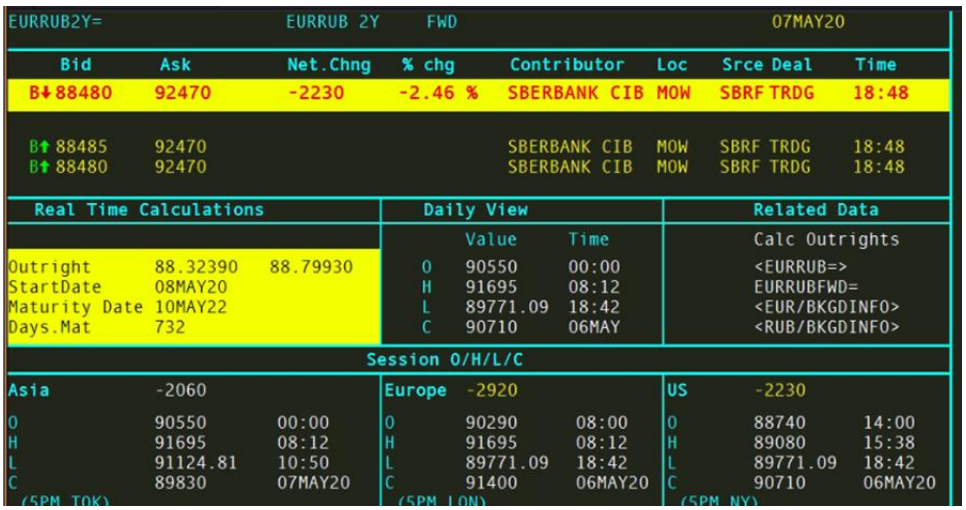
Real Time Calculations			Daily View	Value	Time	Related Data	Calc Outrights
Outright	87.12280	87.48820	O	75400	10:00		<EURRUB=>
StartDate	08MAY20		H	75400	10:00		EURRUBFWD=
Maturity Date	08NOV21		L	78500	15:24		<EUR/BKGDINFO>
Days.Mat	549		C	75500	06MAY		<RUB/BKGDINFO>

Session O/H/L/C

Asia	-200		Europe	-300		US	-300	
O	75400	10:00	O	75400	10:00	O	75200	14:07
H	75400	10:00	H	75400	10:00	H	75300	16:12
L	78700	10:53	L	78500	15:24	L	78500	15:24
C	75300	07MAY20	C	75500	06MAY20	C	75500	06MAY20

Figure 4. Euro/Rub forward bid-ask spread 18M.

(Source: Thomson Reuters Eikon)



EURRUB2Y= EURRUB 2Y FWD 07MAY20

Bid	Ask	Net.Chng	% chg	Contributor	Loc	Srce	Deal	Time
B↓ 88480	92470	-2230	-2.46 %	SBERBANK CIB	MOW	SBRF	TRDG	18:48
B↑ 88485	92470			SBERBANK CIB	MOW	SBRF	TRDG	18:48
B↑ 88480	92470			SBERBANK CIB	MOW	SBRF	TRDG	18:48

Real Time Calculations			Daily View	Value	Time	Related Data	Calc Outrights
Outright	88.32390	88.79930	O	90550	00:00		<EURRUB=>
StartDate	08MAY20		H	91695	08:12		EURRUBFWD=
Maturity Date	10MAY22		L	89771.09	18:42		<EUR/BKGDINFO>
Days.Mat	732		C	90710	06MAY		<RUB/BKGDINFO>

Session O/H/L/C

Asia	-2060		Europe	-2920		US	-2230	
O	90550	00:00	O	90290	08:00	O	88740	14:00
H	91695	08:12	H	91695	08:12	H	89080	15:38
L	91124.81	10:50	L	89771.09	18:42	L	89771.09	18:42
C	89830	07MAY20	C	91400	06MAY20	C	90710	06MAY20
(5PM TOK)			(5PM LON)			(5PM NY)		

Figure 5. Euro/Rub forward bid-ask spread 2Y.

