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Working Paper

Corporate FX hedging: An introduction for the corporate treasury

Frankfurt School - Working Paper Series, No. 233

Provided in Cooperation with:

Frankfurt School of Finance and Management

Suggested Citation: Heidorn, Thomas; Pavicic, Tim; Sieber, Antje (2022) : Corporate FX hedging: An introduction for the corporate treasury, Frankfurt School - Working Paper Series, No. 233, Frankfurt School of Finance & Management, Frankfurt a. M.

This Version is available at:

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Frankfurt School – Working Paper Series

No. 233

Corporate FX Hedging

An Introduction for the
Corporate Treasury

by Thomas Heidorn, Tim Pavicic, Antje Sieber,

November 2022



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Abstract

FX rates are increasingly volatile in recent macroeconomic and geopolitical times of uncertainty. FX risk if not dealt with properly can pose existential threats to companies. Especially fast-growing companies, that have previously not hedged FX risks due to insignificance, need to build up a proper FX risk management. This working paper delivers a comprehensive guide on FX hedging for small and medium enterprises. It should help a treasurer to setup and/or improve their FX hedging approach. The goal of this paper is to provide a treasurer with the necessary tools and knowledge to manage and hedge his company's FX exposure. The paper provides insights on the practical implementation, regulatory framework, and accounting perspective of an FX risk management.

Key words:

Corporate Treasury

Risk management

Corporate hedging

FX hedging

Foreign currency risk

JEL classification: G11, G24, G32, Q56

ISSN: 14369753

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List of abbreviations

BaFin – Bundesaufsicht für Finanzdienstleistungen

BFIXFFT1400 – Bloomberg fixing at 14:00 (Frankfurt time)

CAD – Canadian dollar

CCY – Foreign currency

CEO – Chief executive officer

CIP – Covered interest parity

CNH - Chinese Yuan Renminbi (offshore see 2.2.4)

CNY - Chinese Yuan Renminbi (onshore see 2.2.4)

COV – Covariance

e - Exponentialfunktion

EBIT – Earnings before interest and taxes

EBITDA – Earnings before interest, taxes, depreciation, and amortization

EMIR - Market Infrastructure Regulation

ERP – Enterprise resource planning

ETF – Exchange Traded Fund

EU – European Union

EUR – Euro

F – Forward rate

FED - Federal Reserve System

FX – Foreign exchange

GBP – British pound sterling

HGB – Handelsgesetzbuch

HKD – Hong Kong Dollar

HR – Hedge ratio

IFRS – International financial reporting standards

INR – Indian rupee

KID – Key information document

LEI – Legal entity identifier

ln – natural logarithm

MiFID - Markets in Financial Instruments Directive

MSCI – Morgan Stanley Capital International

n – Number of observations

$N(x)$ – Cumulative normal distribution

NDF – Non deliverable forward

NDO – Non deliverable option

OIS – Overnight index Swap

p.a. – per annum

r_{base} – Interest rate of base currency p.a.

r_{quoted} – Interest rate of quoted currency p.a.

SOFR - Secured Overnight Financing Rate

T – years until maturity

TARF – Target redemption forward

TPF – Target profit forward

US – United States

USD – United States dollar

VaR – Value at risk

w – Weights vector

WpHG – Wertpapierhandelsgesetz

X – Strike

z – Z-score

α – Alpha (confidence level for value at risk)

σ - Standard Deviation

σ_p – Portfolio volatility

σ^2 - Variance

Σ - Variance-covariance matrix

μ - Mean return

1 Introduction

“If we would not have used futures and options during the last 30 years our currency proceeds would have been identical. But during this period, we would have become bankrupt three times.” (Priermeier, 2005, p. 5). This was said by Dr. Wendelin Wiedeking at the annual shareholder meeting of Dr. Ing. h.c. F. Porsche AG in 1997, while he was the CEO. In this quote Wiedeking describes two opposing characteristics of FX risk from a company perspective. On the one hand, when looking at currency proceeds of a company over longer periods it seems like there is little to no difference between hedging FX exposure and leaving the exposure unhedged.¹ On the other hand, short-term fluctuations in FX rates can cause significant damage and in extreme cases drive a company into bankruptcy. While a private investor might tolerate huge short-term volatility in his investment due to his investment horizon, the opposite is true for companies. Corporates want to ensure that their financial performance depends on their operating business and is not highly influenced by short-term fluctuations in FX rates.

1.1 Motivation and Objectives

When comparing exports and imports in the German foreign exchange the importance of FX hedging becomes clear. In 2020 Germany exported goods worth 1.205 trillion EUR and imported goods worth 1.026 billion EUR. A fraction of 63.4% of exports and 63.6% of imports by German companies have been traded with countries that have not adopted the EUR as functional currency (Statistisches Bundesamt, 2020, pp. 26-34). Overall, 43% of the German imports and exports are traded in foreign currency, creating exposure to FX volatility (Schmidt, 2020). In accordance with this, more than 50% of treasurers in Deloitte’s global treasury survey view FX volatility as one of the most important strategic challenges for their company (Cameron and Winther, 2019, p. 7).

The goal of this paper is to provide a treasurer with the necessary tools and knowledge to manage and hedge his company’s FX exposure. The paper will help small and medium-sized companies to set up and/or improve their FX hedging approach.

1.2 Analysis approach

The paper starts with an introduction to Foreign Exchange (FX) markets. The next chapter explains how to handle FX risk. First, the general setup of a treasury considering FX risk management will be discussed. Then approaches on how to identify, quantify, and mitigate FX risk will be analyzed, and the evaluation of hedging strategies is introduced. The next chapter considers the practical implementation of FX risk management. This chapter looks at the regulatory requirements German corporates need to meet to execute FX hedging products/strategies. Furthermore, it compares and evaluates voice and

¹ While this holds for the major currency pairs and Porsche as a German company was mostly exposed to USD exposure one must keep in mind that this does not hold every currency pair.

electronic execution possibilities of hedging products and shows automatization possibilities. The next part summarizes the accounting aspects of FX hedges linked to their respective cash flows according to German (HGB) and international accounting standards (IFRS). The final chapter concludes and summarizes the findings.

2 Introduction to Foreign Exchange (FX) markets

When a German exporter sells machines to a US-company, either the US-company or the German exporter will pay/receive foreign currency. In this case the German exporter needs to exchange USD for EUR (sell USD). In theory, he would need to find a German or European importer who would be willing to buy the exact received USD amount. Since this search would be inconvenient and time consuming the foreign exchange market (FX market) acts as an intermediary to match buyers and sellers of foreign currencies. Nowadays the FX market can be viewed as an electronic network of interlinked banks and FX brokers, who determine prices and settle FX trades among buyers and sellers of foreign currency. Almost 95% of worldwide currency transactions are traded via the interbank wholesale market (Shapiro, 2014, p. 257).

The foreign exchange market can be divided into the spot and the forward market. While in the spot market currencies are traded with a delivery of up to two business days, in the forward market the delivery can be set to an individual future date. In 2019 each day on average a volume of 6,595,471 million USD of FX instruments was traded in the FX market (Bank for International Settlements, 2019). Only 5% of this volume accounts for export and import activities, the remaining 95% relate to cross-border purchases of assets (international capital flows) and trading activity by financial institutions (Shapiro, 2014, p. 257).

Due to the nature of the market, one must understand that there is no single FX market, but rather an interlinked network of participants who function as market makers. Therefore, there is no single exchange traded price for currencies on the spot and forward market. Quotes of market makers might be slightly different, but still close to each other due to electronic linkage among the market makers and participants in the market.

2.1 Price quotation in the FX market

When examining FX quotations e.g., 1.1400 EURUSD the first currency is called the base currency (sometimes also domestic currency) and the second mentioned currency is the quote/accounting currency (sometimes also foreign currency). Domestic/Foreign is not related to the location of the trader, it rather defines the numeraire currency. Hence a EURUSD quote measures the worthiness of 1 EUR in USD. Therefore, the first currency is the one which is traded; and it is measured in the second currency.

A quote of 1.1400 EURUSD or EUR/USD means that 1 EUR (trade EUR) is worth 1.1400 USD (measure in USD). It is also possible to use a quotation of 0.8772 USDEUR, this implies that 1 USD is worth 0.8772 EUR. A EURUSD rate can be transformed into a USDEUR rate by calculating the reciprocal (Wystup, 2008, p. 10). It is important to understand that in the FX market the slash in between EUR/USD has no mathematical meaning as a fraction line, but rather just functions as a separation between two currencies.

Like in other capital markets there is a bid and an offer price (sometimes also called ask quote) in FX markets. Suppose in the interbank market a bid and an offer price would be quoted. This means that a bank would be willing to sell USD to the counterpart for the bid quote of 1.1400 EURUSD and buy USD for 1.1401 EURUSD. The bank would profit from the bid-offer spread in this case 0.0001. The middle 1.14005 EURUSD is called the mid-price (Shapiro, 2014, p. 265).

EURUSD – Spot Price	
Bid 1.1400	Offer 1.1401

Figure 1: FX price quotation

A company who wants to buy an USD amount against EUR is trading on the bid quote, while it can sell USD for the offer quote. Usually, compared to the interbank market a company will pay additional mark-up for a FX trade. Consequently, the interbank bid quote will be reduced (offer quote will be increased) by a pre-agreed percentage of the interbank quote or a fixed amount in Pips. 1 Pip equals 1 0.0001 EUR/USD and 100 Pips are called 1 big figure (0.0100 EUR/USD).²

EURUSD – Spot Price	
Bid 1.1390	Offer 1.1411

Figure 2: FX price quotation with additional mark-up

² There are exceptions like the JPY where 1 pip equals the second decimal place past the decimal point.

When comparing Figure 1 and Figure 2 the difference between an interbank quote and a quote for a corporate client becomes visible. In this example the company agreed on a cost of 10 Pips per trade with its bank. Normally, there is no additional fee for FX trades because the transaction cost/fee will already be included in the FX rate that is dealt to a company. In this above example a trade of buying 1,000,000 USD against EUR would include a mark-up of $\frac{1,000,000 \text{ USD}}{1.1390 \text{ EURUSD}} - \frac{1,000,000 \text{ USD}}{1.1400 \text{ EURUSD}} = 770.14 \text{ EUR}$.

2.2 Different currency types

In general, currencies can be categorized into free floating currencies, pegged currencies, and restricted currencies. Currency restrictions/regulations are subject to frequent changes. Therefore, it is necessary to check which regulations apply before entering a new market or signing contracts, which are denominated in foreign currency. It is recommended to discuss this topic with the banks FX sales representative even if sufficient information can be found online, as he can give practical insights on how to deal with exotic currency types.

2.2.1 Free-floating currencies

The exchange rate of a free-floating currency or convertible currency is determined by supply and demand for the currency in FX markets. Free floating currencies can be traded and held offshore without any restrictions (International Monetary Fund, 2004). Examples for free floating currencies are EUR, USD, or GBP.

2.2.2 Pegged currencies

Pegged currencies are currencies, which exchange rate is fixed against another currency. This might encourage trade and foreign investments because it ensures predictability of exchange rates, thereby facilitating long-term business planning for foreigners. The peg can be announced and controlled by a currency board or the central bank at a fixed rate or within marginal deviations of e.g., 1-2% around the pegged rate (International Monetary Fund, 2004). This means that a pegged currency behaves almost identical as the currency it is pegged to. An example for a pegged currency is the Hong Kong dollar (HKD), which is pegged against the USD in a range of 7.75 - 7.85 USD/HKD. The Hong Kong monetary authority (HKMA) intervenes in the market to maintain the peg (Sin, 2020).

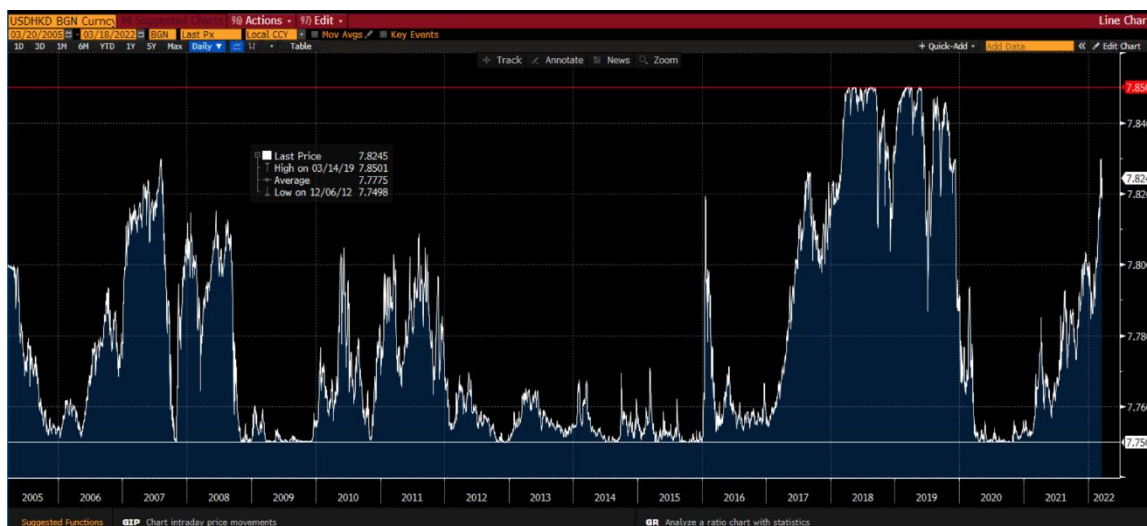


Figure 3: USD/HKD as an example for a pegged currency (Bloomberg, 2022c)

However, the risk that a central bank can't sustain the peg or suddenly removes the peg always remains and should be considered in hedging decisions. Until the Asian crisis of 1997 some Asian currencies like the Thai baht, the Malaysian ringgit, the Indonesian rupiah, and the Philippines peso were pegged against the USD. During the crisis it became increasingly difficult for the respective central banks to maintain their currency pegs, leading to massive depreciation of the respective currencies against the USD and to a removal of the currency pegs (Ito et al, 1998, pp. 257-258). Another example for an unexpected peg removal is the removal of the CHF peg to the EUR by the Swiss central bank (for further details see Figure 7 and Lleo and Ziemba, 2015).

2.2.3 Restricted currencies

Another currency type are restricted currencies. Some countries choose to apply currency restrictions to prevent uncontrolled depreciation and volatility of their home currency, while limiting the country's capabilities to participate in international trade. An additional reason for restrictions might be to limit flight of capital to offshore locations. Such regulations might include prohibition for residents to exchange or to possess foreign currency, limited access to foreign currencies through government-controlled exchange offices, limitations on foreign currency volume that can be imported or exported and/or documentation obligations when engaging in FX trades (DBS Bank, 2020).

The most extreme case of restricted currencies are non-convertible currencies. Those currencies can only be used for domestic transactions and are not freely traded on the global FX markets. Usually, it is only possible to get access to such currencies through subsidiaries or partners that are present onshore. Examples for non-convertible currencies are the Brazilian real (BRL) and the Indian rupee (INR). Both currencies can't be transferred outside of their respective country (BNP Paribas, n.d.). For hedging such

currencies, it is possible to use products like a non-deliverable forward (NDF) or a non-deliverable option (NDO).

