Teemu Rantanen

Currency risk management

Hedging transaction risk

School of Finance
Master's Thesis, Finance
Finance

Vaasa 2024

VAASAN YLIOPISTO
School of Finance
Tekijä: Teemu Rantanen
Tutkielman nimi: Currency risk management : Hedging transaction risk
Tutkinto: Maisterin tutkinto
Oppiaine: Finance
Työn ohjaaja: Anupam Dutta
Valmistumisvuosi: 2024 **Sivumäärä:** 63

TIIVISTELMÄ:

Tämän tutkielman tavoitteena on demonstroida yhdentyyppisen valuuttakurssiriskin, transaktioriskin merkittävyyttä monikansallisesti toimiville yhtiöille, joilla on ulkomaalaisia kassavirtoja, ja esittää useita ulkoisia suojausstrategioita kyseisen riskin hallinnoimiseen. Transaktioriskiä simuloidaan VaR- historiallisella simulaatiomenetelmällä, ja ulkoiset suojausstrategiat ovat rakennettu termiinisopimusten, optioiden sekä rahamarkkinan ympärille perspektiivillä, että strategioiden ominaisuuksia ja soveltuvuuksia vertaillaan keskenään. Suojausstrategiat demonstroidaan hypoteettisen monikansallisen yhtiön kautta, jolla on kassavirtoja US dollarista sekä Britannian punnasta mutta hypoteettinen osuus koskee käytännössä vain esitettyjä kassavirtoja.

Transaktiovaluuttakurssiriskistä on nykyisin tullut yksi merkittävimmistä monikansallisesti toimivien yhtiöiden kohtaamista riskeistä mikä on johtanut valuuttakurssiriskin hallinnoimisen tärkeyden kasvamiseen. Talousjohtajilla, joiden vastuulla on valuuttakurssiriskin hallinta monikansallisissa yhtiöissä pitää olla laaja ymmärrys valuuttakursseista ja niiden mahdollisesta vaikutuksesta monikansallisten yhtiöiden operaatioihin, jotta he pystyvät implementoimaan järkeviä ja tehokkaita suojausstrategiota. Kuitenkin näiden ulkoisten suojausstrategioiden soveltuvuus riippuu pitkälti yhtiöiden riskienhallinnan tavoitteista. Jos yhtiöt haluavat sisällyttää spekulatiivisia makroekonomisia, valuuttanäkemyksiä riskienhallinta strategioihinsa niiden tulee osallistua enemmän sivistyneisiin suojausstrategioihin.

Tämä tutkielman mukaan transaktiovaluuttakurssiriski on (edelleen) merkittävä riski monikansallisesti toimiville yhtiöille perustuen viimeaikaiseen dataan vuoden 2023 EUR/USD ja EUR/GBP valuuttapareista. Esitetyistä suojausstrategioista, termiinistrategia nousee esille soveliaimpana strategiana lyhyen aikavälin transaktioriskin suojaamiseen useiden suotuisien ominaisuuksiensa vuoksi, mutta range-termiinistrategia nousee myös esille erittäin soveliaana useiden syiden seurauksena. Tämä tutkielma on lisäys laajaan kirjallisuuteen valuuttakurssiriskin hallinnoimisen ympärillä, jolla on monia yhteyksiä laajempiin aihekokonaisuuksiin rahoituksen ja taloustieteen osa-alueilla, ja tutkielman löydökset ja päätelmät ovat tuettu ja linjassa aiheeseen liittyvän kirjallisuuden kanssa.

Avainsanat: exchange rates, risk management, derivatives, hedging, strategy

VAASAN YLIOPISTO
School of Finance
Author: Teemu Rantanen
Title: Currency risk management : Hedging transaction risk
Degree: Master's degree
Degree programme: Finance
Supervisor: Anupam Dutta
Completed: 2024 **Pages:** 63

Abstract:

The objective of this study is to demonstrate how significant the FX transaction risk is to multinational companies that have cashflows denominated in different currencies, and to present several external hedging strategies for it. The transaction risk exposure is simulated with VaR historical simulation, and the external hedging strategies are built around forward contracts, options and the money-market with the perspective of comparing characteristics and suitability of the strategies. The hedging strategies are demonstrated through a hypothetical multinational company that has cashflows from US dollar and British Sterling, but the hypothetical part merely concerns the presented cashflow amounts.

FX transaction risk has become one of the primary risks faced by multinational companies, which has highlighted the importance of FX risk management. Financial managers that oversee FX risk management practices in multinational companies must have a broad understanding of exchange rates and their possible influence over the companies' operations in order to implement reasonable and efficient risk management strategies. However, the suitability of these external hedging strategies depends greatly on the companies' risk management objectives. If companies want to incorporate speculative views on macroeconomic outlooks, currencies, in their risk management strategies they need to participate in more advanced hedging strategies.

This study finds the FX transaction risk to be (remain as) a significant risk for multinational companies based on the recent one-year data sample comprising 2023 EUR/USD and EUR/GBP currency pairs. Out of the presented external hedging strategies, the forward contract strategy emerges as the most suitable for the short-term FX transaction hedging due to a number of favoring characteristics, but the range-forward strategy is also considered to be highly suitable for various reasons. This study contributes to the extensive literature around currency risk management which has many connecting points to the broader topics in finance and economics, and the findings and conclusions are aligned and supported by the related literature.

Keywords: exchange rates, risk management, derivatives, hedging, strategy

Contents

Figures

Tables

1 Introduction

Since 1970's when the Bretton Woods exchange rate system was ended and the current floating exchange rate regime was instituded, foreign exchange (FX) rates have become increasingly volatile. As the international FX market has developed towards liberalization and the world continues to globalize, companies are increasingly exposed to consequences of frequently fluctuating exchange rates. Particularly the last few decades have demonstrated how significantly the exchange rates can fluctuate. Multinational companies especially have to face this increasing uncertainty as they operate in a global scale with multiple currencies. This has highlighted the importance of FX risk management as FX risk has become one of the primary risks faced by multinational companies (Yu Xing et al. 2020).

The effect of exchange rate changes has been the subject of extensive theorethical and empirical research in finance and economics. Most of the research has unsuprisingly examined the effects on multinational companies as they have cash flows, assets and liabilites directly affected by the exchange rate movements, but companies that have very limited or non-existent foreign operations also face FX risk. FX risks arise in many ways and occasions – directly and indirectly, and therefore it is imperative for financial managers to understand how to properly assess the risk of exchange rate fluctuations in order to define and implement different risk mitigation strategies to protect their companies from unfavorable changes. In many cases however assessing the risks and determining the most suitable risk management strategies are difficult and consequential tasks and there are several methods to risk management all with their own characteristics (Aggarwal & Harper 2010, Nobanee et al. 2022).

1.1 Objectives of the study

The objective of this study is to demonstrate how significant the FX transaction risk is to multinational companies that have cashflows denominated in different currencies, and to present several external hedging strategies for managing it. The objectives can be summarized into following research questions:

How significant is FX transaction risk for a multinational company?

Is forward contract hedging more suitable for FX transaction risk than other external hedging methods?

The transaction risk exposure is simulated with VaR historical simulation, and the external hedging strategies are built around forward contracts, options and the money-market with the perspective of comparing characteristics and suitability of the strategies. The hedging strategies are demonstrated through a hypothetical multinational company that has cashflows from US dollar and British Sterling.

1.2 Structure of the study

The study consists of several parts – preview to the topic, literature review, theoretical framework, FX data and VaR, hypothetical case-analysis, hedging strategies, and finally the conclusions. Preview to the topic presents the basics of exchange rates and the types of FX exposures. Literature review presents the relating literature, theorethical framework presents the financial instruments and their mechanics. FX data and VaR presents the historical FX data and the derived VaR estimates for the risk reference. Hypothetical case-analysis defines the cashflow positions and presents the external hedging strategies, and then conclusions where the objectives of the study are concluded.

2 Exchange rates and FX exposures

With the guidance of Fama's (1970) efficient market hypothesis, researchers have connected exchange rates to macroeconomic fundamentals. The hypothesis states that prevailing price reflects publicly avaible information to a degree that risk-adjusted profits can not be made by trading on the basis of that information. Therefore asset prices should reflect prevailing expectations and they should without delay react to relevant announcement at the time of the release. Theoretically, the economic fundamentals of a country determine the value of a currency, and these fundamentals have effect on trade and capital flows and therefore they affect the demand and supply of the currency (Neely & Dey 2010, Hutcheson 2003).

There are number of macroeconomic fundamentals regularly announced and updated that influence exchange rates in consistent ways. Interest rates, inflation rates, employment, output and trade balance are among the most influential factors to the FX markets. Monetary, manufacturing, and spending information are also influential. Announcements that raise current domestic or expected future domestic interest rates relative to foreign interest rates tend to immediately appreciate the domestic currency. The market reaction varies however over time, between the countries and business cycles because the response reflects the revised view of the current and future state of the economy. There is also different reactions to macroeconomic fundamentals across countries which have been explained for instance by the differences in likely responses of the monetary authorities to the changed macroeconomic fundamentals. The announcement effects in FX markets are not structural because they depend on market expectations of policy among many other factors and therefore the effects can be unstable (Neely & Dey 2010).

Exchange rates are also influenced by speculative activities. Speculative activitity refers to taking position in currency with an anticipation of a currency appreciation (depreciation), and it can be seen as a factor that might offset exchange rates from reflecting their fundamental value. However, in general terms speculation increases exchange rate volatility and improves market efficiency. Speculative activities can also be seen enhancing information diffusion as they incorporate new information rapidly (Hutcheson 2003, Hasselgren et al 2020).

In the long term, exchange rates can be explained by different dependency relationships. One of the most important one being the Purchasing Power Parity (PPP), a version of The Law of One Price – theory, which (the absolute theory) states that in a perfectly competetive market an easily and freely traded goods should have same price everywhere when prices are shown in same currency. In other words that a basket of goods costs the same in every country if the price is shown in same currency. However the more commonly used relative theory states that the exchange rates between countries merely stabilize changes in price levels (Pugel 2004).

