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The FX Derivatives Trend:
Pricing, Strategies & Hedging Issues

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To my cousin Nick

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ABSTRACT

There is a market out there with a volume of $640 trillion(T). This market, or even better, this world is called over-the-counter (OTC) derivatives market. In such a huge market, it is essential to understand how derivatives work, how they are used and how they are priced. A derivative can be defined as a financial security whose value is derived from an underlying asset or group of assets. Although most underlying assets are stocks, bonds, commodities, interest rates and market indexes, the main underlying assets that we will focus on in this work, are going to be currencies.

The Foreign Exchange (FX) market can be split into three main product areas with increasing complexity:

I. Spot: guaranteed currency exchange occurring on the spot date.
II. Forwards: guaranteed currency exchange(s) occurring on a specified date(s) in the future.
III. Derivatives: contracts whose value is derived in some way from a reference FX rate.

A short flashback is enough to see the role of these products in the entire economy. As they have come under a great deal of criticism in the credit crisis of 2007, a brief comment of regulation is required. After representing the pricing formulas adapted to movements in volatility, the next step is to create a simulation. A business who imports or exports products is exposed to foreign exchange risk. Financial institutions offer a variety of option strategies to their corporate clients, providing thus ways to lock in prices or hedge against unfavorable movements in rates and FX—often for a limited cost. So, hedging strategies and products are going to be examined and priced. A financial institution that sells an option to a client in the OTC markets is faced with the problem of managing its risk. Therefore, the financial institution can neutralize its exposure by buying the same option that it has sold. When the option has been tailored to the needs of a client, though, hedging the exposure is far more difficult. Thankfully, the “Greeks” give a solution.

Keywords: derivatives, forward, option, over-the-counter, currency, foreign exchange, Black and Scholes, hedge, Greeks, delta, volatility, vega, long, short, notional

ABSTRACT

Υπάρχει μια αγορά εκεί έξω με όγκο $640 τρισεκατομμυρίων. Αυτή η αγορά, ή ακόμα και καλύτερα, αυτός ο κόσμος ονομάζεται εξωχρηματιστηριακά παράγωγα. Σε μια τέτοια ογκώδης αγορά, είναι σημαντικό να κατανοήσουμε πώς λειτουργούν, πώς χρησιμοποιούνται και πώς τιμολογούνται. Ένα παράγωγο μπορεί να οριστεί ως ένα συμβόλαιο του οποίου η αξία προέρχεται από έναν υποκείμενο τίτλο. Αν και οι πιο συνηθισμένοι τίτλοι είναι οι μετοχές, τα ομόλογα, τα εμπορεύματα, τα επιτόκια και οι δείκτες αγοράς, ο βασικός μας υποκείμενος τίτλος θα είναι οι ισοτιμίες συναλλάγματος.

Η αγορά συναλλάγματος μπορεί να χωριστεί σε τρεις βασικούς τομείς προϊόντων με αυξανόμενη πολυπλοκότητα:

I. Spot: εγγυημένη ανταλλαγή συναλλάγματος που πραγματοποιείται την ίδια χρονική στιγμή.
II. Forward: εγγυημένη ανταλλαγή συναλλάγματος που πραγματοποιείται σε συγκεκριμένη ημερομηνία (-ες) στο μέλλον.
III. Derivatives: συμβόλαια των οποίων η αξία προέρχεται κατά κάποιον τρόπο από μια συναλλαγματική ισοτιμία.

Μια σύντομη αναδρομή είναι αρκετή για να δούμε τον ρόλο τους σε ολόκληρη την οικονομία. Δεδομένου ότι έχουν υποβληθεί σε μεγάλη κριτική στην πιστωτική κρίση του 2007, μια σύντομη παρατήρηση σχετικά με το νομοθετικό πλαίσιο είναι αναγκαία. Μετά την παρουσίαση των τύπων τιμολόγησης, το επόμενο βήμα είναι να δημιουργηθεί μια προσομοίωση. Μια επιχείρηση που εισάγει ή εξάγει τα προϊόντα της είναι εκτεθειμένη στο συναλλαγματικό κίνδυνο. Τα χρηματοπιστωτικά ιδρύματα προσφέρουν ποικίλες στρατηγικές επιλογών στους εταιρικούς πελάτες τους. Παρέχουν έναν τρόπο να κλειδώσουν τις τιμές, να αντισταθμίσουν τις δυσμενείς κινήσεις των ισοτιμιών συχνά για ένα περιορισμένο κόστος. Έτσι, στρατηγικές αντιστάθμισης κινδύνου και προϊόντα πρόκειται να παρουσιαστούν και να τιμολογηθούν. Το ίδρυμα που πουλάει ένα δικαίωμα προαίρεσης σε έναν πελάτη αντιμετωπίζει το πρόβλημα της διαχείρισης του κινδύνου. Εάν το προϊόν διαπραγματεύεται ενεργά στην αγορά εξωχρηματιστηριακών συναλλαγών, ο χρηματοπιστωτικός οργανισμός μπορεί να εξουδετερώσει την έκθεσή του αγοράζοντας το ίδιο προϊόν που πώλησε. Αλλά όταν το προϊόν έχει προσαρμοστεί στις ανάγκες ενός πελάτη και δεν ανταποκρίνεται στα τυποποιημένα προϊόντα, η αντιστάθμιση της έκθεσης είναι πολύ πιο δύσκολη. Τα Greeks εδώ δίνουν τη λύση.