2.2.4 Special case CNY and CNH (Chinese Currency)

China uses a dual exchange rate system. Thereby, Chinese currency that is traded in China is specified as CNY (onshore Chinese Yuan Renminbi) and Chinese currency that is traded outside China is specified as CNH (offshore Chinese Yuan Renminbi). While CNY is a restricted currency CNH is a free-floating currency. Consequently, each currency has its own exchange rate. This does not mean that two different Chinese currencies are in circulation, the different abbreviations are just used to differentiate between the markets where the currency is traded. China guarantees all importers and exporters to exchange CNH transferred to China into CNY at a 1:1 ratio. Consequently, if a German company needs to pay for Imports from China in Renminbi it will pay in CNH, and it will receive CNH for exports to China. However, some banks offer access to the onshore Chinese market. Here stricter regulations apply and transfers in CNY must be documented accordingly. Trade related transactions as opposed to speculative transactions are approved regularly (Sperling, 2022). If a company conducts regular business in China, it should consider using a bank with onshore Renminbi capabilities to profit from potentially better prices.

$$\text{Renminbi pricing differential} = \text{EUR/CNY} - \text{EUR/CNH}$$

Equation 1: Pricing differential onshore/offshore

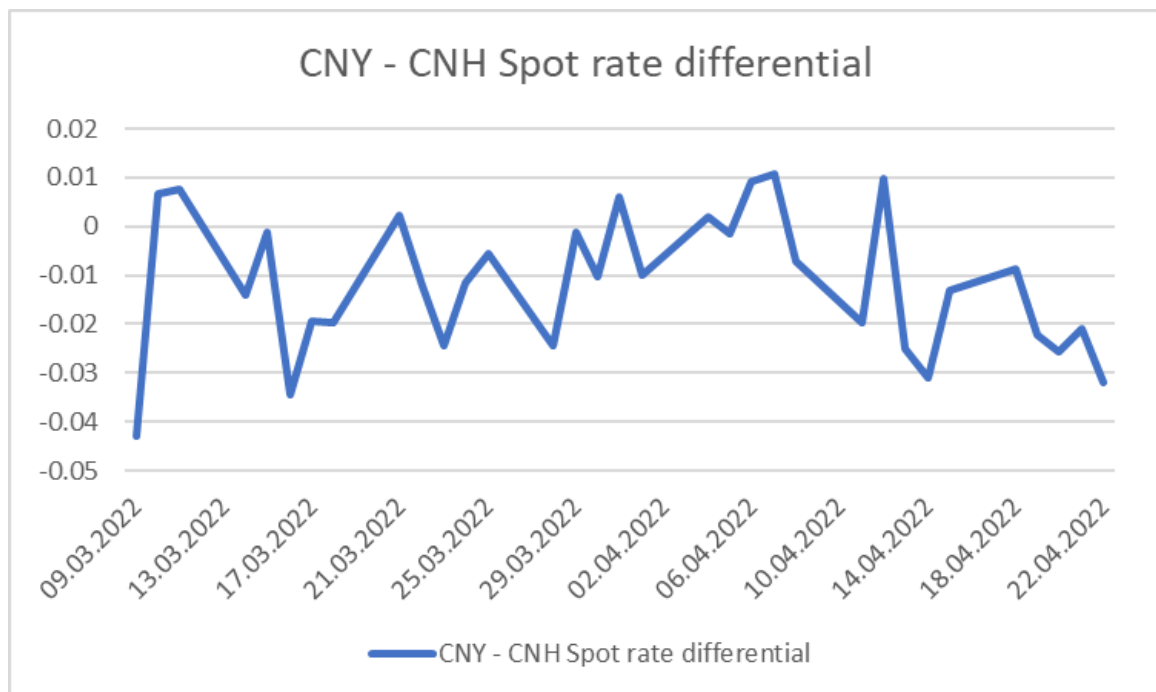


Figure 4: Price differential between CNY and CNH (Bloomberg, 2022i)

While the pricing differential is rather small a company selling an amount of just 7,000,000 Renminbi could have saved $\frac{7,000,000 \text{ CNY}}{6.9606 \text{ EUR/CNY}} - \frac{7,000,000 \text{ CNH}}{7.0034 \text{ EUR/CNH}} = 6,145.91 \text{ EUR}$ on the 09.03.2022 if the company would have traded on the onshore market instead of the offshore market. In the following, CNY will be used interchangeably with CNH. However, a company conducting business in Renminbi that is set up for onshore trading should always monitor the onshore and offshore spot rate and forward rate to decide in which market to trade.

3 FX risk management

In this chapter the process of managing FX risk will be examined. The process can be divided into four main tasks. *3.2 Identifying FX risk, 3.3 Measuring and quantifying FX risk, 3.4 Mitigating FX risk, and 3.5 Performance assessment of FX hedging.* The risk management process will be discussed for a German company whose functional currency is EUR.

FX risk can be divided into three different types:

1. Transaction exposure
2. Translation exposure
3. Operating exposure

Transaction exposure describes the effect that changes in exchange rates have on cash flows, return, and cost of a company for a given sales volume. It measures the FX exposure from the inception until the maturity of an existing financial contract.

Translation exposure is sometimes also called accounting exposure. It describes the effect that changes in exchange rates can have on the value of a firm's consolidated balance sheet and profit and loss statement.

Operating exposure quantifies the impact of a change in exchange rates on a company's potential future cash flows with uncertain notional and its long-term competitive position (McCarthy, 2016, p. 118; Shapiro, 2014, p. 337).

Those three exposures impact a company's capital and earnings and therefore must be considered by a company's treasury when managing FX risk.

3.1 Centralized and decentralized FX hedging

A centralized FX hedging setup means that the aggregated FX exposure of a company is hedged on group level. In contrast a decentralized FX hedging setup holds each subsidiary responsible for hedging

their own FX risk. While the setup of a centralized treasury/FX hedging setup is complex and requires a lot of coordination, it can improve hedging results. A centralized treasury can take advantage of natural offsets before hedging the remaining exposure. This allows companies to reduce the overall hedging cost and optimize their hedging strategy. (Kambil and Calabro, 2016, p. 1).

When comparing a decentralized and centralized treasury in a simplified setting, it can be shown that a centralized treasury improves hedging efficiency and in comparison, reduces FX induced volatility in the profit and loss statement. In this simplified setting Walters (2022) compared a decentralized treasury, where each transactional FX exposure is managed on subsidiary level, to a centralized treasury and an approach where FX exposure remains unhedged. Walters (2022) showed by using a Monte-Carlo simulation that the centralized treasury fixed the EBITDA at an expected value (reducing FX induced EBITDA volatility to zero). Furthermore, he showed that leaving the FX exposure unhedged delivered lower FX induced EBITDA volatility compared to a decentralized treasury that hedges transactional FX exposure on subsidiary level (Walters, 2022). It is important to note that in practice FX induced EBITDA volatility can't be reduced to zero, since forecasts are not 100% accurate. While FX exposure for the viewed risk horizon is reduced, operating (strategic) FX exposure in future periods remains. The centralized treasury will always reduce FX induced EBITDA volatility more than a decentralized hedging approach. However, the second finding is not always true. Depending on the FX exposure, volatility of the unhedged strategy could be higher than the decentralized hedge. In fact, the more offsetting exposure (natural hedge potential) exists on group level the higher the FX induced volatility on EBITDA of a company using a decentralized treasury compared to an unhedged approach.

Banks and FX brokers normally adjust their FX trading costs according to the FX volume they trade with a client during a year. The higher the volume the better the trading conditions for the client. Therefore, the hedging costs for a centralized treasury are further reduced, because of the increased FX volume from the company's subsidiaries. Compared to other countries (e.g., USA, UK, and China), hedging costs in Germany are comparatively low, which again speaks in favor of centralized FX hedging for German companies. Another cost argument are capabilities and knowledge, which are required for FX hedging. If those capabilities are pooled in a centralized treasury as center of competence, costs are further decreased (Seethaler and Steitz, 2007, p. 351).

Because of the above-mentioned advantages of centralized treasuries, chapter 3.2 *Identifying FX risk* discusses the FX risk identification process from a centralized FX hedging perspective. However, the discussed techniques can also be used on single entity level by each decentralized treasury.

3.2 Identifying FX risk

In the following it will be discussed how to identify the three different types of FX risk.

Translation exposure results from held assets that are denominated in a foreign currency. Most of the time this exposure occurs due to foreign subsidiaries of a company. In the consolidated statements the held assets need to be converted into the company's functional currency, which, depending on the underlying FX rates, can create volatility in the balance sheet and income statement. Translation exposure can be identified by summing up the held assets in foreign currency for each currency (Seethaler and Steitz, 2007, pp. 345-346).

Transaction exposure normally stems from contracts (transactions) denominated in foreign currency. But there is also indirect transaction exposure, when the company buys commodities, which are usually priced in USD. If e.g., a German company buys oil for production, where a price with the supplier is agreed in EUR, the company is still exposed to a stronger USD rate. Since oil is traded in USD, the EUR price of oil will increase accordingly if the USD appreciates against the EUR (Kastner, 2018, p. 281; Lester, 2010).

First, the company needs to make sure that it has a reliable forecast for future cash flows. Secondly, based on the forecast the company needs to determine which part of imports and exports are exposed to foreign currency risk. Thirdly, the company needs to monitor which currencies are involved in business and which currencies account for which portion of the overall cash flows.

For some currencies cash inflows and outflows can be netted against each other, thereby creating a natural hedge. As an example, the German company could import raw materials from China, for which it will pay an agreed amount in USD, while it simultaneously sells finished goods to American clients for which it will receive USD. Since the USD the company receives from its exports can be used to pay for the company's imports, no FX hedging is necessary (if both payments occur at the same time). If there is a time lag in between the receiving and paying of the USD amounts, it is possible to use FX Swaps or term deposits to optimize cash flows and FX hedging.

The identification of operating exposure is like the identification of transaction exposure. Here, additionally long-term forecasts need to be considered. It is important to keep in mind that even EUR denominated transactions can be exposed to currency risk. Although the German company can agree with US-American clients to be paid in EUR for its exported goods, the pricing of the transaction will be based on USD terms converted at the current EURUSD rate. Hence, there is no short-term transactional risk for the German company, but the company's sales are exposed to the long-term development of the EURUSD. Foreign competitors could undercut prices and snatch market share from the German company, if their currency weakened compared to the EUR. Consequently, the revenue of

a company might decrease with a stronger EUR, even if the company has no revenue that is denominated in foreign currency (Kastner, 2018, p. 281; Walters 2021).

The focus in the following will be on identifying transactional FX risks, since translation and operating exposure are mostly part of a company's strategy and managed by the management board rather than the treasury.

One of the main parts of identifying FX risk is the risk horizon. When setting a risk horizon, a company identifies until which point in time it can pass on FX rate movements to its customers via increased prices for its products. Only fixed prices that can't be changed are relevant for the risk horizon. The risk of an expected cash flow begins when the sales price of a product is fixed and ends when the cash flow occurs and is converted in functional currency. If a company fixes price lists every year that are valid for one year, the risk horizon equals one year (Kastner, 2018, p. 284).

For identifying currency risk based on forecasts, a currency map can be used. A currency map depicts costs and revenues in their respective currency in each entity of the group. A simplified version is shown in Table 1.

Currency exposure	Parent company	American subsidiary	Chinese subsidiary	Consolidated exposure
EUR	25mn	-5mn	--	20mn
USD	- 3mn	30mn	-5mn	22mn
CNY	-5mn	-10mn	50mn	35mn
GBP	3mn	--	--	3mn

Table 1: Identifying FX exposure through a currency map

The currency map in Table 1 shows the consolidated cash flows of the German company for each currency over the next year. In practice the currency map ideally should include a time dimension showing when a cash flow occurs. To keep it simple Table 1 assumes that each cash flow occurs at the end of the year. It becomes visible that the CNY exposure and the USD exposure of the parent company can be netted with the exposures of the American and Chinese subsidiary. If each subsidiary would hedge its own currency exposure, the natural hedge (netting) would be ignored, thereby creating inefficiencies and unnecessarily increasing hedging costs (Walters 2021).

For setting up a centralized treasury, the parent company or a treasury company will have to act as a hedging counterpart. This will be illustrated by the following example from Table 1. The American subsidiary needs to purchase goods for 5,000,000 EUR (for simplification). This could be hedged individually with a bank, where the American subsidiary buys the EUR amount via a forward that matures in one year. This exact forward transaction could be executed internally between the German

parent and the American subsidiary. Thereby, the parent company would be long 5,700,000 USD (assuming the one year forward rate is 1.14 EUR/USD). Additionally, the German parent needs to buy goods worth 3,000,000 USD and could hedge by buying 3,000,000 USD forward and selling the equivalent EUR amount. Without hedging the German parent would be short 3,000,000 USD. Those two positions can be netted internally before engaging in an external hedging transaction. Leaving the German parent with a netted long position of 2,700,000 USD. Now this remaining USD exposure can be hedged by engaging in a forward transaction selling 2,700,000 USD for 2,368,421.05 EUR.

For foreign subsidiaries it is likely that exposures in currency pairs without the functional currency (EUR) exist. Sticking with the example from Table 1 the parent company needs to buy 5,000,000 CNY against EUR and the Chinese subsidiary needs to buy 5,000,000 USD against CNY. In the case of the Chinese subsidiary a currency pair without including the functional currency (EUR) is used (USD/CNY). For aggregating such an exposure this trade will be split in two currency legs. First the Chinese company will buy USD 5,000,000 from the parent company against EUR and then it will buy the equivalent EUR amount from the parent company against CNY. Consequently, the USD/CNY currency pair is split into a EUR/USD and an offsetting USD/CNY leg. For those internal transactions the forward FX rate will be used, as this is the market rate upon which the existing exposure can be hedged at time of observation (Seethaler and Steitz, 2007, pp. 355-358).

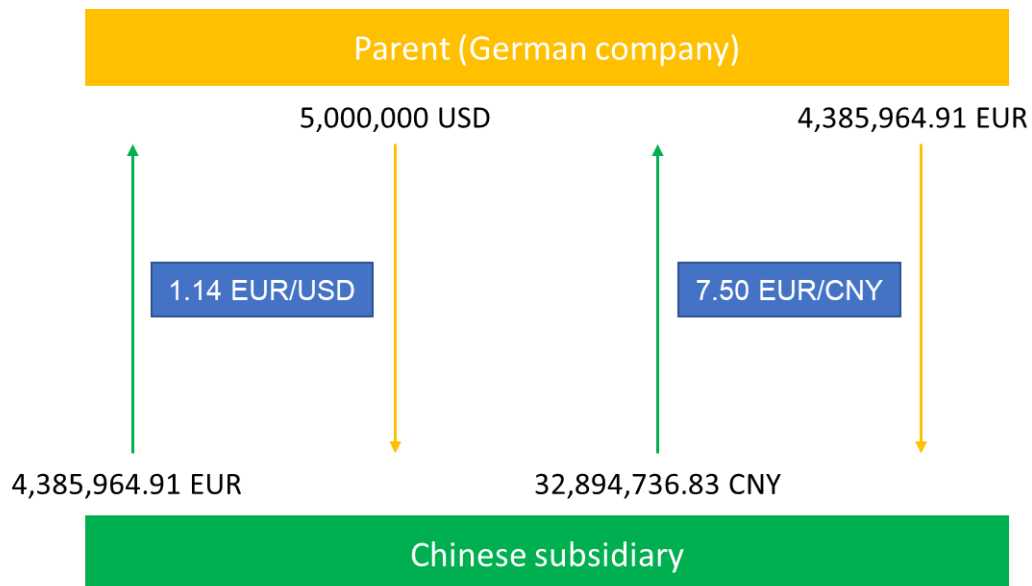


Figure 5: Exposure netting for currency pairs without functional currency

After the Chinese subsidiary splits the exposure of 5,000,000 USD/CNY in two currency pairs and hedges internally via the German parent, the parent company is short 5,000,000 USD against EUR and

long 32,894,736.83 CNY against EUR. Additionally, Table 1 shows that the German parent needs to buy 5,000,000 CNY against EUR (it is short 5,000,000 CNY against EUR). Assuming that the netted USD exposure from the first example has not been hedged, it is long 2,700,000 USD. Those USD and CNY exposures can be netted resulting in a group exposure of being long 27,894,736.83 CNY against EUR and being short 2,300,000 USD against EUR.

When netting the whole exposure from Table 1 and if each subsidiary pays their whole profits as dividends to the German parent in their respective functional currency, the German parent company is left with an overall exposure long 29,220,000 USD, long 67,894,736.84 CNY and long 3,000,000 GBP.

FX position	FX rate	USD position	CNY position	GBP position	EUR position
Parent initial	1.14	-3,000,000.00	--	--	2,631,578.95
	7.50	--	-5,000,000.00	--	666,666.67
	0.85	--	--	3,000,000.00	-- ³
American sub.	1.14	5,700,000.00	--	--	-5,000,000.00
	1.14	30,000,000.00	--	--	-- ³
	7.50	--	-10,000,000.00	--	1,333,333.33
	1.14	1,520,000.00	--	--	-1,333,333.33
Chinese sub.	1.14	-5,000,000.00	--	--	4,385,964.91
	7.50	--	32,894,736.84	--	-4,385,964.91
	7.50	--	50,000,000.00	--	-- ³
Netted	--	29,220,000.00	67,894,736.84	3,000,000.00	-1,701,754.39

Table 2: Exposure netting in a centralized treasury

It is assumed that all cash flows in the above calculations occur in one year. However, in practice there would be an additional time dimension in the above figures, making the netting more complex. Therefore, it is important that each internal and external cash flow is considered with its exact maturity when calculating the overall group FX exposure (Kastner, 2018, pp. 284-285). However, with FX swaps (see 3.4.2) maturities can be shifted easily in the timeline. To maximize the natural hedging all transactions should be separated in the spot and the swap component. With this approach the spot component is independent of the date of payment and can be netted over all forecasted transactions. Therefore, netting is possible independent of different maturities.

³ No EUR position, because foreign currency position is just paid as dividend.

3.3 Measuring and quantifying FX risk

After identifying FX risk, it needs to be quantified. FX risk measures the unexpected direct or indirect loss in a company's assets and cash flows. FX exposure can be measured by the absolute volume of the exposure, the volatility of the currency pairs, and the relationship between the traded currency pairs (Fiedor and Holda, 2016, p. 94; Mella, 2010, p. 18).