Other significant relationships are Fisher-effect and the interest rate parity. According to the Fisher-effect the nominal interest rate consists of two components; of the real interest rate demand and of the inflation expectation. And, as real interest rates are expecteded to be equal in different countries, the nominal interest rates are higher in countries with higher inflation. And if the real yield requirement is higher in other countries, the investors will shift assets to these countries until interest rate differences between countries will even out (due to arbitrage possibilities). The Fisher effect thereby states that (with interest rates affecting exchange rates) a country with a lower interest rate should experience currency strengthening in relation to a currency (in a country) with a high interest rate – the spot exchange rate should develop in the opposite direction by the interest rate difference amount between the countries (Shapiro 1996).

According to the interest rate parity, the interest rate differences should be equal to the discount rate (or premium) in forward rates in the efficient markets otherwise arbitrage possibilities occur. The spot price and forward price are not however always aligned with the interest rate parity which trough covered interest rate arbitrage will influence countries interest rates and exchange rates. The interest rate parity is considered one of the best documented dependency relationships among international finance because due to its empirical applicability (Shapiro 1996).

2.1 Types of FX exposures

Multinational companies can be exposed to FX risks in various ways and circumstances. These different possible risk exposures are categorized into transaction exposure, translation exposure and economic exposure, and regardless of the type they can have significant impact on financial performance and financial position of the companies. In spite of the segregation and distinction between the exposures there is also some overlapping between them.

2.1.1 Transaction exposure

Transaction exposure occurs when a commitment in foreign currency is subject on a settlement to exchange rate gains or losses caused by a change in exchange rates. A change in exchange rates between the functional (domestic) currency and the foreign denominated currency thereby increases or decreases the expected amount of functional currency cashflow on a settlement of the transaction. The longer the time differential between the initiation of the transaction and its settlement, the greater the transaction risk is because there is more time for the exchange rates to fluctuate. Transaction exposure occurs on many occasions for instance, when purchasing or selling goods or services on credit with prices stated in foreign denominated currencies, when borrowing or depositing funds denominated in foreign currencies, or in general when participating in transaction involving foreign currencies. Transaction exposure may

therefore occur in variety of foreign currency denominated assets (receivables, bank deposits), liabilities (account payables, loans), revenue (expected future sales) or income (dividends) (Poniachek 2012).

2.1.2 Translation exposure

When multinational company owns independently reporting foreign business operation whether it be subsidiary or branch et cetera the parent company must decide functional currency in which the foreign entity operates. Typically in developed countries the functional currency is the currency of the entity's country and therefore in many cases the foreign entity has a different functional currency than the parent company. In other cases – typically when the foreign entity is located in less developed country, the entity's functional currency is same as the parent company's one. Dependent on the alternative the (US) accounting standards differ and as a result translation exposure is different.

When the foreign entity uses different functional currency than the parent company, a modified closing rate accounting method is applied meaning all the entity's assets and liabilities are translated to the parent's currency at the prevailing spot FX rate. Equity, however, is translated at a historical spot FX rate, and the possible difference in balance sheet represents FX gain or loss which is booked in the parent's consolidated equity called cumulative translation adjustment. If same functional currency is used, then temporal accounting method is applied meaning any asset or liability that is carried on the entity's accounting at fair value is translated at the prevailing spot FX rate. Therefore there is only translation exposure to fair value accounts and the possible exposure must be included in the parent company's reported earnings (O'Brien 2017).

2.1.3 Economic exposure

Similar to the transaction exposure, the economic exposure refers to the impact FX fluctuations have on a company's actual cashflows however the impact is more indirect and complex. Economic exposure also influences companies that do not have foreign operations by changing their competitive and strategic positioning. For instance if a domestic currency appreciates against foreign currency, importing will become cheaper and hence there will be rise in the volume of product demand. From the exporter's perspective, the exporter will get a compound effect from the exchange rate – more sales converted with better exchange rate. Another example of completely different economic exposure is how global price of metals is set in US dollars. Therefore if US dollar appreciates the metal's price for non- US dollar buyer increases possibly resulting to a lower demand for metals or products that contain lot of metals. Economic exposure can impact companies in variety of different and complex ways and sometimes even recognizing these exposures may be challenging (O'Brien 2017).

3 Literature review

Research on FX risk(s) has significantly increased over the last 25 years and has involved authors around the globe in the process. The increased research and the integration among researchers have clustered different research approaches to highlight different assumptions and conclusions with regard to managing exchange rate risks. Broad research themes such as exposure, volatility, hedging and asset valuation have helped in understanding the related risks in terms of different dynamics while most studies have concluded that firms proactively take measures to minimize the effects of such risks. The insightful conclusions have been reasoned with different theoretical frameworks, diverse methods and data being extracted from a wide variety of sources to understand the research topics in great depth. (Nobanee et al. 2022).

Why then hedge if hedging FX risk may be considered as a “zero-sum game” where one participant’s gain is another one’s loss? After all, if a participant who is hedging for USD/YEN gains on their hedges then another participant who is hedging YEN/USD loses. But even tough one side always wins, and the other side loses, hedging benefits both sides by reducing their risk. Black (1995) describes the hedging gain to be equivalent to the gains from international diversification but paradoxically recommends hedging less than 100 % due to Siegel’s paradox. By doing this and consequently taking some FX risk all hedging participants can add to their expected outcomes.

If the capital markets were perfect (they would not include for instance information asymmetry, taxes, or transaction agency costs) hedging financial risk should not add value to companies. The imperfection in the capital markets, however, creates a rationale for corporate hedging activities, and hedging particularly becomes an important way of managing risks and adding value. According to Glaum (2002) reducing cash flow volatility by hedging reduces the probability of default and thereby the cost of financial distress.

Hedging can also ensure that internally generated cash flows do not fall below levels that would result in needing outside funding in order to fund investments. Hedging cash flows thereby can ensure funding of growth opportunities.

Glaum (2002) also states that hedging can increase the value of firm trough a tax function convexity – that is that the company needs to pay less taxes on a stable stream of income than it would have to if the income was disproportionately high in some periods and relatively low on other periods. However, Glaum (2002) points out relating to tax arguments (although indirectly), that financial leverage is more relevant argument in favor of hedging. By reducing the possibility of a company's bankruptcy, hedging can effectively increase the company's capacity to take on debt, and therefore can allow the company to take on more debt. Taking more debt leads to tax and incentive benefits, and interestingly can be seen in some way as a substitute for equity.

In addition, Glaum (2002) presents managerial interests as incentive for hedging. Since managers are not completely diversified, they are motivated to hedge risks related to their positions – otherwise they might refuse to take positive but risky net present value projects. Hedging, therefore, is also within the shareholders' interest, and additionally managers may be motivated to reduce income volatility in places where they do not have control. Glaum (2002) however points out that managerial argument for hedging is not found strong in many empirical studies but remarks that the study results might be inconclusive due to the data sample having managers with and without stock options. Stock options may provide managers with incentives to speculate because the stock options are tied to the underlying stock volatility.

And lastly, Glaum (2002) brings out economies of scale as an incentive for hedging. Because constructing and having a risk management program involves significant (fixed) costs, it is more feasible for larger companies. Empirical evidence between the company size and hedging practices is very clear with practically all studies finding that larger companies are more likely to use derivates for hedging. On a theoretical level, the relationship is to a degree indeterminate because the expected cost of financial distress is negatively related to the size.

Kim & Sung (2005) examined factors that determine companies' decisions to manage FX risk in an emerging market. Emerging markets might be asymmetrical to developed markets for many reasons, for instance they might be under different exchange rate regime, or their FX derivatives market might be underdeveloped. Korea experienced currency crisis in 1998 which resulted to keeping won-dollar exchange rate stable afterwards, and this again discouraged companies from hedging their FX exposures regardless of the size. Kim & Sung (2005) surveyed 223 Korean firms and found that cost of hedging is the dominant determinant in company's decision to hedge FX risk. They also found that company size does not explain greatly the usage of internal hedging methods, but in terms of external methods such as forward contracts, currency options et cetera, size becomes an important explaining factor. Furthermore, Kim & Sung (2005) interestingly found that foreign currency debts do not explain greatly companies' decision to hedge FX risk, but that export revenue has more explanatory power, especially in public companies. The survey also concluded that out of the hedging methods forward contracts were still most heavily used, followed by two internal methods. Currency options, swaps and futures were relatively infrequently used.

Marshall (2000) surveyed a total of 179 large multinational companies in the UK, USA and Asia Pacific region that were widely exposed to different types of FX risks to examine whether FX risk management practices and attitudes vary between the regions. Marshall found statistically significant regional differences in the objectives and importance of FX risk management, the emphasis between the exposure types, and the techniques used

in FX risk management. First, the survey found that out of three exposure types, distinctly most emphasized in all the regions was the transaction exposure, USA respondents placing the most emphasis. The emphasis on translation exposure and economic exposure were more scattered on the scales between the regions – USA respondents distinctively emphasized less translation exposure than the other regions, ASIA Pacific region respondents distinctively emphasized more both exposure types than USA and UK.

Secondly, Marshall (2000) surveyed the popularity of external hedging methods and found forward contracts to be the most popular method of addressing the transaction exposure with nearly all respondents using them. Additionally, many of the respondents were only using forward contracts, and the average number of methods across all respondents was less than two of the methods listed below. In addition to forward contracts, currency options and currency swaps were used by approximately 50 % of the respondents. Exchange-traded methods, specifically future contracts, were notably more used in Asia Pacific region than in USA and UK.

Sheedy (2001) surveyed 131 Hong Kong and Singaporean firms to examine their use of derivatives and the oversight of risk management programs and found that firms in these two Asian business centers are more likely to use selective or active hedging strategies based on market views than their US counterparts, and that overall they use derivatives with greater intensity. Consequently Hong Kong and Singaporean firms are more likely to use various options than the US counterparts, but still forward contracts are generally preferred hedging products. Sheedy (2001) also notes that Asian firms are less rigorous in their policies related derivatives and derivatives reporting and implies that the lesser oversight may have implications to the results because of performance evaluation.

Pramborg (2005) found in his study that the objective of the hedging activity can differ between countries and that lower derivatives usage could be explained by the immaturity of the domestic derivatives market. The objective of the hedging activity in a country could be more so to minimize earnings fluctuations or to protect the appearance balance sheet than to minimize cashflow fluctuating. Furthermore, regional and country differences have revealed significant hedging practice differences and for instance Bodnar & Gebhardt (1998) have provided evidence that firms in some countries such as in Germany are more likely to use derivatives for hedging indicating also more comfortable approach to the derivatives use.