(Source: Thomson Reuters Eikon)

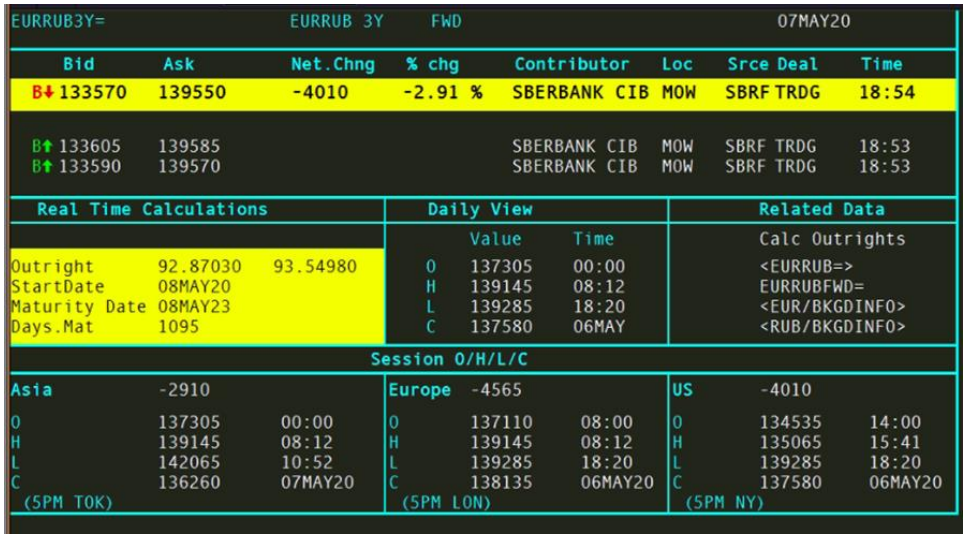


Figure 6. Euro/Rub forward bid-ask spread 3Y.

(Source: Thomson Reuters Eikon)

Appendix 2. Forecasted forward rate values

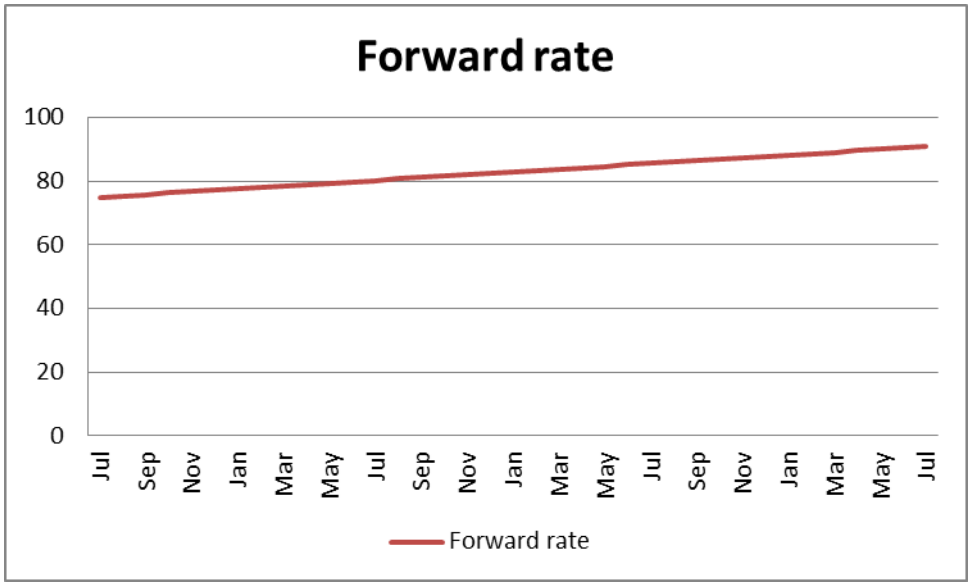


Figure 7. Forecasted forward rate values

(Source: compiled by the author)

Appendix 3. Hedging and non-hedging costs for the 3-year period

Table 1. Costs. Year 1

	Hedging, €	Non-Hedging, €	
6M	0,000391	0,002	July
	0,000391	0,002	August
	0,000391	0,002	September
9M	0,000386	0,002	October
	0,000405	0,002	November
	0,000446	0,002	December
1Y	0,000535	0,002	January
	0,000642	0,002	February
	0,000835	0,002	March
	0,001085	0,002	April
	0,001411	0,002	May
1,5Y	0,001834	0,002	June

(Source: compiled by the author)

Table 2. Costs. Year 2

	Hedging, €	Non-Hedging, €	
	0,002750538	0,002	July
	0,004125808	0,002	August
1,8Y	0,004648602	0,002	September
	0,005578322	0,002	October
	0,006972903	0,002	November
2Y	0,009064774	0,002	December
	0,009689473	0,002	January
	0,01065842	0,002	February
	0,011724262	0,002	March
	0,012896688	0,002	April
	0,014186357	0,002	May
	0,015604992	0,002	June

(Source: compiled by the author)

Table 3. Costs. Year 3

	Hedging, €	Non-Hedging, €	
	0,017477592	0,002	July
	0,019749678	0,002	August
	0,02271213	0,002	September
	0,02611895	0,002	October
	0,030036792	0,002	November
3Y	0,030374461	0,002	December
	0,039486799	0,002	January
	0,051332838	0,002	February
	0,06673269	0,002	March
	0,086752497	0,002	April
	0,112778246	0,002	May
3,5Y	0,146611719	0,002	June