3.3.1 Value at risk

One of the most popular measures for risk quantification is the value at risk (VaR). The VaR quantifies the maximum loss for a given position during a specified time interval with a certain confidence level α . There are three different approaches to determine a VaR (Papaioannou, 2006, p. 5):

1. Historical simulation, which assumes that future currency movements will follow their historical pattern.
2. Variance-covariance approach, which assumes a normal distribution and linear dependence for currency returns.
3. Monte Carlo simulation, which can assume a variety of individual distributions.

The following examples and examinations will focus on the historical simulation and the variance-covariance approach, since they are fast to calculate and easy to implement. A Monte Carlo simulation is normally too complex and extensive to use in a corporate treasury, for further reading on Monte Carlo simulation in context with VaR see Olson and Wu (2010, pp. 135-140). The period calculation of the VaR should coincide with the average period the company needs to hedge/close open positions. A reasonable high confidence level (usually 99% or 95%) should be used to include extreme events (Olson and Wu, 2010, pp. 135-140). To account for corporate decision making, individual hedging processes and illiquid currencies, the VaR in this paper will be calculated for a period of 10 days and with a confidence level of 99%. This parameter setting is the regulatory standard for banks. However, a 99% confidence level in most cases underestimates the tail risks.

$$\text{Standard Error} = \frac{\sigma}{\sqrt{n}}$$

Equation 2: Calculation of Standard Error (Kuckartz et al., 2013, p. 141)

For calculating a historic VaR historic market data is gathered. It makes sense to include periods of high market stress like the beginning of the COVID-19 pandemic and/or the global financial crisis. In general, the more data is used the more reliable the result becomes. However, for FX markets one must be careful as dependencies and market standards in FX markets have significantly changed over the past years.

One example for a changing market environment is volatility in FX markets. FX volatility significantly decreased during the last decade. It declined from its peak at 27.02% on 27.10.2008 to a historic low at 5.18% on 17.01.2020. After a sudden increase during the beginning of the COVID-19 pandemic in early 2020 FX volatility again returned to historic lows.



Figure 6: J.P. Morgan global FX volatility index (Bloomberg, 2022a)

The J.P. Morgan global FX volatility index tracks three-month option implied volatilities of a basket including liquidity-weighted USD based currency pairs.

To account for both arguments the following historic VaR will be calculated over an observation period of five years. In this time frame recent market developments are captured as well as a stress scenario (the beginning of the COVID-19 pandemic).

This data is then used to calculate historic 10-day FX rate value changes. Compared to the current spot rates a profit and loss can be assessed. Based on a predefined confidence level α , the 10-day VaR is then just the α percentile of the historic profit and loss distribution. (Olson and Wu, 2010, pp. 133-134).

The historical simulation with a confidence level of 99% for the exemplary values from Table 1 results in a historical VaR of 1,032,672.54 EUR. This implies that in 99% of cases the maximum loss on the currency exposure of the German company over 10 days amounts to this value. Note that for simplicity in this calculation it is assumed that the exemplary values from Table 1 are already present values of the forecasted cash flows during the next year in their respective currency. When calculating the present value, the exact timing of the cash flows matters, and each individual cash flow must be discounted with

the respective interest rate for the currency and corresponding maturity of the cash flow. Assuming the company has a revenue of 62,000,000 EUR and a net income of 6,200,000 EUR, the overall FX risk with 99% in a worst-case scenario can lower net income by 16.66% over the period of 10 days if unhedged. The one-year 99% confidence VaR with historical simulation amounts to 4,353,338.95 EUR, which would reduce the net income by 70.22%. This emphasizes the importance of hedging a company's FX positions.



Figure 7: EURCHF peg removal (Bloomberg 2022b)

In 2011 the Swiss National Bank pegged the CHF to the EUR at 1.20 EURCHF, due to a massive save-heaven CHF appreciation during the European debt crisis. On the 15.01.2015 the Swiss National Bank decided to remove the 1.20 EURCHF peg against the EUR, which resulted in huge volatility spikes and a rapid appreciation of the CHF against the EUR (Lleo and Ziemba, 2015, pp. 352-354).

For cases like the removal of the CHF peg to the EUR in 2015, where the market environment hugely changed compared to historic levels, it is not appropriate to use an historic VaR. In this case one should use the variance-covariance approach supplemented by option-implied volatility to calculate a VaR.

The volatility of an FX portfolio σ_p can be calculated based on Equation 3. It requires a vector of weights w and a variance-covariance matrix Σ , with currency variance σ^2 and covariance COV as inputs.

$$\sigma_p = \sqrt{w^T \Sigma w}$$

Equation 3: Volatility of FX portfolio calculation (Olson and Wu, 2010, p. 134)

The variance-covariance approach assumes that daily returns are normally distributed and independent. It is calculated by using mean return μ , volatility σ and z-score z as an input in Equation 4. The z-score

is calculated by taking the inverse of the standard normal distribution of the confidence level α . For an α of 99% z equals 2.33.

$$VaR = E(\mu + z * \sigma)$$

Equation 4: Value at Risk calculation with variance-covariance approach (Papaioannou, 2006, p. 6)

The variance-covariance approach with a confidence level of 99% for the values from Table 1 results in a 10-day VaR of 1,032,652.49 EUR. This implies that in 99% of cases the maximum loss on the currency exposure of the German company over 10 days amounts to 1,032,652.49 EUR.

The resulting VaR of the historical simulation is slightly larger than the VaR resulting from the variance-covariance approach for the exemplary values. This is due to historically low option-implied volatility in the FX markets compared to the historical volatility implicitly used as an input in the historical simulation. The period used for calculating the historical VaR includes the beginning of the COVID-19 pandemic, which increases historical volatility and, thereby, also the historical VaR (even though volatility peaked only during a short time frame). However, historical simulation will not always result in a higher VaR than the variance-covariance approach. For the example of the unpegged CHF in the EURCHF currency pair depending on the reviewed period, the historical VaR could be lower since it would include a period of extremely low volatility due to the peg to the EUR.

The biggest advantage of the historical simulation is the simple calculation and implementation. Historical data allows for conclusions and clarification regarding the driving factors in the VaR e.g., decreasing volatility in FX markets. Another plus is that historical data already implicitly contains historic linear and non-linear dependencies. However, the most significant drawback is that historical simulation extrapolates from past data to future results, which won't work in cases like the unpegging of the CHF from the EUR. Here the variance-covariance approach can be used, which also shares simple calculation and implementation as an advantage with the historical simulation. The biggest drawback of the variance-covariance approach is the assumption of normal distribution, which can lead to issues if the underlying risk parameters are not linearly depended e.g., options and is flawed for measuring tail risk (Olson and Wu, 2010, pp. 133-135).

Since the VaR model does not define the maximum loss with 100 percent confidence, firms often set operational limits, such as nominal amounts or stop loss orders, in addition to VaR limits, to reach the highest possible coverage (Papaioannou, 2006, p. 5). To sum up, VaR gives a good feeling and indication of risk. Depending on the currency and market environment a company should decide whether to use a historic VaR or the variance-covariance approach.

3.3.2 Cash flow at risk

Compared to VaR, which shows the maximum loss of a position over a fixed time horizon with a certain confidence level, cash flow at risk shows the maximum difference between planned and expected realized cash flow over a fixed time horizon. Generally, cash flow at risk is calculated for longer periods equivalent to the financial forecasting period. Additional to existing financial risks of a company, cash flow at risk can consider future uncertain cash flows. Thereby, cash flow at risk includes the operational activity of a company and can be viewed as a dynamic value at risk (Hager, 2010, pp. 89-90). The cash flow at risk metric can be used for cash flow forecasting of a company. When using cash flow at risk, it is possible to consider uncertainties in costs, revenues, and other cash flows. Nevertheless, the below example will center on FX exposure due to the focus of this thesis.

To emphasize the difference between VaR and cash flow at risk, the VaR calculation via Monte Carlo simulation will be examined. A large number e.g., 10,000 random paths are simulated representing the EUR/USD rate. In the Monte Carlo simulation, there will be several paths that cross the confidence level of alpha 99%, thereby also considering extreme events. But none of the paths will exactly be on the confidence interval (when considering more than one cash flow). Since none of the paths is exactly following the confidence interval, VaR and cash flow at risk can't be identical.



Figure 8: Cash flow at risk vs. Value at risk

When using VaR instead of cash flow at risk it is assumed that for every point in time, when a cash flow is due, the worst EUR/USD rate (with 99% confidence) will be observed. Empiric evidence confirms that VaR is too conservative for middle to long-term periods (Hager, 2010, pp. 94-95). From a

company's perspective cash flow at risk is more useful for FX management. It is more flexible, accurate for longer periods, and matches the needs of a corporate better than the VaR. However, it makes sense to use both measures. While VaR should be used to measure possible short-term value changes, cash flow at risk can be used in an integrated planning process and when evaluating different hedging strategies. Therefore, VaR should be used for establishing risk limits.

3.3.3 Risk limits

After deciding which risk measure is used for quantifying FX risk, a company needs to decide at which point the FX risk is too high. For establishing a reasonable risk limit, the company should first determine its risk bearing capacity. It can be determined by putting figures, which are impacted by FX risk like EBIT or EBITDA, in relation to a risk measure like VaR or cash flow at risk (Kastner, 2018, p. 299).

$$\text{Risk bearing capacity} \geq \frac{\text{Risk measure}}{\text{Financial figure}}$$

Equation 5: Risk bearing capacity check

An example could be the German corporate using VaR and EBITDA for determining his risk bearing capacity. If the company forecasts an EBITDA of 5,000,000 EUR and VaR of the FX positions is calculated to be 551,645.50 EUR, the risk as a part of EBITDA would amount to $\frac{551,645.50 \text{ EUR}}{5,000,000.00 \text{ EUR}} = 11.03\%$. Under the assumption that the German corporate wants to hedge tail risks and smooth earnings volatility by setting a risk bearing capacity of $\frac{\text{VaR}}{\text{EBIT}} = 5.00\%$. To comply with the risk limit, the corporate would need to increase its hedge ratio. Consequently, VaR would decrease and risk in relation to EBITDA would decrease.

There are three different types of risk limits, the position limit, risk limit, and loss limit. The position limit specifies a limit in EUR that can't be surpassed by a single open FX position. The risk limit uses a risk measure e.g., VaR to set a limit. In this case the risk measure must not surpass the risk limit. Nevertheless, this risk limit can't be guaranteed in extreme cases because the risk measure can increase in sudden jumps depending on the market environment. The loss limit is defined as the maximal loss stemming from FX risk that is acceptable for the company. The loss limit incorporates realized profits and losses during a fiscal year and additionally includes current FX positions valued at forward or forecasted rates. It is important that for calculating already realized losses/profits the FX rate at the time of contractual price fixing is used rather than the FX rate from invoicing (see Figure 15).

A combination of all three limits seems to be best suitable for a corporate. The position limit can be used to decide whether an open FX position needs to be hedged immediately. The risk limit in combination with a loss limit can then be used for managing FX exposure on group level. If a risk limit is close to breach, the treasury needs to use suitable hedging instruments to reduce FX exposure (Kastner, 2018, pp. 300-301).

3.4 Mitigating FX risk

The idea of hedging FX risk is to create an offsetting position that exactly covers the gain and loss of the initial position (Shapiro, 2014, p. 336).

Hedging translation exposure might lead to the risk of hedging FX positions that do not impact the company's cash flows. From an accounting perspective FX exposure is hedged, but from a cash flow perspective this is not the case. Hence, hedging translation exposure creates a cash flow sensitive transaction exposure. Therefore, most companies do not hedge translation exposure (Seethaler and Steitz, 2007, p. 346). Alternatively, options can be used limiting the cash flow (liquidity) risk but leading to a loss in time value. Therefore, out of the money options (see 3.4.2) could optimize the hedge for translation exposure.

This is different for transaction exposure. Here the cash flow of the hedge should match the cash flow from the underlying transaction. It is only possible to hedge operating exposure for a given time horizon (most of the times the maturity of the hedge). In fact, operating risk is not hedged but rather postponed. A possible solution for hedging operating FX risk is changing the value chain in a way that a natural hedge is created (Seethaler and Steitz, 2007, p. 348). This way costs and revenues would be denominated in the same currency and could be netted against each other limiting the operating exposure. This is a strategic decision of the management board and not changeable by a corporate treasury. For the above-mentioned reasons, the focus in the following chapters will be on hedging transaction exposure.

3.4.1 Goals of FX hedging

Before engaging in FX hedging and deciding which hedging strategy to use it is important to specify the goals of FX hedging. According to Kastner (2018, pp.297-298) the following four goals of managing FX risk can be differentiated:

1. Reaching the forecast

If a company wants to ensure that the forecasts are met, it needs to use a high hedge ratio. Consequently, the company gets more time to react to changes in the economic environment. However, achieving this goal means that the FX hedging strategy just shifts current FX rates to future periods, strategic FX risk remains.

2. Reduction of earnings volatility

If a company wants to reduce earnings volatility it can use hedging strategies that consider individual correlations in FX pairs and smooth the risk over a certain time horizon. Additionally, it can use FX instruments to reduce tail risks and ensure that worst case rates are hedged.

3. Mitigate currency results

For mitigating currency results a company needs to hedge FX exposure as soon as it is booked (invoiced), so that underlying transaction and hedge can be matched from an accounting perspective. While this does not lead to currency results accounting-wise, economic FX risk remains.

4. Outperformance

Here the responsibility of the treasury is not just hedging FX risks, it is additionally achieving a profit contribution by taking FX positions according to one's market view. However, those two responsibilities are contrary to each other. The responsibility to deliver additional profit can lead to increased risk taking and further costs, which oppose the general idea of hedging. When such a strategy is used it is important that the company does not enter FX positions without underlying business transactions. It is also crucial that reasonable risk limits are in place to prevent excessive risk taking.

It is important that the goals of the FX hedging strategy and risk limits are known, monitored, and formulated in a treasury guideline. The treasury guideline needs to specify the allowed FX instruments in accordance with the specified goal of managing FX risk.

3.4.2 Standard FX instruments

In this chapter the standard instruments used in FX transactions and FX hedges are explained by using exemplary use cases.

FX Spot

An FX Spot transaction is an exchange of two currencies, where the value date is set latest two banking days ($t+2$) from the execution of the transaction. Nowadays it is also possible to choose a $t+0$ or $t+1$ value date for most currency pairs. However, the spot price that is traded in the market is the price for an exchange with a value date of $t+2$.⁴ The price for earlier value dates will change in accordance with the currency pair's basis and interest rate differential.

⁴ This is market standard for most currency pairs. However, there are exceptions e.g., currency pairs related to RUB or TRY, where market standard is a value date of $t+1$.

FX Forward

A forward contract is a bilateral contract, where both parties are obliged to buy or sell a specified quantity of an asset (in this case a currency) at a specified future time for a specified price (in this case FX rate) (Hull, 2018, p. 28). Consequently, a company that buys an FX forward is contractually obliged to exchange a prespecified notional of a currency for another currency at a pre-agreed FX rate, where the value date is larger than $t+2$. Usually, a forward is used for budgeting, forecasting, and calculating prices. Furthermore, it can be used to hedge a fixed FX rate for a future period, after a price for delivery or sales of goods is fixed in foreign currency.

If a German company sells goods, for which it will receive 1,000,000 USD upon delivery in three months, it is exposed to changes in the EUR/USD rate during the next three months. The FX forward enables the company to lock in a future FX rate (1.1400 EUR/USD), for which it will sell the 1,000,000 USD in three months. Consequently, the company can mitigate FX risk and has planning security. The final exchange rate of the FX Forward is shown in Figure 9.