Lievenbruck & Schmid (2014) examined interestingly in their global study focusing on energy utility companies how cultural differences between countries explain firm's hedging decisions and found that country's long term orientation reduces the probability for hedging and the hedging amount, and that option hedging is less common in countries with high level of masculinity. Also interestingly, the authors find the effect to be strong from both statistical and economic point of view, and that only firm size has consistently higher economic impact out of the standardized variables.

Sah et al. (2022) studied the possible influence that a firm's share structure may have on its hedging decisions and found that companies that have dual class of shares engage in lower levels of FX hedging activities than their non-dual counterparts. The authors attributed this phenomenon to dual share structure firms' aversion to transparency and reluctancy to divert resources away from long-term goals, and to their resistance for short-term market pressures.

Hau et al (2021) found in their interesting study that smaller and less sophisticated market participants incur considerably higher transaction costs for using FX derivates, and that pricing variations between the banks clients can explain why many companies, especially in countries with less-developed derivative markets, may decide not to hedge their FX exposures. The study uses available regulatory data to measure the extent of

price discrimination against non-financial clients in the FX derivatives market – using more than half a million transactions among 204 banks and 10 087 non-financial clients in the euro/US dollar forward market that range from large multinationals to small import-export companies.

According to Hau et al. (2021) 90 % of the corporate clients never trade on multi-dealer platforms where quotes can be requested from multiple dealers simultaneously rather than sequentially from individual dealers. Hau et al. (2021) also state that a greater transparency to OTC-market execution prices would result in more efficient market structure trough comparison.

4 Theoretical framework

In the last few decades, derivatives have become increasingly important in finance. Many types of derivatives such as forward contracts, options and swaps are used in transferring a wide range of risks from one entity to another. In addition to transferring risks, in other words hedging, derivates can also be used for arbitrage and speculative reasons. When derivates are utilized for hedging purposes against unfavorable FX fluctuations it is considered as an external hedging method.

4.1 Derivatives markets

Derivates are traded in two markets – exchange traded markets and over-the-counter (OTC) markets. In exchange traded market, market participants trade standardized contracts defined by the exchange and handled by the exchange clearing house. The clearing house eliminates the credit risk of the counterparty by requiring the participants to deposit funds (also known as margin) to ensure solvency. In OTC- market, market participants trade tailored contracts that can be executed bilaterally, or similarly with the clearing house, with central counterparty. If executed bilaterally, all the terms and conditions applicable are naturally covered in the agreement between the parties. Although OTC markets have more tailor for need nature, after the financial crisis started in 2007, it has become more similar to exchange traded market with more instructive requirements (Hull 2022).

The market size for both derivate markets is significantly large. The principal amounts underlying the transactions, although not the same as the contract values, was 96,5 trillion US dollars for the exchange traded market, and 558,5 trillion US dollars for the OTC market in 2019. The transaction volume between the markets is however the opposite – OTC market has less transactions than the exchange traded market, but the average transactions are much greater. There are many exchanges throughout the world such as the Chicago Board Options Exchange (CBOE) in exchange traded markets that offer several derivates for different needs (Hull 2022).

4.2 Forward and future contracts

Forward and future contracts are both agreements to buy or sell an asset at a future time for a certain price however they differ slightly because they are traded in different derivates markets - forward contracts are traded on the OTC-market whereas future contracts are traded on the exchange. Main differences between the two contracts are summarized as:

Forward	*Futures*
Private contract between two parties	Traded on an exchange
Not standardized	Standardized contract
Usually one specified delivery date	Range of delivery dates
Settled at end of contract	Settled daily
Delivery or final cash settlement usually takes place	Contract is usually closed out prior to maturity
Some credit risk	Virtually no credit risk

Figure 1. Comparison of forward and future contracts (Hull 2023).

As forward contracts are traded on the OTC-market, they are private contracts by nature and unstandardized whereas future contracts are standardized. This consequently means (as forward contracts are essentially tailored between the parties) that forward contracts usually lead to delivery or cash settlement at one specified delivery date whereas future contracts are usually closed before maturity by entering into offsetting contracts and there are several delivery dates. The two contracts also differ in terms of credit risk - forward contracts bare some credit risk as they are settled at the end of the contract, future contracts however do not practically have credit risk since they are settled on a daily basis. Although a significant proportion of future contracts do not lead to delivery of the underlying assets, the possibility of final delivery affects the price determination of the future contract (Hull 2023).

When short-term risk-free interest rates are constant, a forward contract has in theory the same price as a future contract if the delivery date is the same for both contracts. This has been argued with arbitrage theory, and it can be extended to cover situations

where the interest rate is a known function of time. But, in a more real setting where interest rates change unpredictably, forward, and future contracts' prices are in theory no longer the same. If the underlying asset is heavily and positively correlated with interest rates, a future contract will make an immediate gain because it is settled daily. The correlation will increase the rate at which the gains can be invested or inversely at which the loss has to be financed. A forward contract is not affected by interest rate movements in the same sense. Thereby, when the underlying asset is strongly negatively correlated with interest rates, forward prices tend to be slightly higher, and when the underlying asset is strongly positively correlated with interest rates, future prices tend to be slightly higher. Nonetheless, theoretical differences between the two contracts with short maturity are in most conditions so little that they can be ignored. And even though the theoretical models may not reflect all factors, it is reasonable to assume that forward and future prices are the same (Hull 2023).

Forward and future contracts can be segregated into investment assets and consumption assets based on their holding purposes. Investment assets include for instance equities and bonds – assets that are held for investments purposes by at least some traders. Investments assets however do not necessarily have to be held exclusively for investment – gold and silver for instance have many uses as commodities and thereby they can be regarded in both categories. Consumption assets, however, are held primarily for consumption purposes, and not typically for investment purposes. Consumption assets may provide income or bear costs and thereby their pricing differs from investment assets (Hull 2023).

The pricing formula for investment asset forward contracts is:

$$F_0 = S_0 e^{\mathrm{rT}}$$

And the value of the contract (applicable to both assets):

$$f = (F_0 - K)e^{-\mathrm{rT}}$$

where F_0 is the starting price of the forward contract, S_0 being the spot price for the underlying asset, r being the risk-free interest rate and T being the maturity, f being the value of the forward contract, and K being the delivery price. As time goes on K stays the same but the forward price changes resulting to positive or negative contract value. When the forward contract's price changes, the gain or loss on the contract is calculated as the change in contract price multiplied by the size of the position. The gain or loss is the present value of the change in the forward contract price multiplied by the size of the position (Hull 2023).

When the underlying asset of the forward contract is a foreign currency, two interest rates must be considered because foreign currencies can provide a yield. The holder of the currency can earn interest at the risk-free interest rate prevailing in the foreign country by investing the currency in a foreign-denominated bond, for example. By taking this well-known interest rate parity into account the price of the forward contract, the underlying asset if a foreign currency is:

$$F_0 = S_0 e^{(r-rf)\mathrm{T}}$$

where r is the risk-free domestic interest rate and rf the risk-free foreign interest rate. A foreign currency can therefore be regarded as an investment asset since it pays a known yield. If the interest rate parity would not be considered, there would be arbitrage opportunities (Hull 2023).

In the context of hedging, forward and future contracts can be utilized to cover price risks related to selling or buying an asset at a future time. When companies want to hedge their price risks related to selling an asset at future time, they can enter into a short position.

4.3 Options

There are two types of options – call options and put options. A call option gives the holder of the option the right to buy an asset at a future date (called expiration date) for a certain price (called exercise price), whereas a put option gives the holder of the option the right to sell an asset at a future date for a certain price. There are also two sides to every open option contract – long position (buyer of the contract) and short position (seller or writer of the contract). The writer (seller) of the option contract receives payment up front but has in return an obligation to sell or buy the underlying asset (the writer has to put a margin) according to the contract if the contract were to be exercised. The option buyer's profit or loss is the reverse of that for the writer of the option contract. Thereby there are four types of option positions, long positions in call and put options (a & c), and short positions in call and put options (b & d), demonstrated with payoffs in relation to strike price K and asset's price at maturity ST.

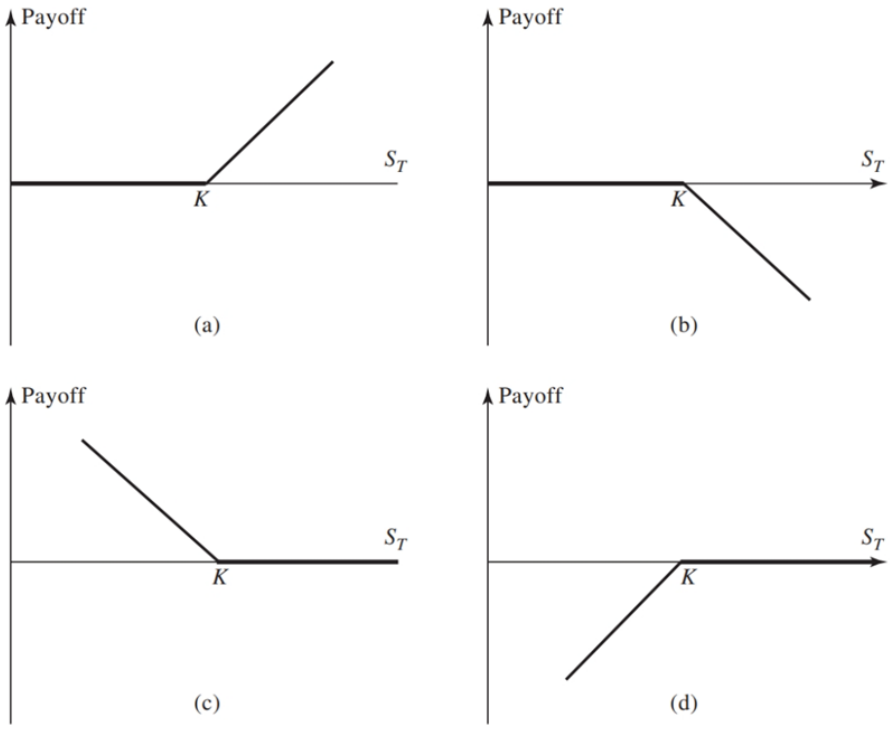

Figure 2. Payoffs from options (Hull 2023).