(Source: compiled by the author)

Appendix 4. Comparing expenses in different strategies

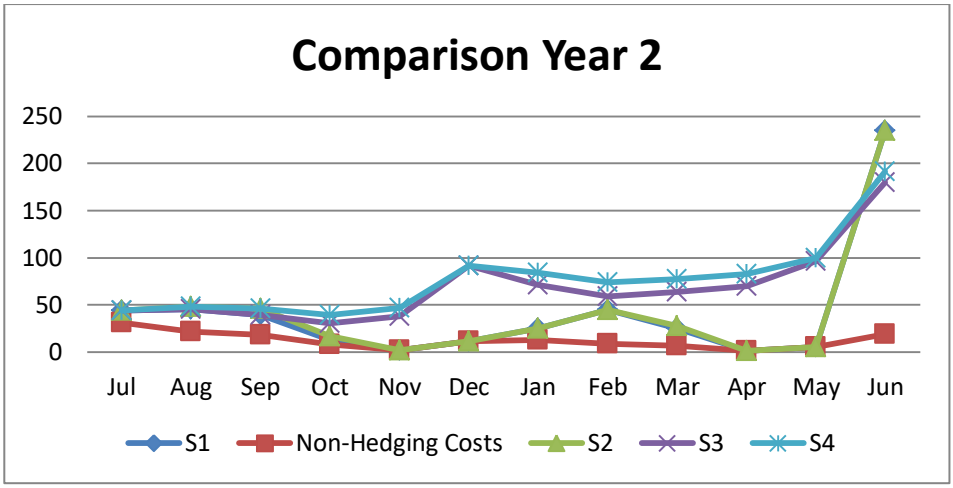


Figure 8. Comparison of expenses in 6 strategies

(Source: compiled by the author)

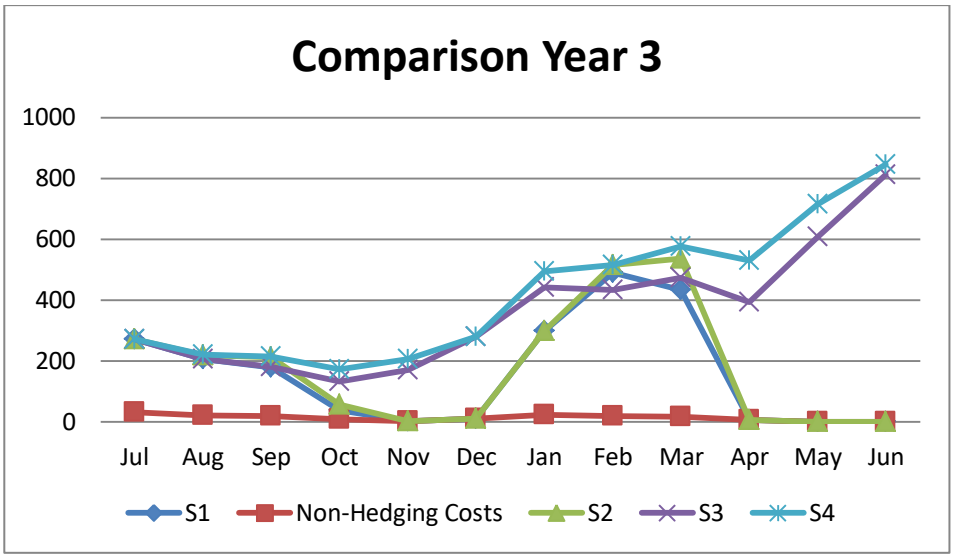


Figure 8. Comparison of expenses in 6 strategies

(Source: compiled by the author)

Appendix 4. Comparing overall and average expenses in different strategies

Table 4. Expenses in every month in 6 strategies, thousand euros

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Sum	Average
Strategy 1	6,578	5,247	4,533	2,831	0,009	8,482	15,63	5,187	4,583	53,09	5,8989
Strategy 2	6,578	5,359	4,741	3,058	0,009	8,482	15,63	5,195	5,234	54,294	6,0327
Strategy 3	6,592	5,253	4,584	2,269	0,009	4,594	6,164	4,734	4,553	38,758	4,3064
Strategy 4	6,592	5,253	4,584	2,269	0,173	4,594	6,164	4,734	4,553	38,922	4,3246
Strategy 5	6,592	5,360	4,791	2,502	0,009	4,594	6,739	5,191	5,211	40,993	4,5548
Strategy 6	6,592	5,360	4,791	2,502	0,273	4,594	6,739	5,191	5,211	41,257	4,5841

(Source: compiled by the author)