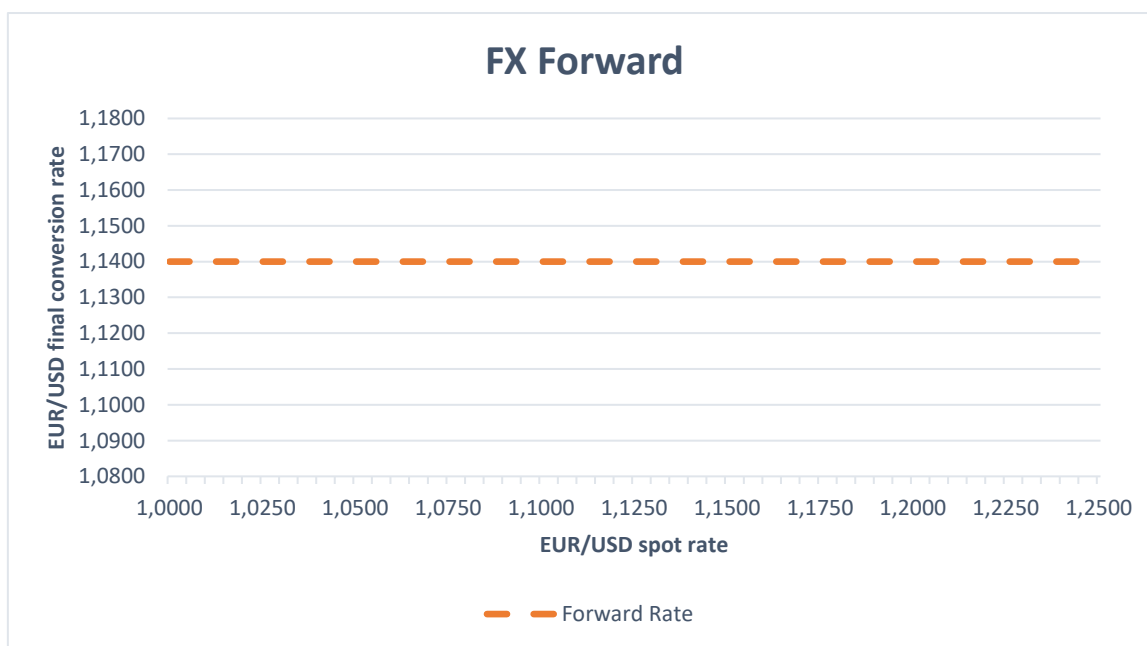


Figure 9: Final conversion rate of an FX Forward

Figure 9 shows the final conversion rate of an FX forward considering the underlying business transaction. In the following, such Figures will be used to show how a hedge in accordance with the underlying business transaction develops for a changing spot rate. Please note that this is not a profit-loss diagram, but rather shows the final conversion rate of a hedge.

However, if the US company is unable to pay or somehow the contract is cancelled, the FX forward turns into an open FX position. In this case the company would be obliged to sell 1,000,000 USD in three months, although they would not receive this USD amount from the US company. Therefore, the company would have to close this position. Depending on the EUR/USD spot rate, this could lead to losses.

Interest parity and FX forwards

Forward prices for currencies are regularly quoted in the FX market. According to the Covered interest parity (CIP) the difference between the spot and forward rate in the FX market must equal the interest differential between the two currencies. An exemplary calculation of the forward rate according to the covered interest rate parity is shown below for a company that wants to sell 1,000,000 USD forward:

1. Company takes out a loan with notional of 1,000,000 USD for 1 year
2. Company sells 1,000,000 USD spot and receives 884,955.75 EUR
3. Company deposits 884,955.75 EUR for 1 year and receives 883,185.84
4. Total cost in USD 1,006,800 – Total proceedings in EUR 883,185.845
5. Forward rate 1 year equals $\frac{1,006,800}{883,185.84} = 1,1400 \text{ EURUSD}$
6. This can be simplified by equation 6.

$$\text{Forward} = \text{Spot} * \frac{(1 + r_{\text{quoted}} * \frac{\text{days}}{\text{day count convention}})}{(1 + r_{\text{base}} * \frac{\text{days}}{\text{day count convention}})}$$

Equation 6: Pricing forwards via CIP (Heidorn/Mamadalizoda, 2019, p. 27-28)

Since the global financial crisis in 2007 the CIP is continuously violated. Counterparty risks, liquidity risk, one-sided hedging demand and constraints on arbitrage activities are the driving force for this violation. During times of crisis the credit risk component and liquidity risk component of the unsecured interest rates play a crucial role in the deviation from the CIP. In normal periods hedging demand imbalance and regulatory constraints on arbitrage are crucial factors for the deviation from CIP (Borio et al., 2016, p. 46; Heidorn/Mamadalizoda, 2019, p 5).

FX Swap

An FX Swap is a combination of two forward transactions or a combination of a spot transaction and a forward transaction (Baba et al., 2008, p. 82). Let's assume a company has hedged a future cash inflow of USD on the 02.02.2022 with a forward (sell USD) that matures at the 02.05.2022. If the company

⁵ Under the assumption of 0.67% USD interest rate and -0.20% EUR interest rate for 1 year.

realizes at maturity (02.05.2022) that the operating cash inflow is delayed, the company is still obliged to sell USD according to the forward transaction, which it does not have. Therefore, it can buy the USD in the spot market (with value date 02.05.2022) and engage in a new FX forward that matches the maturity of the delayed forward. Another example could be that the company after executing the same forward on the 02.03.2022 realizes that the cash flow will already arrive at the 02.04.2022. Then the company could adjust its existing hedge by closing the existing forward hedge by entering in the opposite position and executing the new hedge. Consequently, the initial forward and the opposite forward cancel out and just the new hedge remains. A combination of those two transactions is the so-called FX Swap that is visualized in Figure 10. By using FX Swaps it is possible to adjust the maturity of hedges. Therefore, FX Swaps are instruments for managing liquidity and timing of foreign currency cash flows.

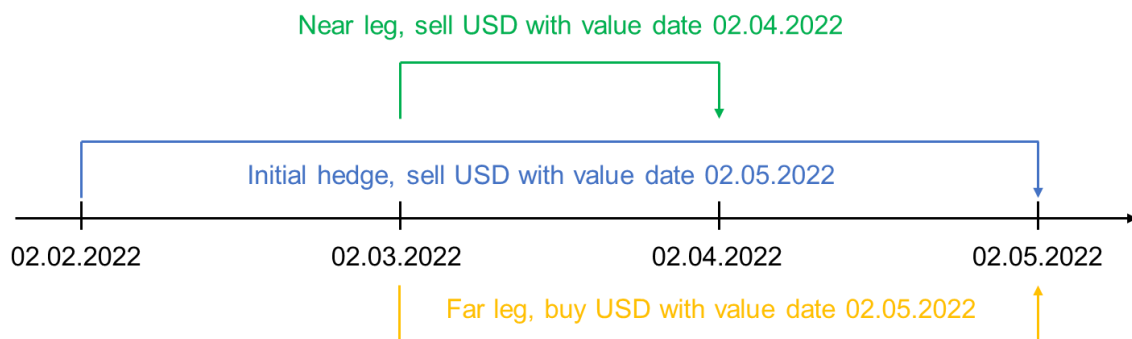


Figure 10: FX Swap

FX Swaps are also useful for exploiting natural hedges. If a German company buys goods for 1,000,000 USD at the 02.03.2022 but knows it will sell the finished products at the 02.05.2022 for 1,500,000 USD, it can use a Swap to align 1,000,000 USD. The remaining 500,000 USD can then be hedged by using a forward.

The forward is just the sum of the spot and the FX swap. This is helpful to better understand the risk, as the spot component typically has a way higher volatility compared to the swap component. With this approach it is also possible to net foreign cash flows independent of the timing. Therefore, the FX swap enables the corporate to move conversions easily along the timeline.

Cross-currency Swap

A Cross-currency Swap is a type of a Swap where, additional to a notional denominated in two currencies, the corresponding interest rates are exchanged. There are various versions of Cross-currency Swaps regarding the interest rate and the frequency of interest rate exchange. Furthermore, it can be

specified whether there will be just an exchange of notional at maturity or also at inception (Hull, 2018, pp. 190-192).

Often Cross-currency Swaps are used for hedging intercompany loans. Let's assume a German company gives a loan to its American subsidiary of 10,000,000 USD for 10 years, with floating USD interest rate payments, where the notional is repaid at maturity. It is assumed that the company has received the USDs from exporting activities. In this case the German parent is exposed to a rising EUR/USD rate and a declining floating USD interest rate.

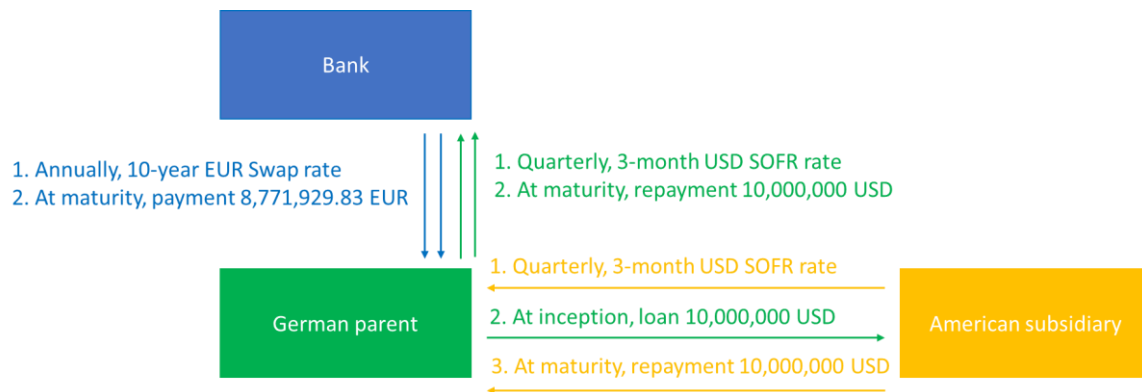


Figure 11: Hedging an intercompany loan via a Cross-currency Swap

In this case the German company mitigates the FX risk of the interest payments and the interest rate risk by exchanging floating USD interest payments for fixed EUR interest rate payments. Additionally, the FX risk of the notional repayment at maturity is mitigated by fixing a EUR/USD exchange rate for the future (in this case a rate of 1.14 EUR/USD is assumed).

FX Option

An option gives the buyer the right to buy (call option) or sell (put option) a specified amount of an asset for a certain price at a future point in time (Hull, 2018, p. 30). An FX option can always be viewed as a put and a call option, depending on the currency perspective. Let's consider a German company that receives 1,000,000 USD in three months. It could hedge by buying a EUR call option. A EUR call option for 1,000,000 USD with a strike rate of 1.1400 EUR/USD and maturity of three months is consequently a USD put option. For having a right to exercise the option the option buyer must pay an option premium to the option seller.⁶ At maturity the option holder can then decide whether he wants to exercise his option. If the EUR/USD spot rate at maturity is larger than 1.1400 EUR/USD the company would exercise the option, since it is able to sell 1,000,000 USD for a better price compared to the market price in the spot market. If the EUR/USD spot rate at maturity is lower than 1.1400 EUR/USD, the company

⁶ For estimating option premiums see Hull (2018, pp. 296-369).

will not exercise the option and sell 1,000,000 USD in the spot market. In summary an FX option allows the company to participate on favorable rate movements, while being hedged against unfavorable rate movements. However, for this benefit the company needs to pay an upfront premium, which reduces the company's liquidity. The strike of an option can be set individually. It makes sense to set the strike at a worst-case level, to reduce the upfront premium. Thereby, the company is protected against tail risks and can cover its costs in a worst-case scenario at acceptable cost.

Additionally, options are a useful instrument when hedging transactions with uncertain cash flows e.g., tenders or expected transactions, where a contract has not been signed yet. In case the hedged transaction does not materialize, by using an option, the company's maximum loss is the paid premium. The final exchange rate of the FX option (EUR call/USD put) including the option premium is shown in Figure 12.

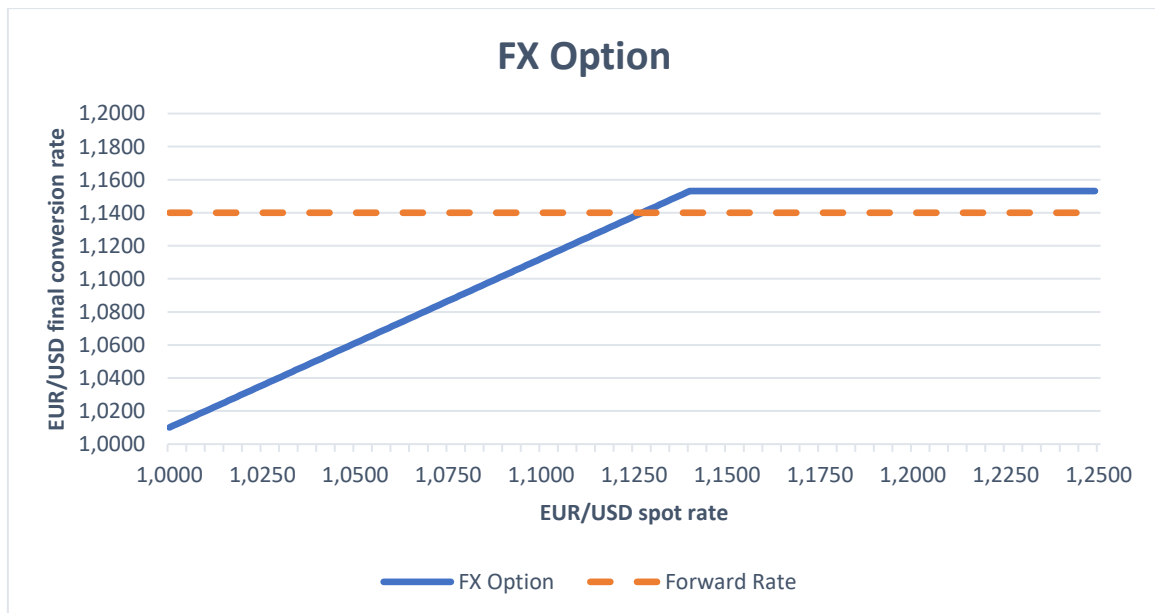


Figure 12: Final exchange rate of an FX Option

The final exchange rate (worst case rate) including the option premium can be calculated by Equation 7 and Equation 8 depending on the direction of the trade (CCY = foreign currency). An exporter will hedge by buying a EUR call option, while an importer will hedge by buying a EUR put option.

$$\text{Worst - case rate} = \frac{\text{Notional in CCY}}{\frac{\text{Notional in CCY}}{\text{Strike}} - \text{Premium in EUR}}$$

Equation 7: Worst-case rate for an exporter

$$\text{Worst – case rate} = \frac{\text{Notional in CCY}}{\frac{\text{Notional in CCY}}{\text{Strike}} + \text{Premium in EUR}}$$

Equation 8: Worst-case rate for an importer

The worst-case includes the option premium in the EUR/USD FX rate. Assuming an option premium of 10,000 EUR, a strike of 1.14 EUR/USD and, by using Equation 7, the worst-case hedged rate for the EUR call option equals 1.1531 EUR/USD.

The break-even rate specifies the minimum spot rate that needs to be achieved, so that the option premium is covered. A break-even rate can be calculated for a spot or forward rate. Usually, the break-even rate is calculated for the corresponding forward rate since this is the comparable hedging possibility.

$$\text{Break – even rate} = \frac{\text{Notional in CCY}}{\frac{\text{Notional in CCY}}{\text{Comparable rate}} + \text{Premium in EUR}}$$

Equation 9: Break-Even rate for an exporter

$$\text{Break – even rate} = \frac{\text{Notional in CCY}}{\frac{\text{Notional in CCY}}{\text{Comparable rate}} - \text{Premium in EUR}}$$

Equation 10: Break even rate for an importer

Assuming an option premium of 10,000 EUR, a forward rate of 1.14 EUR/USD and, by using Equation 9, the break-even rate to the forward for the EUR call option equals 1.1272 EUR/USD.

It is helpful to develop an intuitive approach how the price of an option is determined:

During the time to maturity the value of an American option must be at least the direct execution value (intrinsic value) as it is possible to use the option at any point in time.

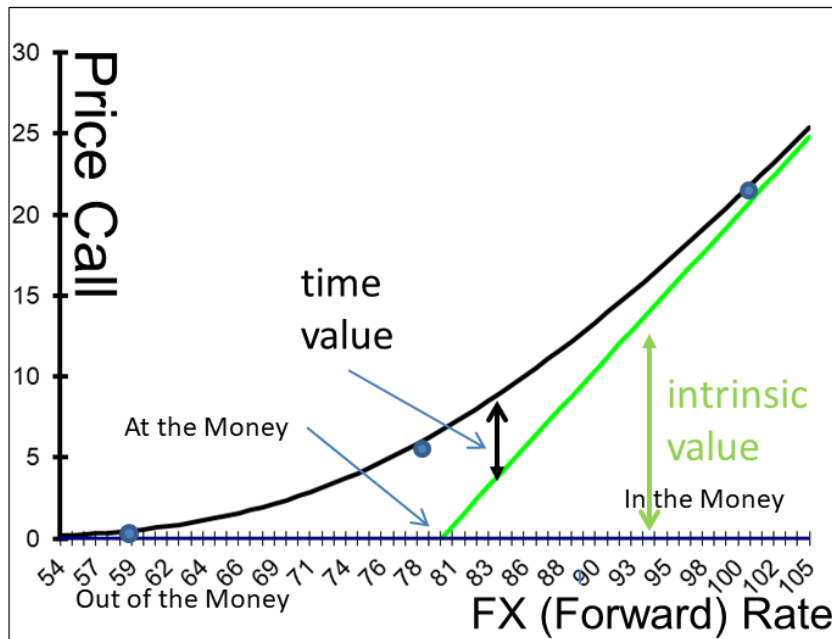


Figure 13: Value of a Call

Typically, the value of an option is above the intrinsic value. Out of the money options have an intrinsic value of zero, but favorable moves of the underlying in the future are possible. Due to that upside chance, the option has a time value. In the money options do have an intrinsic value. However, the option has the full upside potential but only limited downside risk. Due to this insurance aspect, the option value is larger compared to direct execution. Therefore, options with a positive maturity nearly always also have a time value. The difference between American and European style is small, as typically an option is not executed but sold. By selling the option the full value including the time value is realized and not just the intrinsic value. Due to this aspect, a European option can be used at any time.