Options can be characterized into European and American options. European options have fixed expiration date whereas American options can be exercised at any time up to the expiration date. Exchange traded options are mostly American options. Both options can be referred to as in the money, at the money, or out the money, depending on the relationship between the exercise price and the prevailing (spot) price of the underlying asset. In case of call options, in the money means that the underlying asset's price is above the exercise price, at the money means that the underlying asset has the same price as the exercise price, and out the money means that the underlying asset's price is below the exercise price. In case of put options, in the money and out the money are inverse to call options. Therefore, options are only exercised when they are in the money, transaction costs considered.

The value of the options consists of intrinsic value and time value (extrinsic value). The intrinsic value is the value the option has if it were to be exercised immediately – in call options intrinsic value is maximum underlying asset's price minus strike price or zero, in put options maximum strike price minus underlying asset's price or zero. The excess of an option's value over its intrinsic value is time value which can be seen as a time decay of the asset. The longer the time to expiration, the more value the option will have in the form of time value because there is more time to generate intrinsic value. When the time passes time value will decrease, and the option tends to become less valuable however this is affected by how close to the money the option is.

4.4 Pricing of options

In 1973, Black and Scholes discovered a breakthrough in stock option pricing when they used the capital asset pricing model to determine a relationship between the market's required return on the option and the required return on the stock. Black and Scholes developed the most famous and used pricing model for approximating the theoretical value of a European styled option based on the available information:

$$\frac{\partial f}{\partial t} + rS\frac{\partial f}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf,$$

where f stands for price of the option as a function of stock price S and time t, r being the risk- free rate, and σ being the volatility of the stock (Black & Scholes 1973).

Afterwards, the Black & Scholes model was modified by Merton to take dividends into consideration (Merton 1973). Nowadays, the Black & Scholes model is widely used in valuing different financial instruments. The pricing formula can be quoted for call and put options as:

$$Call = S_0 N(d_1) - K\mathrm{e}^{-\mathrm{rT}} N(d_2)$$

$$Put = K\mathrm{e}^{-\mathrm{rT}} N(-d_2) - S_0 N(-d_1)$$

where:

$$d_1 = \frac{\log\left(\frac{S_0}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\log\left(\frac{S_0}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

S_0 being the spot price for the underlying asset, K being the exercise price, r being the continuously compounded risk- free rate, N(x) being cumulative probability distribution function for a standardized normal variable, T being time to maturity and d_1, d_2 being parameters to the N(x).

Therefore, there are six factors affecting the price of a European stock option which are the spot price, the strike price, the time to expiration, the volatility of the stock price, the risk-free interest rate, and the dividends that are expected to be paid. The relationship between the spot price and the strike price is straightforward – for example

a call option payoff is at least the amount by which the stock price exceeds the strike price and thereby it will become more valuable as stock price increases and less valuable when strike price increases. Time to expiration is also straightforward – more time equals more value since there is more time to generate intrinsic value. Volatility, when increased, increases the values of both option contracts because both options benefit from price fluctuation. Since option buyers can only lose option price, the downside risk is limited.

4.5 Currency options

A currency option gives the buyer of the option the right to buy or sell currencies at a specified exchange rate within a specified time. Alternative to forward contracts, currency options are commonly used in hedging against unfavorable exchange rate movements since they can be used to secure certain exchange rate levels. And, since options do not obligate execution, buyer of the currency option can additionally benefit from possible favorable exchange rate movements. Currency options are typically traded in the OTC-market as it allows tailoring of the option contracts to specific needs.

As foreign currencies receive yields equal to the risk-free interest rates, foreign currencies' risk-free interest rates need to be considered in the valuation of the currency options - similarly as known dividend yields would be considered in the stock options. Therefore, the pricing equation for European currency options is:

$$Call = S_0 e^{-rf T} N(d_1) - K e^{-rT} N(d_2)$$

$$Put = K e^{-rT} N(-d_2) - S_0 e^{-rf T} N(-d_1)$$

Where:

$$d_1 = \frac{\log\left(\frac{S_0}{K}\right) + \left(r - rf + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\log\left(\frac{S_0}{K}\right) + \left(r - rf - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

r is the domestic interest rate and rf the foreign interest rate.

Currency options are suitable for FX hedging since they can be utilized in various ways – for building complex and sophisticated hedging strategies or simply using them as plain vanilla style. According to Shamah (2004) common incentives to use currency options are:

When buying a currency option:

1. To limit downside exchange rate fluctuation risk while maintaining potential upside gains
2. To provide a hedge for contingent risk and,
3. To increase certainty in financial planning

When selling a currency option:

1. To provide income immediately trough receiving premiums and,
2. To provide flexibility when used with other instruments as a part of FX hedging strategies

4.6 Range forward option strategy

Options can be utilized in various ways in order to build more advanced hedging strategies. They can be used in combination – for example buying and selling them simultaneously, to construct boundaries for possible scenarios. By doing so, the hedger can preserve the possibility to gain from favorable exchange rate movements while limiting the downside risk and the cost of the hedging. Thereby, the hedger can speculate on the exchange rate developments while not necessarily having to bear expensive costs in return.

With a range forward option strategy, a hedger can create lower and upper boundaries in which the exchange rates can fluctuate. The strategy requires taking two option positions – buying a put option and selling a call option, or vice versa, depending on whether hedging cash inflows or outflows. If hedging cash inflows, a put option is bought with strike price K1 while a call option is sold with strike price K2. If hedging cash outflows, a put option is sold with strike price K1 while a call option is bought with strike price K2. Payoffs from hedging against cash inflows (short position) a, and against cash outflows (long position) b.

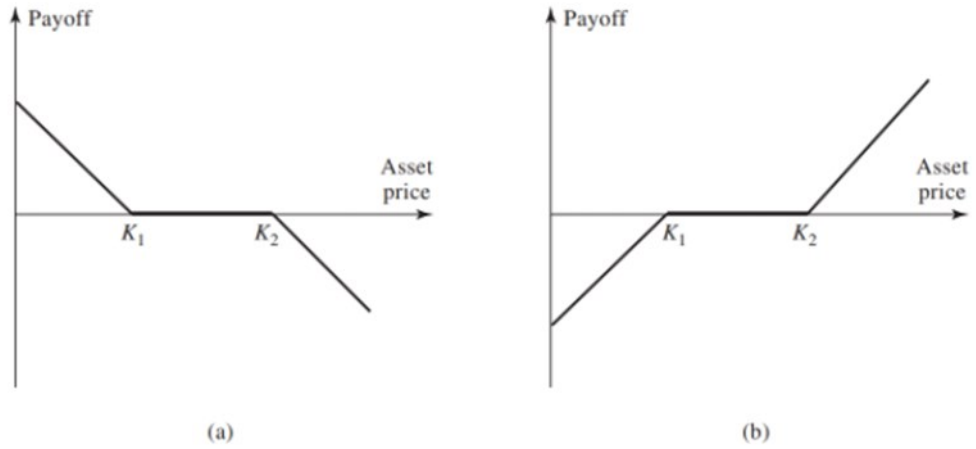

Figure 3. Payoffs from range forwards (Hull 2023).

In short position, if the exchange rate in future proves to be less than K1, the put option is exercised and as a result exchange rate K1 is utilized. If the exchange rate is between K1 and K2 neither option is exercised and as a result the prevailing exchange rate is utilized. And, if the exchange rate is greater than K2, the call option is exercised and as a result the exchange rate of K2 is utilized. Therefore, strike prices K1 and K2 represent lower and upper boundaries in which the exchange rate can fluctuate (Hull 2023). And, since range forward is typically set so that the price of the put option is equivalent to the price of the call option, range forward is practically a zero-cost hedging strategy.

4.7 Volatility

Volatility means different things in different contexts but in derivative pricing models such as in Black & Scholes model, volatility is considered to be the expected standard deviation. It is imperative to understand volatility in the derivatives pricing models because it is the only estimated variable for example in Black & Scholes model as other variables are known. Because of this, the option buyer can be seen taking a long position in volatility since it will profit from the increased volatility, and conversely, the seller can be seen taking a short position since it will profit from the decreased volatility (Iqbal 2018).

Hull (2023) presents three alternative methods to estimate volatility:

1. Historical volatility
2. Estimated volatility and,
3. Implied volatility

Hull (2023) expresses the historical volatility as:

$$S = \sqrt{\frac{1}{n-1}\Sigma_{i=1}^{n}(u_i - u)^2}$$

In which i is the time period, u_i is the continuously compounded returns and u is the mean of the continuously compounded returns. The time interval from the historical data could be, for instance, daily, weekly, or monthly, and the changes between the intervals are subject to review when calculating the historical volatility. The historical volatility is considered in this study when calculating the option prices.

The implied volatility is essentially the market expectation of the future volatility. The implied volatility cannot be calculated directly but it is instead iterated. According to Dumas et al. (1998), the mechanism of iterating the implied volatility can be illustrated as following:

$$C(\sigma) - C_x$$

Where, $C()$ represents the option pricing equation, σ the volatility parameter and C_x the theoretical value of the option. The equation essentially uses an iterative algorithm to find the value of σ so that the equation would equal to zero.

For the estimated volatility, there are several different methods that are used to estimate future volatility. Some of the well-known methods (that are based on the historical volatility) are exponentially weighted moving average (EWMA), autoregressive conditional heteroskedasticity (ARCH) and generalized autoregressive conditional heteroskedasticity (GARCH). An important feature of these models is that they don't assume volatility nor correlation to be constant (Hull 2023).

4.8 Currency swaps

Currency swaps are contracts to exchange two streams of future cash flows in different currencies. They are essentially used to convert debt denominated in one currency into debt denominated in another currency. The basic "plain vanilla" currency swap is a fixed-for-fixed swap, in which the cash flows are based on straight bonds in two currencies. A straight bond has no other features than coupon interest and principal repayment, and thereby the swap requires only two coupon interest rates, notional principal, and the time until maturity. Any two counterparties can then agree to exchange cash flows based notionally on these straight bonds regardless of whether they own the bonds or not.

A simple example would be a 5-year 6 % US dollars for 4 % Swiss francs currency swap, with notional principal of 1000 US dollars. The cash flow payments would be based on two five year straight bonds, denominated in US dollars, and Swiss francs with annual coupon interest payments. As the coupon rate for 5-year US dollar bond is 6 %, and the principal is 1000 US dollars, the coupon payments are 60 US dollars per year (0,06x1000). At the end of last year the principal is also repaid. The Swiss franc bond equals, if the spot FX rate is for example 1,6 for US dollar, 1600 Swiss francs with 64 Swiss francs annual coupon payments (0,04x1600), and the principal repayment of 1600 Swiss francs at the end of last year.

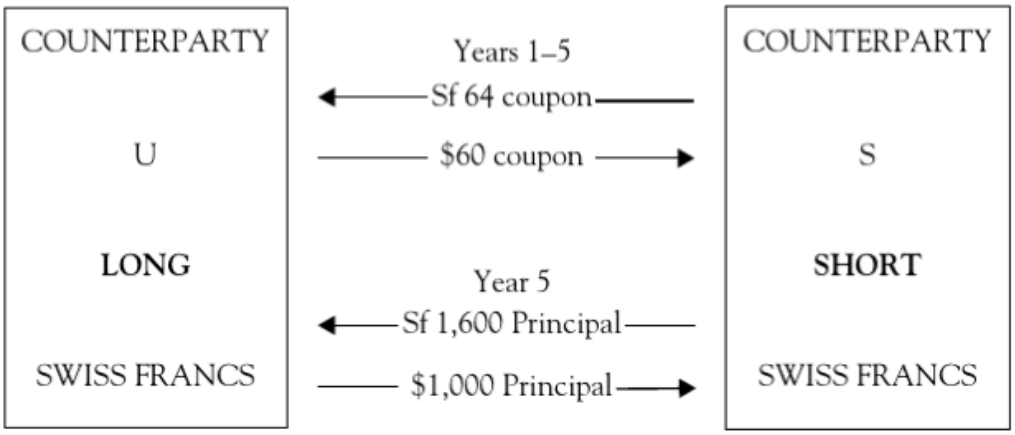

Figure 4. Currency swap illustration (Hull 2023).

Counterparty U would agree to receive from counterparty S, the annual Swiss franc cash flow of 64 for five years and the 1600 Swiss francs at maturity. Counterparty S would agree to receive from counterparty U the annual US dollar cash flow of 60 for five years and the 1000 US dollars at maturity. Therefore, counterparty U has the long position on Swiss francs and the counterparty S has the short position on Swiss francs.

If the coupon rates on the underlying bonds are the same as their market yields, the currency swap is called at-market swap. In at-market swap, the principal of each bond is equal to the present value of its future cash flows, in other words, present values of the swapped cash flows are equivalent at time 0. Currency swaps most often initiate as at-market swaps (Thomas O'Brien 2017).

4.9 Counterparty risk

Counterparty risk is a risk that the counterparty with whom the other party has entered into a financial contract will fail to fulfil their contractual agreement obligations. To some extent counterparty risk can be considered as credit risk, a risk that another party may fail to pay debts due to insolvency, however two aspects differentiate financial contracts with counterparty risk from traditional credit risk. In counterparty risk, the value of the contract in future is uncertain and, in most cases, significantly so, and since the value of the contract can be positive or negative, counterparty risk is commonly bilateral thereby each counterparty has risk to the other (Gregory 2015).

4.10 Value-at-Risk

Measuring risk thoroughly and accurately has always been an important subject. In the 1990's J.P. Morgan initiated a risk management concept called Value-at-Risk (VaR) to summarize potential risk arising from a broad spectrum of causes. Since then VaR has been increasingly used both in practice and in theory for the management of financial risk. More specifically, VaR is used to evaluate the minimum expected loss of a portfolio of assets over given holding period at a given level of probability. In other words, it

demonstrates within a certain probability how the portfolio will fall in value by more than a certain amount (Bi & Zhou, 2020).

According to Alexander & Choudhry (2013) the calculation of VaR estimate follows four general steps.

1. Determine a time period
2. Select a degree of certainty (confidence level)
3. Create a probability distribution of likely returns for the instrument or portfolio under consideration and,
4. Calculate the VaR estimate.

The time period is usually set for one day to demonstrate how much the given portfolio may lose in a one-day period. The degree of certainty may depend on the review perspective – for example 95 % confidence level indicates the greatest loss of value that the portfolio has to endure say 95 times out 100 but 99 % confidence level indicates the greatest loss of value the portfolio has to endure 99 times out 100. 99 % confidence level thereby demonstrates rather "catastrophic" or worst case scenario that may occur. The probability of distribution of likely returns can be constructed with several methods such as the historical simulation, Monte-Carlo simulation, or variance-covariance method. Then the VaR estimate can be interpreted from the probability distribution based on the chosen parameters – for example if there are 100 observations and the confidence level is 95 %, 1-day VaR with historical simulation method would be the 95th most adverse change in portfolio value (Alexander & Choudhry, 2013).

The calculated 1-day VaR can also be extended to estimate VaR for longer time periods if the changes in the portfolio value on consecutive days have independent identical normal distributions with zero mean, otherwise the extended VaR is rather an approximation. The extended VaR can be expressed as a function of two parameters; time measured in days N, and the confidence level X (Hull 2017):

$$N(day)\ VaR = 1day\ VaR \times \sqrt{N}$$

In historical simulation the probability distribution is constructed with historical data meaning the historical data is used as a guide to what will happen in the future. It is the simplest method for calculating the VaR – it calculates potential losses using actual historical returns (changes in portfolio values) in the risk factors and thereby captures the non-normal distribution of risk factor returns. As a result, it makes no explicit assumptions about the variances of portfolio assets and the correlations between them, nor does it make assumptions about the shape of the distribution of asset returns (or normality), and it does not require simplification or cash flow mapping (Alexander & Choudhry, 2013)

Although VaR is a widely used concept for summarizing financial risks, it is not a unified method for measuring risk since there are several calculating methods to it which all produce different estimates. Therefore, it is rather a quantitative statistical approach to risk measurement which captures risks than can be quantified – a measurement tool for market risk exposure (Alexander & Choudhry, 2013).

5 FX historical data & VaR estimates

This study applies year 2023 EUR/USD and EUR/GBP daily exchange rate changes as a basis for the historically simulated VaR estimates. Only a one-year data from 2023 is being applied since applying data for instance from the previous three years would include the effects of the global pandemic Covid-19. And, including an abnormal event such as the Covid-19 in the VaR data would distort the significance of the VaR estimates. Thereby, the 2023 data can be considered as a better proxy for predicting the transaction risk for the following year under more normal market conditions.

The two currency pairs are well suited for the hypothetical case-analysis since they provide a broader perspective on the suitability of the hedging strategies – EUR/USD is far more volatile than the EUR/GBP which better demonstrates the usefulness of the hedging strategies. The two currency pairs also demonstrate the subjectiveness of the transaction risk, and how that may or should influence the approach to the hedging decisions or policy.

5.1 Exchange rate data

The following graphs describe the full year 2023 developments of the EUR/USD, and the EUR/GBP currency pairs – in other words how much volatility and consequently transaction risk there has been derivable to this study. The figures 1 and 2 demonstrate the constant fluctuation of the currencies, although the Pound sterling has been less volatile. The EUR/USD had the lowest value of 1,0469 in early October whereas the highest value of 1,1255 in July – average value being 1,0813. The EUR/GBP had the lowest value of 0,8511 in July and the highest value of 0,8933 in February while the average value being 0,8697 (European Central Bank, 2024).

Figure 5. EUR/USD exchange rates in 2023 (European Central Bank 2024).

Figure 6. EUR/GBP exchange rates in 2023 (European Central Bank 2024).

Table 1. Descriptive statistics for 2023 EUR/USD & EUR/GBP exchange rates.

Currency	**USD**	**GBP**
Observations	259 days	259 days
Mean	0,01426 %	-0,0076 %
Standard Deviation	0,46855 %	0,30214 %
Variance	0,00219 %	0,00091 %
Skewness	0,10425	-0,03334
Kurtosis	0,44571	0,55614

Table 1 describes the 2023 exchange rate data for both currency pairs with common descriptive factors. Skewness assesses the extent to which a variable's distribution is symmetrical and kurtosis compares the dataset distribution to the normal distribution. If the distribution of changes in variable leans towards right or left tail of the distribution, the distribution is considered as skewed. When skewness is equal to 0, the dataset can be considered as a symmetrical dataset or a normal distribution. A dataset with high or positive kurtosis indicate that the distribution has heavy tails or (many) outliers, conversely a negative kurtosis indicates lack of outliers (Hatem et al. 2022).

It is insightful to understand the distribution of changes, specifically how skewed the distribution is, when conducting a historical simulation to arrive at the VaR estimates. We can see from Table 1 that the datasets can almost be considered as symmetrical datasets, however, with some outliers - if the datasets would have included a lot of outliers (kurtoses would have been greater) then it is sensible to use greater confidence intervals in historically simulated VaR estimates and additionally an expected shortfall (method) to demonstrate the effect further that the outliers may pose. However, as it is within this case, both distributions have reasonably low skewness and kurtosis hence there is no need to present the expected shortfall (method), but still different confidence intervals are presented.

5.2 VaR estimates

From the 2023 datasets, by using the historical simulation method, the following VaR estimates were calculated for both currency pairs. The percentage VaR estimates can be converted to value VaR estimates simply by multiplying it with the given portfolio values. There are three different confidence intervals which demonstrate the number of outcomes that can be included in the interval. For instance, the 95 % confidence interval means that in 246 observations out of the 259 total observations, the loss did not exceed the -0,74 %. As the datasets were relatively small in terms of observations, the 99,5 % VaR represents the worst daily loss in the given year – there are not enough observations to calculate VaR estimates further with acceptable accuracy. However, if the data samples were much larger there would be almost inevitably different market conditions or abnormal events included that would distort the VaR estimates (Akhtekhane & Mohammadi 2012).

Table 2. Daily VaR estimates.

Currency	**USD**	**GBP**
VaR 95 %	-0,7404 %	-0,4767 %
VaR 99 %	-1,1061 %	-0,7419 %
VaR 99,5 %	-1,4441 %	-1,0592 %

To estimate losses to a longer period than for a single day, the daily VaR estimates can be extended with the equation presented in section 5.10. The daily VaR estimate is often first calculated as there may not be sufficient data to estimate the variable's changes over a longer period. The following two tables demonstrate the estimated value-at-risk when the daily VaR estimates are extended – they are solid approximations since the distributions requirements for them to hold exactly true do not fulfill perfectly (Hull 2024).