If the value of the underlying increases the price of a call also increase. However, these changes are not linear. In the out of the money range a rise of the underlying increase the hope, but only slightly. At the money the effect is approximately 50% of the movement in the underlying. For very deep in the money options, it approaches one. The relationship of the change in the price of the underlying to the price of the option is called Delta. Mathematically it is the slope of the option price curve. The change of Delta is called Gamma which describes the convexity of the curve.

If the time to maturity is reduced, the value of the option has to decline, as the insurance is now for a shorter period. This is measured as Theta and typically describes the loss of value for one business day. The most important factor is volatility, which is measured as the standard deviation of the change of the

FX-rate (not of the rate itself). Increased volatility will lead to a higher insurance value; therefore, the price of the option has to increase. This is measured in Vega, which evaluates the price change due to 1% rise in volatility. The volatility can change considerably over time. In an uncertain environment, typically options are very expensive. Therefore, using options in the corporate treasury is opportunistic. In many cases insuring tail risks in “good times” is very attractive but too expensive in “bad times”.

Finally in the FX realm the underlying of the option is the corresponding forward not the spot rate. Therefore, an option is at the money (forward) if the strike is equal to the forward. As the interest differential between the currencies is already expressed in the forward, it has only an influence via the forward movement on the option price.

The price of FX Options can be calculated via the Black 76 model, which is shown in equation 11 (Hull, 2018, pp. 335-339, for a detailed evaluation please refer to Heidorn 2017 pp 211 -214.

$$Call = e^{-r_{quoted} * T} [F * N(d_1) - X * N(d_2)]$$

$$Put = e^{-r_{quoted} * T} [X * N(d_2) - F * N(d_1)]$$

$$d_1 = \frac{\ln\left(\frac{F}{X}\right) + \sigma^2 * \frac{T}{2}}{\sigma * \sqrt{T}} ; \quad d_2 = d_1 - \sigma * \sqrt{T}$$

Equation 11: Black 76 equation (LME, n.d.)

With r = interest rate, X = Strike, F = Forward σ = *Volatility*, T = *Maturity*

FX non deliverable forward (NDF) and FX non deliverable Option (NDO)

A non-deliverable forward is used to hedge payments in currencies which can't be traded offshore (see 2.2.3 *Restricted currencies*). It is not possible to settle those currencies for a German based subsidiary (BNP Paribas, n.d.). One example are Indian rupees (INR). If a German company agrees to receive a payment for its exports of 10,000,000 INR at maturity, it won't receive INR even though the Indian company transfers INR. The payment will automatically be converted to EUR by the Indian central bank before leaving the country. Still the German company is exposed to FX risks, because the EUR amount that will be received varies according to the EUR/INR rate from inception of the contract until the payment date. It is not possible to use a FX forward as a hedge, because INR can't be settled offshore. The NDF works like a cash settled FX forward. At inception the counterparties decide on a fixing that will be used (e.g., BFIXFFT1400, which is the Bloomberg Fixing of the EUR/INR rate at 2 pm CET). At maturity there won't be any currency exchange but rather a cash settlement of the NDF contract (Lipscomb, 2005, pp. 1-3). Let's assume the German company hedged via an NDF at a rate of 85.00 EUR/INR (selling 10,000,000 INR) and the EUR/INR rate at maturity was fixed at 90.00 EUR/INR.

Then the company would receive a cash settlement from the NDF that exactly covers the difference between the hedged and fixed EUR/INR rate. In this case the cash settlement amounts to $\frac{10,000,000 \text{ INR}}{85.00 \text{ EUR/INR}} - \frac{10,000,000 \text{ INR}}{90.00 \text{ EUR/INR}} = 6,535.94 \text{ EUR}$. Please note that this transaction is not completely hedged and subject to basis risk. The basis risk stems from a different fixing time and rate compared to the time and rate the actual FX exchange is performed by the Indian central bank (Hull, 2018, pp. 76-80). If the central bank or another counterparty use a specified fixing for the FX exchange the basis risk can be eliminated by using the same fixing for the NDF.

A FX non-deliverable option works like a cash settled option. It is normally used when one of the currencies from the hedged currency pair is not convertible (tradable offshore) (Commerzbank AG, 2022, p. 1). Like the NDF it is subject to basis risk.

3.4.3 Structured FX instruments

There are various structured products that are used depending on the individual situation of a company and its market opinion. Structured FX products mainly combine the features of the instruments presented in 3.4.3 *Standard FX instruments* and enable the company to include a market opinion in its hedging strategy. It is important to fully understand the instruments used for hedging. This enables a treasury to use the appropriate instrument depending on the underlying business requirement.

Structured products are priced as “zero-cost” strategies. This means that the company buying those products does not have to use liquidity to engage in those trades. However, this does not mean that the products are traded without cost for the company (Wystup, 2006, p. 31). A structured product has a fair market value. When such a product is priced by a bank, the product parameters are set to achieve a negative market-value from the client’s perspective. This can be clarified with a simple example of a forward that is traded with an included mark-up. In this case the fair market price would be the traded forward rate in the market, however the institution selling the forward includes mark-up in the forward rate, creating an initial negative market value of the forward for the client.⁷ If the product would be traded without costs for the company, the company would have to receive the negative market value as a payout, or the product parameters would need to improve from the companies perspective. This payout is kept by the institution selling the structured product to the company and hence quantifies the cost of the product.

⁷ Essentially the forward is traded (bought) in the market for a rate by the bank. Then a mark-up is included in the rate that is passed on to the client. The difference between those rates approximately quantifies the clients negative market value and the cost of the forward.

In this thesis the focus will be on three different types of structured FX products: Risk reversals, participating forwards, and target profit forwards, as those are the most common structures among midcap corporates. Each of those structures can be further refined. For further variations and structured FX products see Wystup (2017).

Risk Reversal

The risk reversal allows a company to hedge a fixed worst-case rate, while being able to benefit from favorable spot rate movements. The profit potential of this product is limited. In its simplest form it can be constructed by combining a long call (put) option and a short call (put) option with different strikes and the same notional (Wystup, 2006, p. 31).

Let's consider a German company that receives 1,000,000 USD in one year and wants to hedge by trading a risk reversal. The company expects the EUR/USD rate to decline.

Spot rate	1.1300 EUR/USD
Maturity	1 year
Forward rate	1.1400 EUR/USD
Notional	1,000,000 USD
Worst-case rate	1.1650 EUR/USD
Best-case rate	1.1150 EUR/USD

Table 3: Product parameters of risk reversal

- If the spot rate at maturity is above the worst-case rate of 1.1650 EUR/USD, e.g., at 1.1800 EUR/USD, the company can sell 1,000,000 USD for the worst-case rate of 1.1650 EUR/USD.
- If the spot rate at maturity is below the worst-case rate of 1.1650 EUR/USD and above the best-case rate of 1.1150 EUR/USD, e.g., 1.1200 EUR/USD, the company can sell 1,000,000 USD in the spot market.
- If the spot rate at maturity is below the best-case rate, e.g., 1.0200 EUR/USD, the client must sell 1,000,000 USD at the best-case rate of 1.1150 EUR/USD.

By trading a risk reversal, a company can hedge a worst-case rate that is slightly worse than the forward rate, while being able to benefit from favorable spot rate movements, bound by the best-case rate. A company does not need to use liquidity for engaging in this hedging transaction (Wystup, 2006, pp. 31-32).

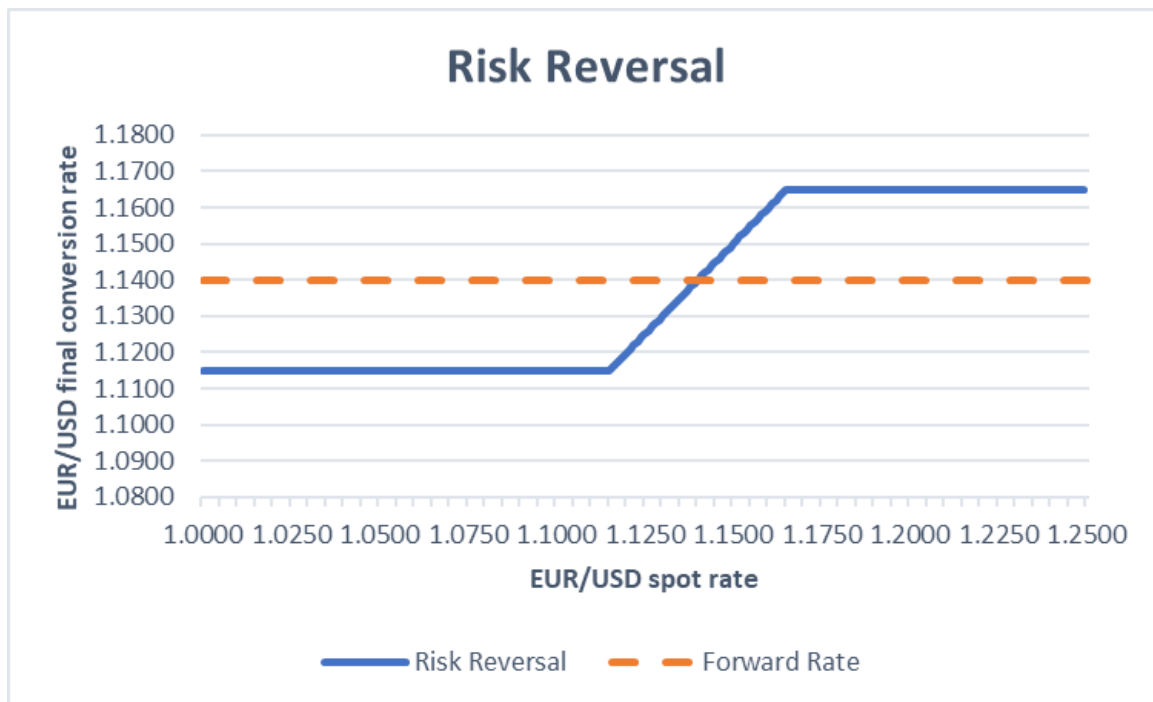


Figure 14: Final exchange rate of a Risk Reversal (Wystup, 2006, p. 32)

The risk reversal is a useful tool to hedge limited price-escalation clauses targeting the FX rate. It can also be used if the worst-case rate fits the company's calculation to ensure limited participation on an improving FX spot rate until the best-case rate.

Participation Forward

The participation forward allows a company to hedge a fixed worst-case rate, while including its market opinion to benefit from spot rate movements. The profit potential of this product is limited. In its simplest form it can be constructed by combining a FX forward (worst-case rate) and an FX knock-out option (limited profit potential) (Wystup, 2006, p. 45).

Let's consider the following example. A German company receives 1,000,000 USD in one year and wants to hedge by trading a participation forward. The company expects the EUR/USD rate to decline.

Spot rate	1.1300 EUR/USD
Maturity	1 year
Forward rate	1.1400 EUR/USD
Notional	1,000,000 USD
Worst-case rate	1.1650 EUR/USD
Knock-Out trigger (European style)	1.0450 EUR/USD

Table 4: Product parameters of participating forward

- If the spot rate at maturity is above the worst-case rate of 1.1650 EUR/USD, e.g., at 1.1800 EUR/USD, the client must sell 1,000,000 USD for the worst-case rate of 1.1650 EUR/USD.
- If the spot rate at maturity is below the worst-case rate of 1.1650 EUR/USD and above the knock-out trigger of 1.0450 EUR/USD, e.g., 1.0600 EUR/USD, the client can sell 1,000,000 USD in the spot market.
- If the spot rate at maturity is below the worst-case rate of 1.1650 EUR/USD and below the knock-out trigger of 1.0450 EUR/USD, e.g., 1.0200 EUR/USD, the client must sell 1,000,000 USD at the worst-case rate of 1.1650 EUR/USD.

The participation forward can also be constructed with an American-style knock-out trigger. If the trigger is touched just once, the company must sell the USD notional for the worst-case rate. Please note that this is just one example of a participating forward, there are various alternatives (Wystup, 2006, pp. 144-146).

The company can hedge a worst-case rate that is slightly worse than the forward rate, while being able to benefit from its market expectations. This participation is bound by the knock-out. In contrast to the risk reversal the buyer of a participation forward reverts to the worst-case rate after the knock-out is triggered. Therefore, for the same worst-case rate the participation forward, delivers a higher participation (the knock-out trigger is further away from the strike, compared to the best-case rate in the risk reversal).

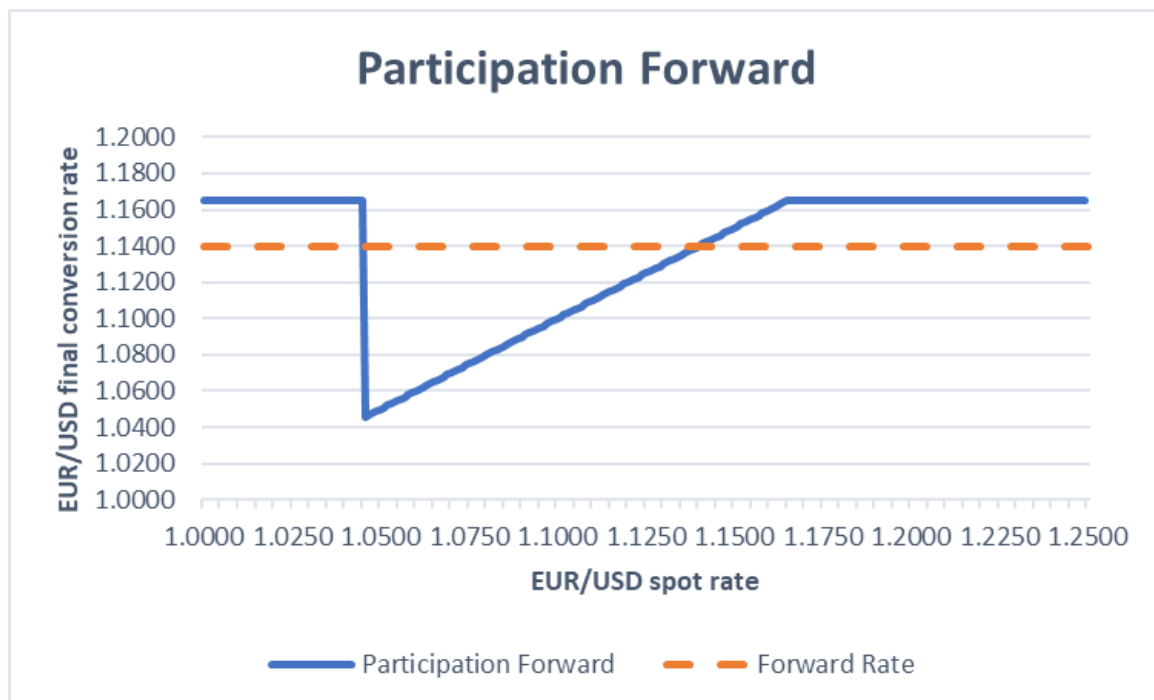


Figure 15: Final exchange rate of a Participation Forward (Wystup, 2006, p. 146)

If the worst-case rate fits the company's calculation, a participation forward is a useful tool to benefit from spot movements according to the company's market opinion. The company does not need to use any liquidity for this strategy and achieves a cheaper worst-case rate compared to an FX option due to the limited participation.

Target Profit Forward (TPF)

The target profit forward (TPF) is sometimes also called target redemption forward is a highly customizable outperformance strategy that allows the buyer to hedge a rate over a specified time horizon that is better than the comparable forward rate (Deutsche Bank AG, 2022b). Let's consider the following example. A German company receives 1,000,000 USD per month over the next year and wants to hedge by trading a TPF. The company expects the EUR/USD rate to be stable over the next year.