Table 3. 30-day VaR estimates.

Currency	**USD**	**GBP**
30-day VaR 95 %	-4,0553 %	-2,6110 %
30-day VaR 99 %	-6,0584%	-4,0636 %
30-day VaR 99,5 %	-7,9097%	-5,8015 %

Table 4. 90-day VaR estimates.

Currency	**USD**	**GBP**
90-day VaR 95 %	-7,0241 %	-4,5224%
90-day VaR 99 %	-10,4934 %	-7,0383 %
90-day VaR 99,5 %	-13,6999 %	-10,0485 %

6 Hypothetical case-analysis

Basis for this hypothetical case-analysis is a large European industrial company which exports heavy machinery to customers in the US and UK markets. The export contracts are most typically large and require extensive manufacturing times. The contracts are negotiated so that the cash inflows (exporting revenues) will occur on a monthly basis for one year at a time, and since the US-market is invoiced in US dollars, and the UK-market in Pound sterling, the company faces FX transaction risk when converting these cash inflows into its own functional currency euro. Between the open exposure period, the values of these cash inflows and the sales contracts can change significantly if the exchange rates were to fluctuate extensively.

6.1 Cashflow position

To understand the company's exposure to different currencies, it is first necessary to understand the net cashflow position of the company. More specifically, how much overlapping there could be in terms of cash inflow and outflow in the same currency at the same time, to understand the net cashflow position in the period. By doing this the offsetting effect of having two opposite cashflows in the same currency at the same time can be removed, which after the actual net exposure can be assessed.

As the company receives its export revenues from the US dollar and the Pound sterling the cash inflows are far greater than the cash outflows that the company has to transfer into those same currencies in order to acquire the necessary production parts. Thereby the cash outflows are reduced from the cash inflows and as a result the cashflows are netted to cash inflows for the upcoming twelve months. The cash flows are based on the sales agreements, thereby they will occur with certainty unless the sales agreements are breached.

Table 5. Cash inflows (netted) for the next 12-months.

Month	**USD (thousands)**	**GBP (thousands)**	**Total (thousands)**
1	15 000	10 000	25 000
2	35 000	15 000	50 000
3	40 000	35 000	75 000
4	45 000	25 000	70 000
5	25 000	25 000	50 000
6	35 000	30 000	65 000
7	50 000	40 000	90 000
8	50 000	45 000	95 000
9	20 000	20 000	40 000
10	40 000	25 000	65 000
11	45 000	30 000	75 000
12	50 000	50 000	110 000
Total	450 000	350 000	800 000

6.2 Risk management approaches

The purpose of FX transaction risk management is to reduce unfavorable variance in the value of future expected cash inflows or outflows. And furthermore, dependent on the risk management instrument used, to speculate on the market developments and take advantage of them. There are various ways to approach the transaction risk management however this study considers only external hedging methods and within the context of hedging cash inflows. Hence, the following four approaches can be considered relevant for this study (Eiteman et al. 2013):

1. No hedging
2. Hedge from forward-markets

3. Hedge from option-markets
4. Hedge from money-markets

No hedging means leaving the cash inflows completely unhedged while accepting the possible outcomes that the transaction risk may impose. Hedge from forward markets and hedge from option markets mean participating in derivatives markets to purchase forward contracts or options for hedging purposes. And the hedge from money markets means tapping into the bond markets to secure debt denominated in foreign currency for hedging purposes. In spite of the previously presented significant VaR estimates, no hedging approach is still used as a comparable approach when concluding the suitability of the hedging strategies.

7 Forward contract strategy

First hedging strategy for the hypothetical case-analysis is the forward contract-strategy which aims to eliminate the transaction risk to a large extent by setting in exchange rates for the future. When the new sales contracts are signed and they become certain, the company can enter into forward contract agreements in order to prevent variation in future cash flows. By preventing variation in the cash flows, the company can better ensure profit margins and financial predictability, however given that the forward contracts oblige to act accordingly, the company may lose the opportunity to exchange cash flows with more favorable exchange rates.

The following table presents Nordea's indicative forward rates for EUR/USD and EUR/GBP for the upcoming twelve months starting from May 2024. The real applicable forward rates may however differ from the ones presented since forward contracts are traded over-the-counter and thereby are subject to a negotiation. The following indicative forward rates are quoted monthly up to six months, then between three months up to a one year (Nordea, 2024).

Table 6. Nordea's indicative forward rates quoted at 5/2024.

Currency	Time period	Buy	Sell	Currency	Time period	Buy	Sell
USD	SPOT	1.0672	1.0887	GBP	SPOT	0,8516	0,8696
USD	1M	1.0685	1.0901	GBP	1M	0,8525	0,8706
USD	2M	1.0701	1.0901	GBP	2M	0,8535	0,8716
USD	3M	1.0716	1.0931	GBP	3M	0,8545	0,8726
USD	4M	1.0732	1.0948	GBP	4M	0,8555	0,8736
USD	5M	1.0747	1.0963	GBP	5M	0,8565	0,8746
USD	6M	1.0763	1.0979	GBP	6M	0,8575	0,8756
USD	9M	1.0815	1.1031	GBP	9M	0,8607	0,8788
USD	1Y	1.0861	1.1078	GBP	1Y	0,8637	0,8818

Since the cash flows of the company are netted and as a result only cash inflows remain, the currencies concerned need to be sold with forward contracts. Naturally, if the opposite was true, then vice versa. Thereby, as the domestic and operating currency of the company is euro, in order to hedge against the weakening of the US dollar (since the weakening of US dollar decreases the cash inflow amounts in euros) the company must sell US dollars with forward contracts. Assuming that the uncertainty related to EUR/USD continues, the following hedging strategy could be viable for US dollar exposure.

Table 7. Forward contract hedge.

Currency: USD (1000)								
Month	1	2	3	4	5	6	7	8
Cash inflow	15 000	35 000	40 000	45 000	25 000	35 000	50 000	50 000
Forward rate	1.0901	1.0901	1.0931	1.0948	1.0963	1.0979	1.1031	1.1031
Forward contracts	-15 000	-35 000	-40 000	-45 000	-25 000	-35 000	-37 500	-37 500
Hedged position	100 %	100 %	100 %	100 %	100 %	100 %	75 %	75%
Open position	0	0	0	0	0	0	12 500	12 500
Euros	13 760	32 107	36 593	41 103	22 803	31 879	-	-

When the company receives the cashflows at the end of each month it then sells the US dollars for euros with the counterparty according to the forward contract agreements. If the hedged position is 100 % the forward contract covers the whole cashflow amount for the corresponding period, if less, the cashflows are only partially covered. Leaving some open position enables strategy adjustment, for instance according to market conditions, if any drastic developments were to happen.

By looking at the full year 2023 EUR/USD (figure 1) volatility range of 1,04 – 1,12 that represents over 7 % change, and more particularly the developments within the year, we can see that there are periods where US dollar has fluctuated significantly. For instance between the end of February and the early May there has been almost 5 % decrease in value for US dollar. However, on the other hand, between the mid-July and the mid-October, US dollar has strengthened about 6 %. The following table is presented to illustrate the effect on the company's cashflows and the cost or benefit of the forward contracts.

Table 8. Cost/benefit of the forward contract strategy.

Currency: USD (1000)								
Month	1	2	3	4	5	6	7	8
Cash inflow	15 000	35 000	40 000	45 000	25 000	35 000	50 000	50 000
Forward rate	1.0901	1.0901	1.0931	1.0948	1.0963	1.0979	1.1031	1.1031
Simulating spot rate	1.0901	1.0998	1.1153	1.1497	1.1152	1.0890	1.0750	1.0680
In euros	13 760	32 107	36 593	41 103	22 803	31 879	45 623	45 699
Partial hedge effect	0	0	0	0	0	0	296	372
Overall cost/benefit	0	283	728	1 962	385	-260	-888	-1 117

Even though the company can set the cash flows of the first six months to fixed euro amounts (since they are hedged completely) and considering that it costs essentially nothing to enter into the forward contracts, we can see from the table that the cost or benefit from using forward contracts can actually be very significant if the exchange rates prove to be highly volatile. We can see in months three and four when US dollar is

simulated to weaken that using forward contracts start to yield significant benefit. On the other hand going more forward, when the US dollar is simulated to strengthen in months six, seven and eight, the cost of using forward contracts starts to increase significantly. In months seven and eight, however, the overall cost is to a large extent reduced by having open positions converted with the prevailing exchange rate. This highlights the dynamic of forward contracts – when they are used for longer-term hedging, they may become very costly. A similar strategy could be constructed to Pound sterling cashflows however the hedging period could be longer since the volatility of the currency is much lower than in US dollar.

8 Option strategies and the money-market hedge

Another commonly used financial instruments for hedging the transaction risk are options. Options are more complex instruments than forward contracts in terms of pricing and characteristics, however they can be utilized to construct more sophisticated and flexible hedging strategies. Buying an option provides the possibility to buy or sell a certain asset at a certain price before a specified date whereas selling an option creates an obligation to redeem the option contract accordingly until the specified date. As the profit distribution is not binary, the buyer pays premium (price) up front for the option and the seller receives it. Thereby, option hedging typically involves direct transaction costs, however with bought options, the transaction costs are consequently the maximum loss as the exchange of currencies will only take place with the exercise price (option contract) if it is more favorable than the prevailing exchange rate. Hence, the essential characteristics of an option for its buyer are those of risk limitation and unlimited profit potential. Options are also useful instruments for when there is uncertainty over timing of FX cashflows since they can be exercised more freely (Shamah 2004).

8.1 Plain vanilla

In the case of cash inflows, the company needs to use put options in order to hedge against the weakening foreign currencies. Due to the increasing premium costs (options becoming more expensive with longer maturities) option hedging is more viable for short term considerations. To calculate put option prices (based on the B-S-M equation presented in section 5.5) this study uses spot price and exercise price from the table 2 (exercise price being three month sell rate), one-hundred day maturity, annualized volatility from 2023, one-week Euribor as a domestic risk-free interest rate, US treasury rate and SONIA interest rate as foreign risk free interest rates (European Central Bank, 2024, U.S. Department of the Treasury, 2024, Bank of England, 2024).