Spot rate	1.1300 EUR/USD
Maturity	1 year
Average forward rate	1.1350 EUR/USD
Notional per fixing	500,000 USD / 1,000,000 USD (2x leverage)
Fixings	Monthly, 6 guaranteed (significant)
Strike	1.1100 EUR/USD

Table 5: Product parameters of discrete TPF (Deutsche Bank AG, 2022b)

- If the spot rate at the first fixing is above the strike rate of 1.1100 EUR/USD, e.g., at 1.1800 EUR/USD, this fixing counts as a significant fixing, the company must sell 500,000 USD for the strike rate of 1.1100 EUR/USD.
- If the spot rate at the 6th fixing is below the strike rate of 1.1100 EUR/USD, e.g., 1.0600 EUR/USD, and there have already been 5 significant fixings, the company must sell the leveraged volume of 1,000,000 USD for the strike rate of 1.1100 EUR/USD. The count of significant fixings remains at 5.
- If the spot rate at the 8th fixing is above the strike rate of 1.1100 EUR/USD, and e.g., at 1.1900 EUR/USD, and there have already been 5 significant fixings, the client must sell the 500,000 USD for the strike rate of 1.1100 EUR/USD. After this fixing this trade has reached the maximum of 6 guaranteed (significant) fixings and the transaction is terminated.

By trading a TPF the company can achieve a better rate than the comparable forward rate. The strike rate of this product needs to be compared to the average forward rate over the next year. To achieve this rate the company shorts volatility when trading a TPF. There are two major risks. If the spot rate at fixing is below the hedged strike rate, then the company would like to sell its hedged amount in the spot market but is obliged to sell the leveraged amount of 1,000,000 USD for the strike rate. In a worst-case scenario the EUR/USD spot rate is below the strike at every fixing and the trade matures in one year. In

this case the company is constantly selling USD for a worse price compared to the spot rate until the trade matures. Compared to the average forward rate as of trade execution, the company was still able to hedge for a better rate. The second risk is an early termination of the trade. If in total 6 fixings are above the strike rate (significant fixings), the trade terminates before maturity and leaves the rest of the exposure unhedged (Yang/Liao and Chen, 2018, pp.70-71; Deutsche Bank AG, 2022b).

The TPF is a highly complex product. It should not be used as the only hedging instrument, since it can terminate early and leave a large portion of FX exposure unhedged. When including the TPF in a hedging strategy, one must consider the leveraged notional, so that the overall hedge ratio of the company never exceeds 100%. Additionally, the company needs to react fast or accept a lower hedge ratio if FX rates move. The TPF is a useful instrument, but requires constant monitoring, so that a company can react fast if unexpected movements in FX rates occur. There are many other variations of target profit forwards, for further details please see (Wystup, 2017, pp. 291-317).

3.4.4 Individual cash flow hedging

Individual cash flow hedging can be applied to every single cash flow that is denominated in foreign currency. Normally it is used if the goal of the hedging strategy is reaching the forecast (see *3.4.1 Goals of FX hedging*). In this approach each single cash flow is hedged individually. For this approach it is required to calculate each cash flow separately, so that it is possible to hedge adequately. Normally, in contrast to a portfolio-based approach, individual cash flow hedging is used when there is not a fixed price table for imports/exports and prices for each single transaction vary. It is also used for large and strategically important transactions.

Transaction exposure solely focuses on foreign currency cash flows. Here it can be differentiated between planned, contracted, and already booked cash flows. Each category of cash flows differs regarding the certainty of happening. The hedge ratio can be adjusted according to the uncertainty and maturity of a cash flow. The more certain and the closer the entry date of a cash flow is the higher the hedge ratio should be. Additionally, if a cash flow is further away in the future, it is easier for a company to adjust prices to changes in FX rates (Seethaler and Steitz, 2007, p. 348).

$$HR = \frac{\textit{Hedged exposure}}{\textit{Exposure}}$$

Equation 12: Hedge ratio

The hedge ratio describes the fraction of hedged FX exposure in relation to the overall FX exposure. The hedge ratio should never exceed 100% since this would create a new exposure in the opposite direction and increase risk.

Managing transaction exposure requires the determination of a risk horizon during which FX risks are measured and managed. Economically FX risk emerges even before a transaction is booked from an accounting perspective. Consequently, it is important to classify each cash flow by its timing and likelihood of occurrence.

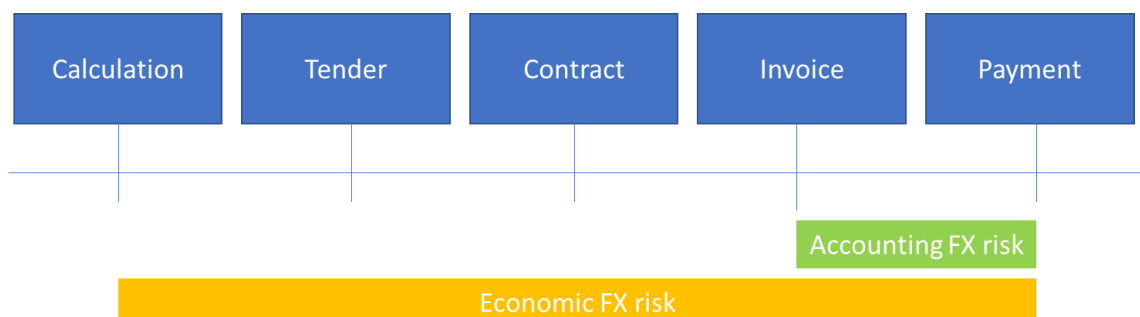


Figure 16: FX risk from accounting and economic perspective (Seethaler and Steitz, 2007, p. 350)

During the calculation period, it makes sense to use the forward FX rate (with maturity congruent to payment date) and adding a risk buffer for fluctuations in the FX rate until the transaction is contracted. Depending on the likelihood and timing of a transaction the hedge ratio needs to be adjusted with the appropriate hedging instruments (Seethaler and Steitz, 2007, p. 351). The calculated risk buffer can also be used to pay the premium for an option-based hedge. The FX option would hedge the FX spot risk from the calculation period of the transaction until the contract is signed. In this case the risk of fluctuations in the FX spot rate is hedged while volatility in Swap rates remains unhedged. Usually those periods are short, so that option premiums are comparatively cheap and fluctuations in Swap rates can be neglected.⁸ In a scenario where the transaction is not contracted, depending on the FX rate, the company can either let the option expire (without any obligation to execute) or execute the option and make a profit by closing the position in the spot market. The highest potential loss is the paid option premium (see 3.4.3 Standard FX instruments) After the contract is signed the company can hedge the transaction via a forward contract.

3.4.5 Portfolio-based approach

Normally the portfolio-based approach is used in centralized treasuries (see 3.1 Centralized and decentralized FX hedging). In a centralized FX hedging setup, a consolidated group FX exposure can be viewed and hedged as a portfolio of different currencies. The portfolio-based approach can also be supplemented with individual cash flow hedging. In this case the portfolio-based approach is used for normal and recurring transactions, while strategically relevant and one-off transactions are hedged

⁸ It is also possible to hedge future Swap rates via options or forwards. Such a hedge would have been valuable for German exporters in 2021, before the FED raised interest rates in March 2022 and signaled further rate hikes for 2022.

individually. It is important to mention that FX rate forecasts and market views should not have an impact on the strategic hedging decision (risk horizon and hedge ratio), as it is impossible to predict future FX rate movements. First, a hedging strategy/policy should be specified by a company depending on internal business requirements and hedging goals. Then in a later stage when executing the strategy, a treasury can decide which FX instruments to use, based on market views, forecasts, and budgeting rates. The main decision point should be the type and certainty of a cash flow in foreign currency, while market views should be used for short-term and tactical decisions (Lester, 2010).

For using a portfolio-based approach a budget rate/calculated FX rate and regular cash flows are needed. There are different approaches to determine budget rates. Some companies use the spot rate at the beginning of a fiscal year, some use the average spot rate in the previous year. Using spot rates seems unfair, since, depending on the side of a trade, the forward points, which would be used for a forward hedge, can be either beneficial or disadvantageous regarding the spot rate. Therefore, the most logic approach is to use the average forward FX rate over the budgeting/risk horizon, as this is the comparable fixed hedging possibility at the time of budgeting. The risk horizon equals the validity of the budget rate. Let's focus on one currency pair (EUR/USD) assuming that a German company receives a monthly cash flow of 1,000,000 USD and calculates its budget rate over the period of 2022 at 1.1350 EUR/USD, as this is the average EUR/USD forward rate over the next year. If the company tries to reach its forecast with its hedging strategy the company could decide on a hedge ratio of 80% (Equation 12) and hedge each month by selling 800,000 USD forward with the respective maturity of the cash flow at the beginning of the year. Hereby the company would have a constant hedge ratio of 80% and could adjust hedges if FX exposure changes.

If the goal of the hedging strategy is reduction of earnings volatility (*3.4.1 Goals of FX hedging*) there are two common strategies for hedging FX risk, the 1/3-Mix, and the layered hedging approach.

1/3 Mix

The 1/3 Mix leads to a hedge ratio of 66,67%. In this case $\frac{1}{3}$ of the overall FX exposure is hedged via forwards, $\frac{1}{3}$ is hedged via options, and $\frac{1}{3}$ is left open and bought/sold via spot transactions. This leads to a situation where irrespective of the direction of a move in the FX rate $\frac{2}{3}$ of the FX exposure are hedged in a favorable way (Deutsche Bank AG, 2022a). Let's focus on one cash flow, where the company receives 1,000,000 USD in one year to visualize this effect.

FX rates	Hedge	Spot increases	Spot decreases
Spot EUR/USD	1.1300	1.2000	1.0600
Option	1.1500	1.1500	1.0600
Forward	1.1400	1.1400	1.1400
Average rate	1.1400	1.1633	1.0867

Table 6: 1/3 Mix without including the option premium

If the spot rate increases from 1.13 EUR/USD to 1.20 EUR/USD, the forward enables the company to sell $\frac{1}{3}$ of the USD amount for a hedged rate of 1.14 EUR/USD, while it can also exercise the option and sell $\frac{1}{3}$ of the USD amount for a rate of 1.15 EUR/USD. The open position is fully exposed to moves in the spot rate and therefore $\frac{1}{3}$ is sold spot for a rate of 1.20 EUR/USD, leading to an overall realized rate of 1.1633 EUR/USD. So, in this case the option and the forward improve the hedged rate. If the spot rate decreases to 1.06 EUR/USD, the option and the open position would improve the overall hedged rate, while the company is obligated to sell $\frac{1}{3}$ for the hedged forward rate of 1.14 EUR/USD. Overall if the FX spot rate increases $\frac{2}{3}$ of the FX exposure are hedged, and if the FX spot rate decreases the company can participate on improved FX spot rates with $\frac{2}{3}$ of its FX exposure. Consequently, the goal of reducing earnings volatility can be achieved, while mitigating tail risks (Deutsche Bank AG, 2022a). It is not necessary to distribute the notional equally between those three instruments. It is also possible to choose different hedge ratios e.g., hedge 50% via forwards and 25% via options and spot transactions respectively to achieve the goal of reducing earnings volatility.

In the above example the company must pay an option premium (10,000 EUR) for acquiring the right to sell 1,000,000 USD at maturity for a rate of 1.15 EUR/USD. This must be considered when calculating the 1/3 Mix. The option premium can be considered in a worst-case rate.

The worst-case rate including the option premium for the spot rate of 1.06 EUR/USD equals

$$\frac{1,000,000 \text{ USD}}{\frac{1,000,000 \text{ USD}}{1.06 \text{ EUR/USD}} - 10,000 \text{ EUR}} = 1.0714 \text{ EUR/USD}$$

$$\frac{1,000,000 \text{ USD}}{\frac{1,000,000 \text{ USD}}{1.15 \text{ EUR/USD}} - 10,000 \text{ EUR}} = 1.1634 \text{ EUR/USD}$$

(the option is exercised with strike of 1.15). Therefore, the

above-described hedge rates would need to be adjusted upwards:

FX rates	Hedge	Spot increases	Spot decreases
Spot EUR/USD	1.1300	1.2000	1.0600
Option	1.1634	1.1634	1.0714
Forward	1.1400	1.1400	1.1400
Average rate	1.1445	1.1678	1.0905

Table 7: 1/3 Mix including the option premium

The break-even rate to the forward for the above-mentioned option (premium: 10,000 EUR, sell 1,000,000 USD, strike 1.15 EUR/USD, maturity one year) equals

$$\frac{1,000,000 \text{ USD}}{1.14 \text{ EUR/USD}} + 10,000 \text{ EUR} = 1.1272 \text{ EUR/USD}$$

by using Equation 9. To achieve a hedging rate of 1.14 EUR/USD (including the option premium) the spot rate needs to decline to 1.1272 EUR/USD.

Layered Hedging

A layered hedging strategy is normally applied to a forecast/risk horizon of 12 months to three years. One example is shown in Figure 16.

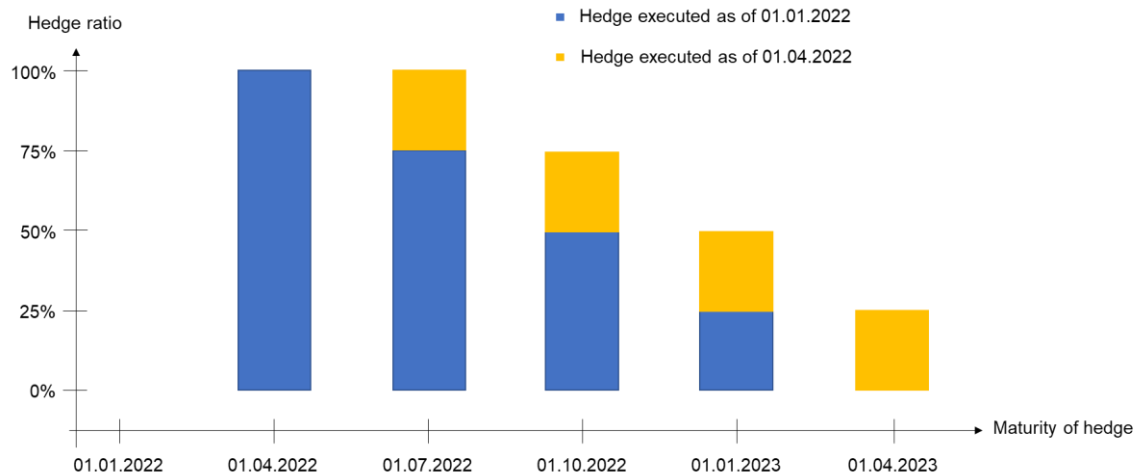


Figure 17: Layered hedging

The layered hedging strategy smooths the yearly FX rate and enables the company to reduce FX volatility and consequently earnings volatility (3.4.1 Goals of FX hedging). This leads to an improvement in the ability to react to abrupt changes in FX rates and mitigates tail risks. Additionally, the mark-to-market swings of the FX positions can be reduced, due to the smoothed FX hedging rate. In Figure 16 the company plans its monthly cash flows over a one-year period. At the beginning of the hedging strategy (01.01.2022) it hedges 100% of its quarterly exposure (if it desires to achieve an overall hedge ratio of 80%, those numbers are applied to 80% of the exposure) with a maturity of three months,

75% of its quarterly exposure with a maturity of 6 months, 50% of its quarterly exposure with a maturity of 9 months and 25% of its quarterly exposure with a maturity of 12 months. In the next quarter for each maturity, it hedges 25% of its exposure, achieving an average EUR/USD hedged rate, where at any given point in time the next 3 months are hedged 100%, the next 6 months for 75% the next 9 months for 50%, and the next 12 months for 25%. It will take 1 year from the start of implementation of this strategy until the average hedging rate is achieved. In the above example, starting with the 01.10.2023 every cash flow with maturity of 3 months will be hedged with an average rate over the past year consisting of the quarterly hedge rate. Layered hedging can be applied with different maturities and different hedge ratios to a company's individual risk horizons (Garvin, 2013, pp. 38-39).

In the following example, the above-mentioned layered hedging approach is depicted for 01.10.2020 – 01.10.2021 with actual realized rates.