Consequently, with the given input values, the put option for US dollar is priced at 0.063, and the put option for Pound sterling at 0.034. The three-month strategy will cover the total cash inflow amount from the first three months which can then be either converted with option contracts or with (if more favorable) prevailing exchange rate at the end of month three. The total US dollar amount of 90 000 equals to premium costs of 5 670, and the total Pound sterling amount of 60 000 equals to premium costs of 2 040. Thereby the exercisable amount minus the premium is 77 126 euros from the US dollar, and 66 422 euros from the Pound sterling. The following tables demonstrate the cash flow effect of volatile exchange rates and the value that the put options have in relation.

Table 9. Option hedge for USD.

Currency: USD			
Spot-price	**Without hedging**	**Forward contracts**	**Options**
1,0400	86 538	82 334	81 351
1,0700	84 112	82 334	78 925
1,0931	82 334	82 334	77 126
1,1400	78 947	82 334	77 126
1,1800	76 271	82 334	77 126

Table 10. Option hedge for GBP.

Currency: GBP			
Spot-price	**Without hedging**	**Forward contracts**	**Options**
0,8200	73 170	68 760	70 832
0,8500	70 588	68 760	68 250
0,8726	68 760	68 760	66 422
0,9000	66 666	68 760	66 422
0,9300	64 516	68 760	66 422

The option column of the tables represents the cashflow that the company receives when considering the paid premium of the put options and whether the option is exercised or not. For instance in US dollar, we can see that the exchange rate of 1,14 would convert to 80 357 euros but when the paid premium of the put options is considered, exercising the put options result to a greater cashflow. On the other end of the spectrum we can see that converting the cashflows with the prevailing exchange rates results to a greater cashflow than if the put options were to be exercised. Similarly in Pound sterling, when the put option premiums are considered, exercising the put options result to a greater cashflow when the exchange rate goes above 0,8726. And when less than 0,8500, converting with the prevailing exchange rate results to a greater cashflow.

The put options secure the minimum cashflow amount while still maintaining the possibility to gain from favorable exchange rate movements. But even though the put options start to accumulate value when the foreign currencies depreciate so that the strike price is greater than the prevailing price, the premiums may be very costly and offset the benefits to a large extent. The costs are however very dependent on at what level the minimum cashflow amount is secured. If the strike price is unfavorably further away from the prevailing exchange rate when buying the options, the premiums are consequently much smaller than when the strike price is closer to the prevailing exchange rate.

8.2 Range forward

A range forward strategy, or a collar strategy as it is also often referred as, is a slightly more advanced option strategy than the plain vanilla option strategy. It involves taking two option positions simultaneously – buying one option and selling another option in order to create a range of acceptable exchange rates. If the prevailing exchange rate at maturity is between the created range, the exchange of currencies will take place with the prevailing exchange rate, and if the prevailing exchange rate is outside the created range the exchange of currencies will take place by executing one or the other option depending on which side of the range is exceeded.

A range forward strategy is usually structured so that there is very little or no upfront premium to be paid as the cost of the bought option is less than or equal to the received premium from selling the other option. As a result, the company can take advantage of favorable exchange rate movements up to a predetermined level without necessarily having to bear upfront costs for it. As the maximum profit is limited, the (protective) range forward strategy can be seen as a neutral or slightly bullish strategy against market expectations.

Since the company assumes the previous year's VaR estimates to be reliable indicators for the following year, and since the VaR estimates indicate (with 99,5 confidence level) that there may be a 13,7 % maximum loss of value in USD, and a 10 % maximum loss of value in GBP, the company wants to construct an alternative hedging strategy where cash inflows do not depreciate more than 5 % in the first three months.

Therefore, the company will construct a 90-day range forward strategy with a 5 % lower and upper limitations creating the exchange rate range of 1,147 - 1,038 for US dollar, and the exchange rate range of 0,916 - 0,8238 for Pound sterling. Consequently, by using these limits as strike prices and the other same input values used in the plain vanilla option strategy, the US dollar put option with a strike price of 1,147 would cost 0,093 and the premium received from the call option with a strike price of 1,038 would

be 0,088 the net cost being 0,005. Similarly, the Pound sterling put option with a strike price of 0,916 would cost 0,06 and the premium received from the call option with a strike price of 0,8238 would be 0,057 the net cost being 0,003. Therefore, the premium cost for the US dollar strategy would be 90 000 x 0,005 = 450, and the premium cost for the Pound sterling strategy 60 000 x 0,003 = 180. Furthermore, considering the premium costs, the limits convert to possible ranges of 78 073 - 86 271 euros for US dollar, and 65 305 – 72 614 euros for Pound sterling.

Table 11. Range forward strategy for USD.

Currency: USD			
Spot-price	**Without hedging**	**Forward contracts**	**Options**
1,0150	88 669	82 334	86 271
1,0380	86 705	82 334	86 271
1,0931	82 334	82 334	81 884
1,1470	78 465	82 334	78 073
1,1800	76 271	82 334	78 073

Table 12. Range forward strategy for GBP.

Currency: GBP			
Spot-price	**Without hedging**	**Forward contracts**	**Options**
0,8000	75 000	68 760	72 396
0,8238	72 833	68 760	72 396
0,8726	68 760	68 760	68 553
0,9160	65 502	68 760	65 322
0,9400	63 829	68 760	65 305

Again, the option column of the tables represents the cashflow that the company receives when considering the net cost (premium) of the options and whether the options are exercised or not. Upon expiry, if the spot rate is below the bought put option's strike price the company sells the currency with the put option strike price, and if the spot price is above the strike price of the sold call option the company sells currency with the call option strike price. If the spot price is between these strike prices, the company sells currencies with the prevailing exchange rate.

Given the very low (net) cost of the combined options, the offsetting effect of the premiums to the cashflows is very small and therefore the strategy does not require extensive fluctuation in exchange rates to become beneficial. However, the upside potential is limited to the strike price of the call option thereby further positive developments in the exchange rates cannot be utilized as the spot prices (1,015 and 0,800) that exceed the call option strike prices demonstrate.

8.3 Money-market hedge

By exploiting the covered interest rate parity condition (interest rate differential), a money-market hedge can be constructed to create a "synthetic" forward rate for hedging the FX transaction risk. More specifically, by exploiting money-markets to borrow foreign or domestic currency in an amount equivalent to the present value of the cash inflow or outflow and lending it to the opposite currency. As the company needs to secure its cash inflows, it needs to borrow the foreign currency discounted with the interest rate, convert the debt into domestic currency with the prevailing exchange rate, then place the converted debt on a deposit with the domestic interest rate, and when the cash inflow occurs, repay the foreign currency debt plus the interest (Bash et al. 2016). Effectively, a three-month money-market hedge could be constructed for the company with the following input values.

Table 13. Inputs for a money-market hedge.

Currency: USD	
Spot-rate	1,0887
3-month Forward rate	1,0931
3-month US Treasury rate	5,25 %
3-month Euribor	3,82 %
Cash inflow	90 000

As the company is able to get a 1,31 % (adjusted for the period) interest rate for the three months it needs to borrow 88 836 US dollars, convert it with the spot-rate of 1,0887 (to 81 598 euros), and "deposit" it to an account which receives the interest income of 0,96 % in the three months (resulting to 82 377 US dollars). Consequently, by constructing a money market hedge with the given inputs, the company would get an implied 3-month forward rate of 1,0925 which is slightly better than the Nordea's indicative 3-month forward rate of 1,0931. The three month US dollar amount would then convert to 82 379 euros.

A money-market hedge, although being slightly more complicated (due to its number of steps) than a forward contract, can be an effective alternative hedging method for FX transaction risk. Especially for smaller companies that may not have access, or at least to competitive pricing in FX forward markets, or for currencies where forward contracts are not very available. The construction of a money-market hedge may however be cumbersome, and the rates may also significantly negatively differ from the actual rates or the ones that are used to price forward contracts.

9 Conclusions

Since the current floating exchange rate regime was instituted, the international FX market has developed towards liberalization, and as the World continues to globalize multinational companies are increasingly exposed to the significant consequences of constantly fluctuating exchange rates. As a result, FX risk has become one of the most meaningful risks for multinational companies and consequently has highlighted the importance of FX risk management. Financial managers that oversee FX risk management practices in multinational companies must have a broad understanding of exchange rates and their possible influence over the companies' operations in order to implement reasonable and efficient risk mitigation strategies.

This study's objectives were to demonstrate how significant FX transaction risk is for a (hypothetical) multinational company and to compare various external hedging methods and their suitability for the transaction risk management. By doing so, this study has contributed to the extensive literature around currency risk management which has many connecting points to the broader literature in finance and economics. The calculated VaR-values have provided recent evidence that the transaction risk is (remains as) a significant risk for multinational companies even under presumed normal market conditions. For example, the 90-day US dollar VaR (based on 2023) with a 99 % confidence level indicates over 10 % possible loss of value in the cash inflows for the period. Out of the hedging strategies the forward contract strategy emerges as a more suitable short-term strategy due to the characteristics. An intuitive and easy to understand and implement, highly effective and includes very little initial costs if the forward rates are quoted to an established and large company that frequently uses forward contracts. But since there is no possibility to benefit from favorable exchange rate movements with forward contracts, the strategy might turn out to be costly in retrospect.

The suitability of external hedging methods depends greatly on the company's risk management objectives. If companies want to incorporate speculative views on macroeconomic outlooks, currencies, in their risk management strategies they need to consider more complex risk management strategies. Then, specifically options come into use. The financial managers must then have a deeper understanding of the hedging instruments given the more complex characteristics and associated costs. Out of the option risk management strategies, the range-forward strategy also emerges as highly suitable for the short-term FX transaction risk hedging. It falls between the forward and the plain vanilla option strategies as it has characteristics from both strategies – the cost of the forward strategy and the (limited) upside potential of the option strategy. The cost especially is a very important factor when comparing the usefulness of the strategies. In the plain vanilla option strategy the initial cost can "push" the breakeven point quite far so that in order to concretely benefit from the upside aspect the currency must fluctuate extensively. Thereby, lowering the initial cost brings down the break-even point, making it easier to capitalize on the strategy even though the benefit might be limited to a certain level.

10 References

Aggarwal, R. & Harper, J.,T. (2010). “Foreign exchange exposure of domestic corporations” *Journal of International Money and Finance*. 29. 1619-1636.