Hedge Date	Maturity			
	04.01.2021	01.04.2021	01.07.2021	01.10.2021
--	04.01.2021	01.04.2021	01.07.2021	01.10.2021
02.01.2020	1.1426	--	--	--
01.04.2020	1.1065	1.1091	--	--
01.07.2020	1.1304	1.1327	1.1350	--
01.10.2020	1.1778	1.1800	1.1824	1.1848
04.01.2021	--	1.2276	1.2301	1.2326
01.04.2021	--	--	1.1799	1.1823
01.07.2021	--	--	--	1.1873
Layered Hedge	1.1393	1.1623	1.1818	1.1968
Spot rate	1.2253	1.1778	1.1852	1.1601
Forward 01.10.2020	1.1778	1.1800	1.1824	1.1848

Table 8: Layered Hedging comparison table (Bloomberg, 2022h)

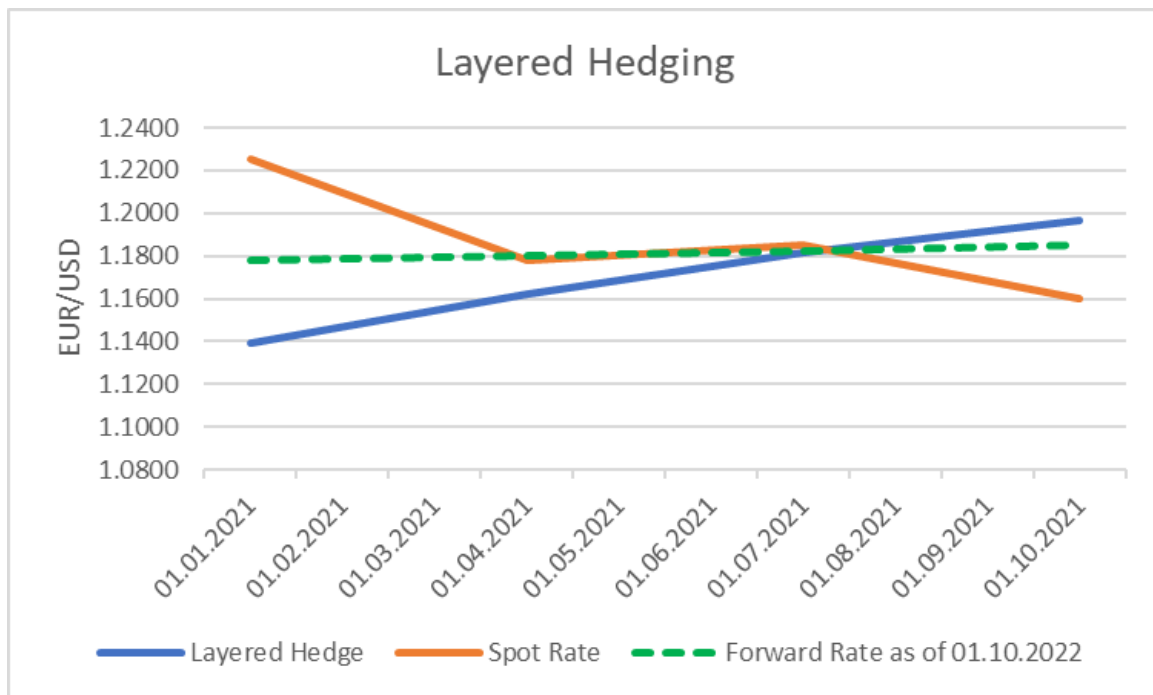


Figure 18: Layered hedging comparison graph (Bloomberg, 2022h)

The above Table 8 and Figure 17 show the averaging and smoothing effect of the layered hedging strategy in this simplified example. Compared to an open position the volatility of the FX rate is much lower and a smooth transition in the hedge rate from quarter to quarters is achieved. This effect would be larger for a layered hedge executed monthly or in shorter intervals. For comparison reasons hedging 100% of the exposure for one year in advance as of the 01.10.2020 via forwards is included. This hedge is the least volatile and is rather flat, due to the small interest rate differential and basis in this period for EUR/USD. However, one year later at the 01.10.2021 the following year would need to be re-hedged at then valid forward rates. Depending on the market environment, this could lead to large jumps in the hedge rate compared to a layered hedging approach.

Furthermore, the 1/3 Mix can be integrated into a layered hedging approach and a variety of instruments can be used for both strategies.

Outperformance strategies

In a portfolio-based hedging approach the hedging strategies of 1/3 mix and layered hedging can be supplemented by outperformance strategies to improve the hedging rate. In this case the forward component in the 1/3 Mix is changed to the outperformance instrument and/or used as an instrument in the layered hedging strategy. It is recommended to just use outperformance instruments as a supplement to a hedging strategy and not solely rely on outperformance products, since they carry significant risk and are not classical hedging instruments. The general idea of outperformance instruments is that the

hedged notional and/or the maturity of the hedge is unknown. For taking the risk of an uncertain maturity and/or uncertain notional in the hedge, the company trading such an instrument achieves a hedge rate that is better compared to the average forward rate for the matching maturity (Deutsche Bank AG, 2022a). An example for an outperformance strategy in FX hedging is a Target Profit Forward (TPF). This product is discussed in *3.4.4 Structured FX instruments*.

It is also possible to build a FX portfolio with different maturities and types of target profit forwards. Hereby TPFs with long maturities and low amount of significant (guaranteed) fixings are used to achieve attractive hedging rates. This strategy can be combined with knock-ins and/or knock-outs to limit tail risks. The idea is that the TPF terminates early (ideally before the next budgeting period). Thereby an attractive hedging rate is achieved for the budgeting period. After an early termination of a TPF a new TPF can be executed (again with a better hedging rate compared to the budgeting rate). Such strategies are a short bet on volatility and will work in most cases until a tail event happens and they turn bad. In such cases the company still needs the hedged foreign currency amount but must accept hedged FX rates that can be far worse than comparable spot rates over the maturity of the trade. Consequently, it is important that those strategies comply with risk limits, hedging policies, and are carefully monitored.

Correlation based proxy hedges

When a company has a diversified FX portfolio it can use natural “proxy hedges” before hedging its exposure. Different currency pairs exhibit correlations e.g., an emerging markets currency is usually negatively correlated to the USD. Therefore, a company must be careful when just hedging a portion of its FX exposure, as this could increase FX risk depending on correlations among their FX exposures. Another example are currency correlations to commodity prices. For example, let’s take a company that exports oil and has exposure to CAD (e.g., paying wages in its Canadian subsidiaries). Since Canada is a net exporter of oil the currency is positively correlated with the oil price. In this case a natural “proxy hedge” is in place due to the positive correlation between oil and the CAD. Just hedging the CAD exposure would dissolve this “proxy hedge” and could increase market risk, rather than mitigating it (Lester, 2010). While such correlations hold long-term, they tend to break down during times of market turmoil and volatility spikes.

Before hedging takes place, a company should not just consider natural hedges but also natural “proxy hedges”, to improve the efficiency and costs of its hedging strategy. To mitigate tail risk, it can use out of the money options. This approach allows the company to simultaneously make use of the correlation benefits, while being protected against the breakdown of correlation (tail risk) in extreme scenarios (Lester, 2010).

3.5 Performance assessment of FX hedging

After a hedging strategy has been executed it is important to evaluate its performance. Hereby a company can recognize issues and improve the hedging strategy/policy going forward. Consequently, the first step of performance assessment is to clearly specify the goal of a company's hedging strategy. In the second step the company needs to define measures to evaluate performance based on the goals. If a company's goal is to reduce earnings volatility, it could compare FX related earnings volatility compared to previous years and to an unhedged approach. It is recommended to use more than one performance measurement. Hedging costs and the VaR are viable measurements irrespective of the above-mentioned hedging goals (Golden, 2016). The third step is to evaluate the realized hedge performance against the specified goals, and benchmarks like an unhedged approach, a 100% hedge rate, and the previous year's results. It is important to outline deviations and try to understand the drivers for results, so that the hedging strategy/policy can be adjusted to improve results in the future.

4 Practical implementation of FX hedging

In this chapter the practical implementation of FX hedging will be discussed. First, the regulatory requirements before a corporate can trade FX hedging instruments will be examined. Since this thesis examines FX hedging from the perspective of a German company, the focus will be on German and European law. Additionally, this chapter investigates the implementation and execution of FX hedging strategies over electronic trading platforms. Hereby single dealer platforms are compared to multi dealer platforms. Finally, the usage and implementation of FX automation possibilities, which started to emerge in the past few years will be discussed.

4.1 Regulatory setup for trading OTC derivatives

After the financial crisis the global financial markets have been regulated by introducing new laws. For trading financial instruments to hedge FX exposure the two prevailing regulations are the Markets in Financial Instruments Directive II (MiFID II) and the European Market Infrastructure Regulation (EMIR). The goal of MiFID II is to improve the functionality and transparency of financial markets and protect consumers in the European Union (EU) (BaFin, 2018, p. 123). EMIR should limit risks in the European derivative market and impose reporting obligations for parties involved in trading derivatives (BaFin, 2022). FX spot transactions are excluded from those regulations.

4.1.1 Client classification according to MiFID

According to MiFID II every company needs to be classified in retail client, professional client, or eligible counterparty. This should ensure that every client receives the necessary protection and level of information regarding his knowledge and experience with financial instruments.

A retail client receives the highest protection and level of information. If a company does not fulfil the requirements for a professional client or an eligible counterparty it is classified as a retail client. To be classified as a professional client the company must fulfill two out of the following three requirements (§67 (2), no. 2 WpHG):

Balance sheet total	> 20,000,000 EUR
Revenue	> 40,000,000 EUR
Equity	> 2,000,000 EUR

Table 9: Requirements for MiFID classification as a professional client

A company who does not fulfill the above requirements can request to be classified as a professional client, if two out of the following three requirements are met (§67 (6) WpHG):

- The client has executed 10 or more FX derivative trades with a minimum notional of 25,000 EUR during every quarter of the last four quarters on average.
- The portfolio of FX derivatives is larger than 500,000 EUR.
- The client worked in a position in the financial industry, which required knowledge regarding FX derivatives.

An eligible counterparty has the lowest protection level and is defined as a financial institution according to §67 (2), no. 1 WpHG.

A client can always request to be classified to a higher protection level but can't reduce his protection on request without meeting the above stated requirements (§67 (5-6) WpHG). Depending on the classification the onboarding process of a company will take more time and require more documents. The higher the protection level, the more information a company will receive before trading and the more complex the initial setup will be.

4.1.2 Regulatory setup

The derivative market, where FX hedging instruments are traded, is a highly regulated market. Therefore, a company must fulfill several requirements before it can execute FX hedging instruments.

The first requirement according to EMIR is obtaining a Legal Entity Identifier (LEI) code. This code is used to match derivative transactions to a company/institution and report them to the BaFin (BaFin, 2022). A LEI can be obtained within 24 hours on the internet (various websites) and costs on average 40-100 EUR per year. The fee for the LEI is received by the LEI supplier and not the institution, which trades with the company (EQS Group AG, n.d.).

Additionally, a German master agreement for financial derivative transactions with EMIR-attachment is required. This contract specifies the legal and structural terms of derivative transactions between the bank and the company.

A bank needs to make sure that treasury employees of retail clients have knowledge and experience regarding the products, which they are trading. Additionally, a retail client must have received the newest Key information document (KID) for and an ex-ante cost disclosure for the FX instrument he wants to trade before executing the trade (Boehm and Loff, 2018). A KID is a standardized document, which describes the features of a hedging product and considers it as an investment without the underlying transaction. This sometimes leads to confusion. Therefore, it is recommended for clients to request a term sheet, which explains the functionality of the hedging instrument, while considering the underlying transaction. The ex-ante cost disclosure quantifies the expected cost of the instrument before execution. For professional clients and eligible counterparties, MiFID assumes the required knowledge and experience for trading FX derivatives and therefore this process is not required. The knowledge and experience of a retail client, including his hedging habits and financial figures are noted in a German Securities Trading Act document (WpHG-Bogen). This document is used to assess the suitability and appropriateness of new trade requests of a retail client.

According to MiFID a client must receive a trade confirmation of every FX related trade the client executes (BaFin, 2022). FX derivatives need to be confirmed by an authorized trader in the company. Today most banks/financial institutions offer FX confirmations via an electronic trading platform, e-mail, or FAX.

As a derivative can accumulate a positive value from the bank's perspective, it is subject to credit risk. Consequently, a company must have a credit line and a settlement limit to trade FX derivatives with a bank. Those limits depend on the creditworthiness of the client. If a client needs more credit line and settlement limit than a bank would grant him, he can pledge collateral to increase those limits (Basel Committee on Banking Supervision, 2000, pp. 1-14).

In today's highly regulated environment, setting up a company to trade FX derivatives takes 2-8 weeks on average. If a company is calculating a large FX transaction and not enabled for trading FX hedging instruments, it needs to consider this setup period by including a safety buffer, or by not closing a contract before being able to execute hedging instruments.

4.1.3 Costs related to FX instruments

Even products without upfront fee include costs. The cost of the product is embedded in its structure. Retail clients will receive an ex-ante cost disclosure before executing a trade (Boehm and Loff, 2018). Professional clients have the right to ask for an ex-ante cost disclosure. It is always recommended to

check the ex-ante cost disclosure and to know how much a product and the service of the financial institution selling the product cost. Irrespective of the client classification a company will receive a yearly ex-post cost disclosure, which lists the costs that occurred due to FX derivative trading in the past year (Boehm and Loff, 2018).

According to MiFID II, a cost disclosure needs to be separated into product and service costs. Product costs comprise the bank's cost of creating the product e.g., structuring cost, hedging cost and the trader spread. Service costs are charged for the advice and service a bank delivers and include the sales spread (Deutsche Bank AG, 2018, p. 2). Let's assume a forward is traded in the interbank market for a bid price of 1.1400 EUR/USD and an offer price of 1.1401 EUR/USD. If a client sells USD to the bank and receives a rate of 1.1431 EUR/USD, 0.0030 Pips in EUR/USD are service costs. The difference between the mid-price and the offer price roughly quantifies the product costs (0.00005 Pips in EUR/USD). The more complex the structured product is, the higher are the product costs. The more notional the company trades per year with the bank, the lower will be the service cost.

4.2 Electronic trading platforms

Trades in the FX market can be executed on the telephone (voice trading) or via electronic trading platforms. In 2019 voice trading still accounted for "40% of global FX activity by value" (SWIFT, 2020). The other 60% are executed via so called electronic trading platforms. Electronic trading platforms are continuing to gain market share, they allow better market access, lower trading cost, and increase transparency across FX markets. They can be divided into single-dealer and multi dealer-platforms.

4.2.1 Single-dealer platforms

Almost every bank that offers FX instruments to its clients offers its own single-dealer platform. Those platforms are usually desktop or web-based applications. Nowadays most banks offer access to their electronic trading platforms via mobile. Those applications are usually for free, because the bank/FX broker wants to encourage its clients to use platforms, thereby reducing costs, operational errors and streamline processes. Those single-dealer platforms are intuitive and similar to each other.

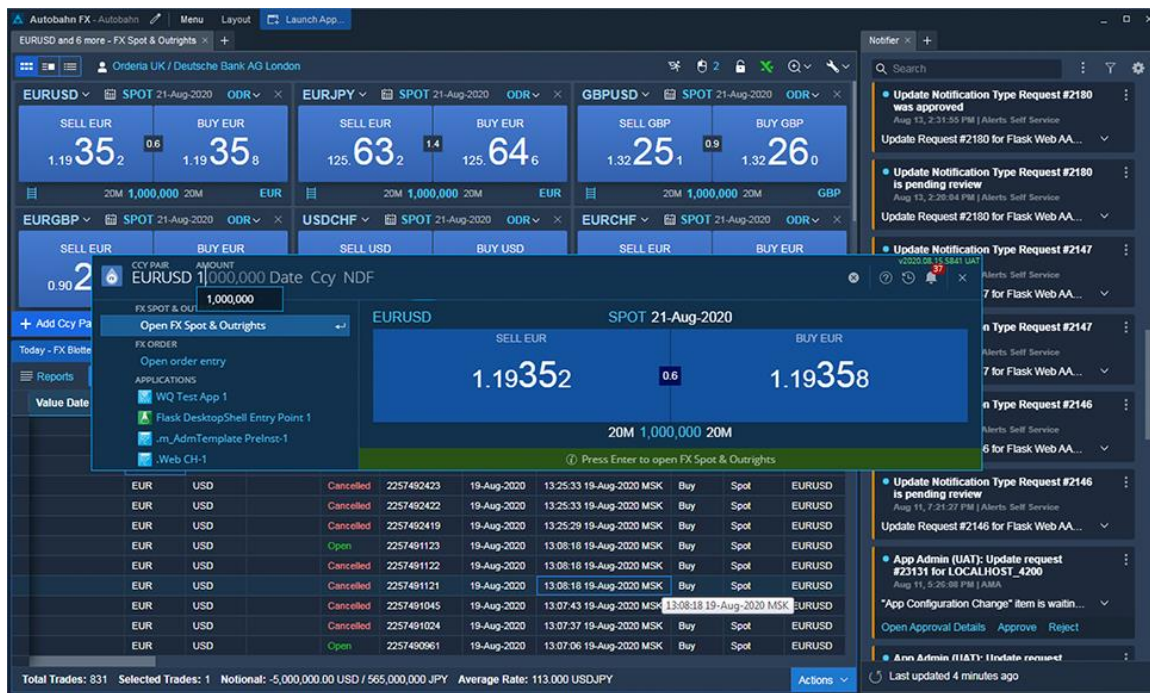


Figure 19: Single-dealer platform - Deutsche Bank Autobahn (Deutsche Bank AG, 2021a)

Standard FX instruments like spot-, forward-, and Swap transactions (sometimes options) can be traded over those platforms. This enables a company to execute trades during any time of the day. Additionally, single-dealer platforms provide customizable overviews over open and historic FX trades. This trade documentation can automatically be exported to Excel or Outlook. It is also possible for companies to confirm MiFID relevant trades over the platform. Furthermore, most single-dealer platforms offer access to research and trading commentary by the bank's professionals (Gaswirth et al., 2017, p. 6). This information is helpful to understand the current market environment and to make tactical decisions regarding the execution of FX hedges. The main argument against single dealer platforms is that a company just receives one price. However, a single-dealer platform reduces information leakage, which could lead to prices moving against a company who wants to execute large size trades. In most single dealer platforms, it is possible to view the banks estimated liquidity and volatility for certain currency pairs during the day (Deutsche Bank AG, 2021a). It is recommended to review and incorporate this information in ones hedging strategy. Before executing less liquid or more exotic currency pairs, it makes sense to talk to the bank's sales representative and trader. They have better market access, market information, and can give helpful advice on how and when to execute certain trades. Trading eastern European currencies in the late evening or Asian currencies during times where the Asian markets are closed can lead to bad prices due to less liquidity in the markets.

4.2.2 Multi-dealer platforms

Multi-dealer platforms e.g., 360T and FXall, offer price transparency and enable the user to choose the best price for an FX transaction among several banks. However, when a company is using a multi-dealer platform to execute large trades, or trades in less liquid currency pairs, every institution asked for a price will have knowledge of the requested trade. This can lead to adverse prices for the company (SWIFT, 2020). Therefore, those trades should be traded bilaterally and discussed with one institution. It makes sense to execute those trades over the phone and discuss them with a trader, to get advice when to execute them with regards to liquidity in the market. There are various algorithms that can be used for executing large size orders (Deutsche Bank AG, 2021a). Using a multi-dealer platform requires multiple FX setups at different banks and an efficient cash management. In fact, for smaller companies it can make more sense to use single-dealer platforms. FX transactions are priced regarding the total FX notional in a year. If a small company splits its already small FX exposure between multiple banks, it will less likely receive attractive trading conditions. Additionally, a FX trading setup requires the bank to conduct a KYC process and therefore causes substantial costs. Some banks might refuse to setup a client for FX trading in case he uses a multi-dealer platform or asks for special trading conditions due to cost-benefit calculations.

In summary multi-dealer platforms are suitable for larger institutions, who have FX trading setups with more than just one bank and for regular size transactions. For large size executions and trades in less liquid currency pairs it is still recommended to get advice from a professional.

4.3 FX workflow automation

Nowadays the next step to electronic trading platforms is FX workflow automation. It is possible to automatize almost every recurring process regarding FX trades. A bilateral contract between the company and a bank specifies when and how trades will be automatically executed. When certain conditions are met the bank automatically executes FX transactions. This can include the following use cases (Deutsche Bank AG, 2021b):

- Target balance automation. Hereby a company specifies individual target balances for its currency accounts for a certain period. The FX workflow solution ensures that the account balances are always as specified by buying or selling the required currency amount.
- Automated reconciliation of payments and collections against FX hedge contracts. Hereby the workflow solution has access to existing FX hedges of a company. Instead of buying the required amount in foreign currency for cross-border transactions, existing hedging transactions are swapped to the payment date. If the company receives a USD payment in the middle of the month and has a forward hedge for the end of the month in place, the USD payment will be swapped accordingly.

- Automated hedging execution. Herby the workflow solution executes trades by a certain rule set. If a client follows a layered hedging strategy, the hedging transactions will be executed as specified in the contract.

Cross-border transactions in restricted markets that normally require a complex process can be automatized by using FX workflow solutions (Deutsche Bank AG, 2021b). If certain trades should not be executed based on the prespecified rules due to special circumstances, it is possible to pause the workflow automation. It is recommended to use those capabilities for portfolio-based strategies. Especially for companies with a small treasury team this is a viable solution to save time and cost.

5 Hedge accounting

Hedge accounting is used to accurately capture the economic situation of a company and depict the hedges in accordance with its underlying positions (Loser, 2019, p. 25). In the following chapter hedge accounting, according to German accounting standards (HGB) and according to international accounting standards, will be discussed, as German companies that are “capital-market oriented” need to report according to international accounting standards (EU parliament, EC No. 1606/2002). A “capital-market oriented” company is a company whose securities are traded on an organized capital market in the EU (§264d HGB).

Let’s assume a German company exports goods to the US for 1,000,000 USD. The US company orders the goods on the 31.10.2022, delivery is 30.04.2023 and payment is due on the 31.06.2023. To hedge this transaction the German company uses a forward under which the German company is obliged to sell 1,000,000 USD at a rate of 1.1400 EUR/USD. The production costs are 800,000 EUR.

The spot rates are as follows:

Date	31.12.2022	30.04.2022	31.06.2022
Spot rate	1.00 EUR/USD	1.30 EUR/USD	1.20 EUR/USD

Profit and loss statement (in EUR)	With hedge accounting			Without hedge accounting		
	2022	2023	cumulative	2022	2023	cumulative
Revenue	0	877,193	877,193	0	769,231	769,231
Inventory change	0	-800,000	-800,000	0	-800,000	-800,000
Operating result	0	77,193	77,193	0	-30,769	-30,769
Financial expense	0	0	0	-122,807	0	-122,807
Financial income	0	0	0	0	230,769	230,769
Financial result	0	0	0	-122,807	230,769	107,962
Profit	0	77,193	77,193	-122,807	200,000	77,193

Figure 20: Profit and loss statement with and without hedge accounting (Loser, 2019, p. 24)

Figure 20 shows the impact of hedge accounting on the profit and loss statement of the German company. By using hedge accounting the underlying transaction and hedging transaction are reported as a valuation unit. Therefore, there is no impact on the profit and loss statement in 2022 and on the financial result in both years. The operating result in 2023 shows the profit from the hedged transaction $\frac{1,000,000 \text{ USD}}{1.14 \text{ EUR/USD}} - 800,000 \text{ EUR} = 77,193 \text{ EUR}$. However, if hedge accounting is not used, the underlying transaction and the hedging instrument are reported and evaluated separately. Consequently, value changes are recognized in the financial result. On the 31.12.2022 the forward has a negative value of $\frac{1,000,000 \text{ USD}}{1.14 \text{ EUR/USD}} - \frac{1,000,000 \text{ USD}}{1.00 \text{ EUR/USD}} = 122,807 \text{ EUR}$ for which a provision is created, and the value change is recognized as financial expense. Upon delivery on the 30.04.2022 the revenue is recognized with the spot rate. Leading to an operating result of $\frac{1,000,000 \text{ USD}}{1.30 \text{ EUR/USD}} - 800,000 \text{ EUR} = -30,769 \text{ EUR}$. In 2023 the provision can be dissolved, and a profit of 122,807 EUR can be realized. Additionally, the forward contract has increased in value, so $\frac{1,000,000 \text{ USD}}{1.14 \text{ EUR/USD}} - \frac{1,000,000 \text{ USD}}{1.20 \text{ EUR/USD}} = 43,860 \text{ EUR}$ have to be realized as financial income and the increase in value of underlying transaction by $\frac{1,000,000 \text{ USD}}{1.20 \text{ EUR/USD}} - \frac{1,000,000 \text{ USD}}{1.30 \text{ EUR/USD}} = 64,103 \text{ EUR}$ has to be realized. The cumulative result does not change, but without hedge accounting

the operating result is exposed to fluctuations in FX rates. Therefore, hedge accounting should be used to report an accurate economic situation of a company that hedges FX risks.

5.1 Accounting according to international accounting standards (IFRS)

Under IFRS a company can choose whether it wants to use hedge accounting. For a cash flow hedge it is possible to report the underlying business transaction and the hedge as a *valuation unit* by using hedge accounting. Thereby the operating income is not exposed to fluctuations in the FX rate (Loser, 2019, p. 24). The requirements for using hedge accounting under IFRS 9 are as follows (Thompson and di Paola, 2017, p. 8):

The hedging relationship consists only of eligible hedging instruments and eligible underlying transactions. The hedge is effective, considering that an economic relationship exists, credit risk does not dominate value changes, and the hedge ratio is consistent with the risk management strategy. Formal designation and documentation of risk management objective and strategy, hedging instrument, hedged item, nature of risk being hedged, and hedge effectiveness are necessary.

In general, every financial instrument which is evaluated at fair value and affects the profit and loss statement of a company is eligible for hedge accounting.⁹ Consequently, the instruments from 3.4.2 *Standard FX instruments* and 3.4.3 *Structured FX instruments* qualify as eligible instruments for hedge accounting, if they are traded with an external party (Thompson and di Paola, 2017, p. 14). Single transactions and a group of underlying transactions qualify for hedge accounting, if it/they are recognized assets or liabilities, unrecognized firm commitments, forecasted transactions or net investments in a foreign country. Forecasted transactions need to materialize with high probability to qualify for hedge accounting (Thompson and di Paola, 2017, p. 18).

Hedge effectiveness is defined as the part of the value change in the underlying transaction, which is covered by the value change in the hedge instrument (Hochreiter, 2016, p. 90). An economic relationship exists when value changes of the underlying transaction and the hedge instrument move in opposite directions. For a classical cash flow hedge e.g., with a forward this is simple and can be done in a qualitative assessment. For more complex portfolio-based strategies, a quantitative assessment is necessary to show the economic relationship. Additionally, for the hedge to be effective the credit risk of the underlying transaction and the hedge transaction can't dominate the value changes of it. Take a high-risk bond investment in foreign currency that is hedged with a forward as an example. In this case the credit risk rather than the FX rate would dominate value changes of the bond and thereby the economic relationship would not work. Furthermore, the hedge ratio used in hedge accounting needs to

⁹ This does not include traded short options if they do not hedge a long option embedded in the underlying transaction (Barckow et al., 2013, pp. 8-11).

be equivalent to the hedge ratio used for risk management purposes. Measuring hedge effectiveness is forward looking and needs to be checked continuously (at least at time of designation, each reporting date, and when significant changes regarding effectivity occur). Finally, hedge ineffectiveness must be measured. The portion of the hedge that is inefficient must be valued individually and recognized in the profit and loss statement. Inefficiency can be measured with “dollar offset tests”. Hereby the value change of the underlying transaction and the hedge instrument are compared, and the absolute difference is quantified as the inefficiency (Barckow et al., 2013, pp. 12-14).

The formal designation and documentation regarding hedge accounting for a German company that uses hedge accounting for forecasted USD receivables could exemplary look as follows (Thompson and di Paola, 2017, pp. 120-126/226-228):

Risk management objective:

Protecting cash flows from goods sold in the US. The cash flows are denominated in USD and converted in functional currency (EUR).

Strategy for undertaking the hedge:

Minimizing adverse impact of EUR/USD rate movements on USD cash flows by executing offsetting FX forward contracts.

Type of the hedge: Cash flow hedge

Nature of the risk being hedged: FX risk

Hedged item:

USD cash flow resulting from goods sold to company X in the US (contract no. 1111). Amount of 1,000,000 USD, which will be paid on 31.05.2022.

Hedging instrument:

FX forward (sell 1,000,000 USD at 31.05.2022 with strike rate 1.1350 EUR/USD) executed with Deutsche Bank AG (ID 1234).

Method of assessing the hedge effectiveness:

Both a qualitative and quantitative approach is used for assessing hedge effectiveness at inception:

Regarding the critical terms of the forward and the underlying transaction, an economic relationship can be confirmed. Additionally, a scenario analysis showed that the fair value of the forward and the fair value of the underlying transaction move in opposite directions (scenario analysis should be included here).

Our credit rating, the credit rating of company X, and the credit rating of Deutsche Bank AG are stable and do not dominate value changes of the underlying transaction and the FX forward.

The hedge ratio equals 100%, the whole amount of 1,000,000 USD (underlying transaction) is hedged by a forward with the same notional.

Based on the above, the hedge is effective and hedge accounting can be applied.

5.2 Accounting according to German accounting standards (HGB)

Under German accounting standards (HGB) in contrary to IFRS it is necessary to combine an underlying transaction and a hedge transaction into a valuation unit. For forecasted transaction a company can decide whether it wants to use hedge accounting (§254 HGB). German accounting standards offer more leeway regarding hedge accounting compared to IFRS, as not all requirements for hedge accounting are explicitly stated and explained in the HGB.

For using hedge accounting under HGB, existence of comparable risk, intention to hedge and hold assets until maturity, hedge efficiency, and documentation of the valuation unit are required. Eligible underlying transactions are accounting wise recognized assets, liabilities, pending transactions, and forecasted transactions that will materialize with high probability (§254 HGB). Under HGB every financial instrument is eligible for hedge accounting, if it is used for hedging purposes (Schüler, 2016, p. 22). Consequently, the instruments from *3.4.3 Standard FX instruments* and *3.4.4 Structured FX instruments* qualify as eligible instruments for hedge accounting.

Comparable risk means that FX exposure must be hedged with FX hedging instruments. The intention to hedge and to hold the hedging instrument until the underlying transaction materializes means that a valuation unit can only be dissolved before maturity for plausible economic reasons. Under HGB, like under IFRS, hedge efficiency means that value changes in the underlying transaction are offset by opposed value changes in the hedging instrument. The hedge efficiency needs to be checked at least at every reporting date. Under HGB the measurement of hedge efficiency is not explicitly discussed. Therefore, it is recommended to use IFRS hedging efficiency measurements (see 5.1 *Accounting according to international accounting standards*). The minimum documentation requirements for hedge accounting under HGB are (Schüler, 2016, pp. 27-29):

- Hedged risk type, notional and maturity of hedge.
- Designation and description of underlying transaction and hedging instrument.
- Method and result of measuring hedge efficiency and hedge inefficiency

6 Summary

In summary FX risk is an important topic for a company and can have substantial impact on a company's financials. Therefore, a company should always monitor FX risk and use a viable hedging strategy to mitigate FX risk. FX induced volatility by open FX positions should never endanger the company's success or the company. Open FX positions should only remain unhedged if they are in the specified risk limits and risk bearing capacity. Thereby, risks of large losses up to insolvency can be mitigated.

For hedging FX risk it is recommended to setup a centralized treasury, as it can take advantage of natural offsets before hedging the remaining exposure, which allows companies to reduce overall hedging cost and optimize their hedging strategy. When exploiting natural hedges, a company should also consider natural proxy hedges. This requires an integrated planning process where each entity uses the same system, so that an aggregated hedging approach is possible. The first step of FX hedging is identifying FX risk across all subsidiaries, for this task a currency map and accurate forecasts are useful. In the second step, those FX risks need to be quantified by using risk measures like VaR or cash flow at risk. Those risk measures are useful for setting up risk limits and understanding the impact of FX rates on a company's financial results. In a third step, a company needs to set goals for FX hedging and develop a hedging strategy congruent to their hedging goals. It is important that a company's board specifies a treasury guideline, which delivers a framework in which the company's treasury can operate. This guideline should specify the goals of FX hedging, corresponding risk limits and viable instruments that can be used for FX hedging.

When executing a hedging strategy, the treasury must understand the type of currency exposure and what restrictions and/or specialties apply. Furthermore, the treasury needs to fully understand all angles of FX hedging instruments that the company uses for hedging. It is always recommended to discuss such topics with the bank's professionals. It is important that executed FX strategies are closely monitored. Structured FX instruments combine useful features of standard FX instruments and enable a company to include its own market opinion for tactical decisions in their hedging strategy. However, a structured product should only be used if the worst-case is acceptable for a company. Furthermore, a company should first strategically decide on a hedging strategy without including market opinions, as the market is unpredictable. After deciding on the hedging strategy, a market opinion can be used for tactical decisions, as long as risk limits and the hedging strategy are followed.

A company needs to regularly assess the performance of its hedging strategy. The performance assessment should not focus on FX revenue, but rather measure performance according to a company's hedging goals and hedging benchmarks. In hindsight a hedge is always good when the FX rate is turning against the company, while leaving the position open would be the best-case scenario when the FX rate

is developing in the companies favor. However, a company should earn money with its core business and not with its hedging strategy. Therefore, a company should always hedge FX risk and individually decide on the hedge ratio and the hedging strategy based on its risk bearing capacity.

Nowadays, companies should use electronic trading platforms to execute their FX hedging strategies. They deliver better transparency, efficiency, and useful market information. Herby multi-dealer platforms are suitable for larger institutions, who have a FX trading setup with more than just one bank and for regular size transactions. For large size executions and trades in less liquid currency pairs it is still recommended to get advice from FX professionals. Companies with less FX exposure should regularly compare and check FX prices, when trading via single-dealer platform. FX workflow automation solutions allow companies to further improve their FX hedging process and automatize recurring processes.

Furthermore, it is highly recommended to use hedge accounting for showing the accurate economic situation of a company. Without hedge accounting the operating result of a company is impacted by FX volatility, although the company hedges its FX exposure. This could create a wrong image of the economic situation of a company.

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