Akhtekhane, S., S. & Mohammadi, P. (2012). ”Measuring Exchange Rate Fluctuations Risk Using the Value-at-Risk”. *Journal of Applied Finance & Banking*. Vol 2 (3), 65-79.

Alexander, C. & Choudry, M. (2013) “An introduction to Value- At- Risk” John Wiley & Sons, Incorporated 2013. 30-32.

Bank of England. (2024). SONIA interest rate benchmark for sterling markets. Available at https://www.bankofengland.co.uk/markets/sonia-benchmark

Bash, A., Awadhi, A. & AlAli, M., S. (2016). “The effectiveness of financial hedging techniques: a Gulf Cooperation Council perspective”. *International Journal of Accounting and Finance*. 6(3). 219.

Bi, J. & Zhu, Y. (2020) “Value at risk, cross- sectional returns and the role of investor sentiment”. *Journal of Empirical Finance*. 56, 1-18.

Black, F. & Scholes, M. (1973), “The valuation of options and corporate liabilities”, Journal of Political Economy 81, 637-654.

Black, F. (1995) “Universal Hedging: Optimizing Currency Risk and Reward in International Equity Portfolios”. *Financial Analysts Journal*. 161.

Bodnar, G., M. & Gebhardt, G. (1999). “Derivatives usage in risk management by US and German non-financial firms: A comparative survey”. *Journal of International Finance and Management Accounting*. Vol 10. 153-187.

Eiteman, D. K., Stonehill, A. I. & Moffett, M. H. (2013) “Multinational Business Finance”. Pearson Education, Incorporation 2013. 303-307.

European Central Bank. (2024). EUR/GBP currency data. Available at https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-gbp.en.html

European Central Bank. (2024). EUR/USD currency data. Available at https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html

European Central Bank. (2024). Key ECB interest rates. Available at https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html

Glaum, M. (2002). “The Determinants of Selective Exchange Risk Management – Evidence from German Non-Financial Corporations”. *Journal of Applied Corporate Finance*. 14 (4).

Gregory, J. (2015). “The XVA Challenge: Counterparty Credit Risk, Funding, Collateral and Capital”. John Wiley & Sons, Incorporated. 57.

Hasselgren, A., Peltomäki, J. & Graham, M. (2020). ”Speculator activity and the cross-asset predictability of FX returns”. *International Review of Financial Analysis*. 72

Hatem, G., Zeidan, J., Goossens, M. & Moreira, C. (2022). “Normality Testing Methods and the Importance of Skewness and Kurtosis in Statistical Analysis”. *BAU Journal – Science and Technology*. Vol 3 (2).

Hull, J. (2024). “Options, Futures, and Other Derivatives, Ebook [Global Edition]. Pearson Education 2022.

Hutcheson, T. (2003). “Exchange Rate Movements as Explained by Dealers” *Economic Papers*, Vol 22 (3), 35-46

Iqbal, A. S. (2018), “Volatility”. John Wiley & Sons, Incorporated 2018. 23.

Kim, W. & Sung, T. (2005) “What makes firms manage FX risk?” *Emerging Markets Review*, 6, 264.

Lievenbruck, M. & Schmid, T. (2014). “Why do firms (not) hedge? – Novel evidence on cultural influence”. *Journal of Corporate Finance*. Vol 25. 92-106.

Marshall, A.P. (2000), “Foreign exchange risk management in UK, USA and Asia Pacific multinational companies”. *Journal of Multinational Financial Management*. 10, 186-208.

Merton, R. C. (1973) “Theory of rational option pricing”, *The Bell Journal of economics and management science*. 141-183.

Neely, C.J. & Dey, S.R. (2010) “A Survey of Announcement Effects on Foreign Returns” *Federal Reserve Bank of St. Louis Review*, 92(5), 417-463

Nobanee, H. et al. (2022). ”Bibliometric Analysis of Foreign Exchange Risk” *Journal of Governance and Regulation*. 11(1).

Nordea (2024). Forward rates for the upcoming twelve months. Available at https://pankki.nordea.fi/tietoa-nordeasta/tietoa-nordeasta/valuuttakurssilistat.flex#tab=Termiinikurssit

O'Brien, T. (2017). "Applied International Finance 1: Managing Foreign Exchange Risk, Second Edition". Business Expert Press.

Poniachek, H.,A. (2012). "International Corporate Finance: Markets, Transactions and Financial Management". Taylor & Francis Group. 273.

Pramborg, B. (2005). "Foreign exchange risk management by Swedish and Korean nonfinancial firms: A comparative survey". *Pacific-Basin Finance Journal*. Vol 13. 343-366.

Pugel, T., A. 2004. "International Economics" Twelfth Edition. New York, USA: Mcgraw – Hill. 455-458.

Sah, N., Banerjee, A., Malm, J. & More, D. G. (2022). "A risky affair: Dual class and FX hedging". *Finance Research Letters*. Vol 47.

Shamah, S. (2004). "A Currency Options Primer". John Wiley & Sons, Incorporated. 39

Shapiro, A., C. 1996. "Multinational Financial Management". Fifth Edition. USA: Prentice-Hall. 204-209

Timmer, Y., Hoffman, P., Langfield, S. & Hau, H. (2022). "Why many firms get a bad deal when hedging currency risk". VoxEU- CEPR available at https://cepr.org/voxeu/columns/why-many-firms-get-bad-deal-when-hedging-currency-risk

U.S. Department of the Treasury. (2024). Treasury Bill Rates. Available at https://home.treasury.gov/resource-center/data-chart-center/interest-rates/TextView?type=daily_treasury_bill_rates&field_tdr_date_value_month=202406

Yu, X., Wan, Z., Tu, X. & Li, Y. (2020), ”The optimal multiperiod hedging model of currency futures and options with exponential utility”, *Journal of Computational and Applied Mathematics*. 366, 1-12.

11 Appendices

Appendix 1. FX transaction risk emphasis.

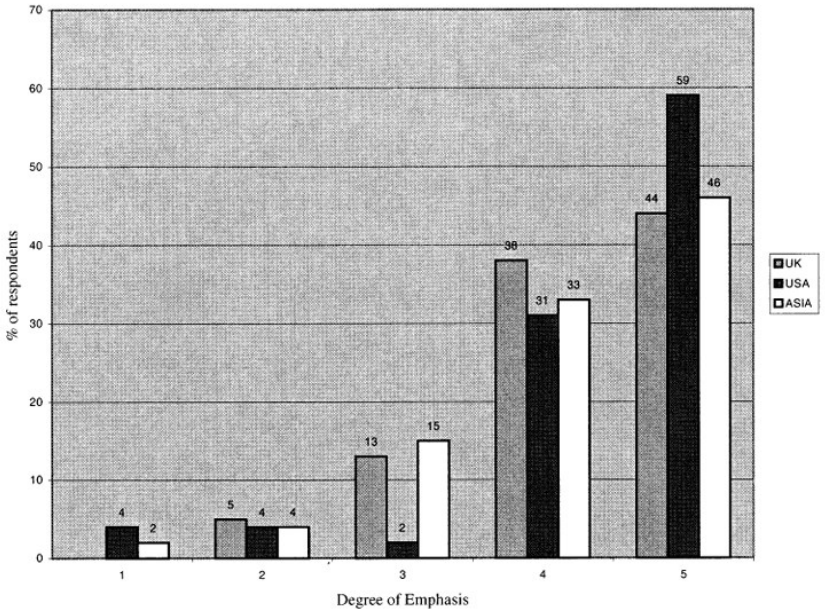

Fig. 3. Emphasis on transaction risk. 1, least important; 5, most important.

Appendix 2. The popularity of hedging instruments for managing FX transaction risk.

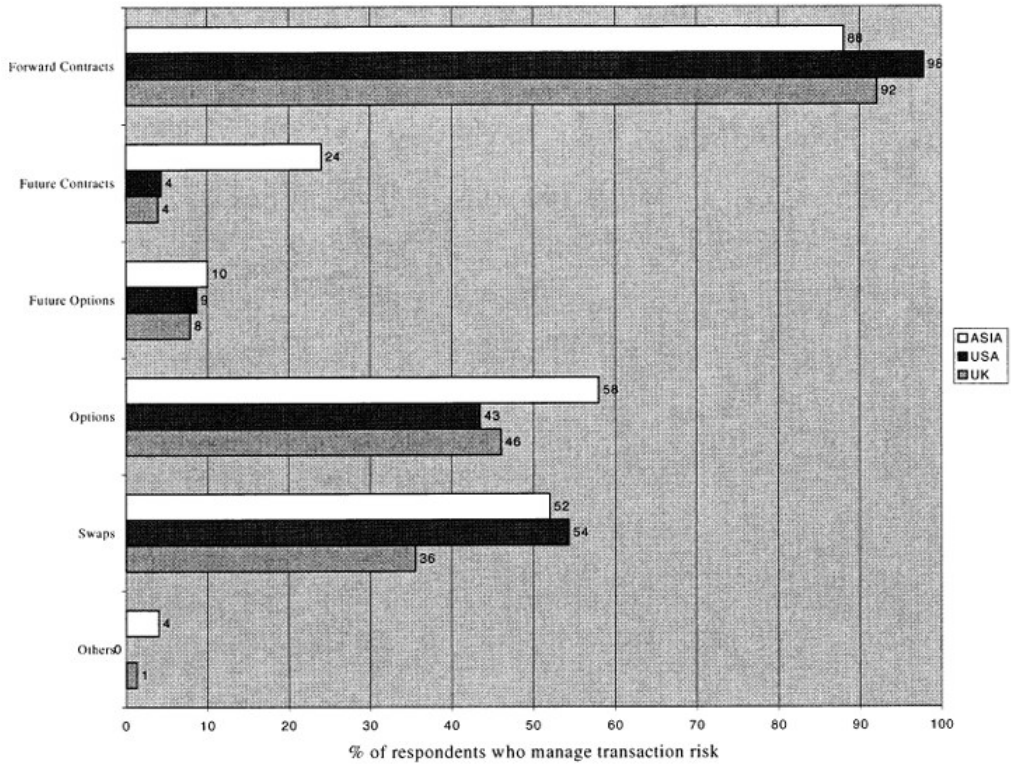

Fig. 7. External methods used for managing transaction risk. Respondents could choose more than one method.

Appendix 3. Price spread between non-financial clients in the FX derivatives market.