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List of Abbreviations

ABBREVIATION	EXPLANATION
ATM	At-the-money
B	Billions
BIS	Bank for International Settlements
CBOT	Chicago Board of Trade
CFTC	Commodities Future Trading Commission
CCY	Currency
ECB	European Central Bank
FX	Foreign Exchange
FWD	Forward
ITM	In-the-money
LTCM	Long Term Capital Management
M	Millions
OTC	Over-the-counter
OTM	Out-of-the-money
P&G	Proctor & Gamble
P&L	Profit & Loss
SG	Societe Generale
T	Trillions
TWI	Trade-Weighted Index

Glossary

TERM	DEFINITION
Arbitrage	Arbitrage occurs when a security is purchased in one market and simultaneously sold in another market at a higher price, thus considered to be risk-free profit for the trader.
Gross Domestic Product(GDP)	Total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period.
Collateralized Debt Obligation (CDO)	Complex structured finance product that is backed by a pool of loans and other assets and sold to institutional investors.
Credit Default swap (CDS)	Financial derivative or contract that allows an investor to "swap" or offset his or her credit risk with that of another investor, i.e. a lender is worried that a borrower is going to default on a loan, the lender could use a CDS to offset or swap that risk.
Commodity	Basic good used in commerce that is interchangeable with other commodities of the same type. Some traditional examples of commodities include grains, gold, beef, oil, and natural gas.
Consumer Price Index(CPI)	Measure that examines the weighted average of prices of a basket of consumer goods and services, such as transportation, food, and medical care. It is calculated by taking price changes for each item in the predetermined basket of goods and averaging them.
Counterparty risk	The likelihood or probability that one of those involved in a transaction might default on its contractual obligation.
Credit exposure	Refers to the total amount of credit that a lender avails to a borrower.
Credit risk	The possibility of a loss resulting from a borrower's failure to repay a loan or meet contractual obligations. Traditionally, it refers to the risk that a lender may not receive the owed principal and interest, which results in an interruption of cash flows and increased costs for collection.
Currency war	Refers to a situation where several nations seek to deliberately depreciate the value of their domestic currencies in order to stimulate their economies at the same time.
Current account	Records a nation's transactions with the rest of the world—specifically its net trade in goods and services, its net earnings on cross-border investments, and its net transfer payments—over a defined period.
Future	Legal agreement to buy or sell a particular asset at a predetermined price at a specified time in the future. Futures contracts are standardized for quality and quantity to facilitate trading on a futures exchange.

Hedge fund	Investment fund that pools capital from accredited investors or institutional investors and invests in a variety of assets, often with complicated portfolio-construction and risk management techniques.
Margin	Money borrowed from a brokerage firm to purchase an investment.
Market risk	The possibility of an investor experiencing losses due to factors that affect the overall performance of the financial markets in which he or she is involved. Market risk, also called "systematic risk," cannot be eliminated through diversification, though it can be hedged against in other ways.
Market sentiment	Refers to the overall attitude of investors toward a particular security or financial market. In broad terms, rising prices indicate bullish market sentiment, while falling prices indicate bearish market sentiment.
Market value	The price of a security that can be bought or sold in the marketplace.
Notional value	How much total value a security theoretically controls—it is the sum of options, forwards, futures, and foreign exchange currencies.
Real Effective Exchange Rate (REER)	Measures the value of a specific currency in relation to an average group of major currencies.
Secondary market	Place where investors buy and sell securities they already own.
Short selling	Refers to the sale of a security or financial instrument that the seller has borrowed to make the short sale. The short seller believes that the borrowed security's price will decline, enabling it to be bought back at a lower price.
Sovereign bond	Debt security issued by a national government.
Trade-Weighted Effective Exchange rate Index(TWI)	Economic indicator for comparing the exchange rate of a country against those of their major trading partners.

CHAPTER A: The History of Derivatives

1.1 Derivatives in BCE, CE, now and forever

Around 4000 BCE, the Sumerians started to use writing and mathematics to develop a revolutionary new accounting method for financial transactions using clay tokens stored in a clay vessel, and later clay writing tablets, to represent commodities, recording delivery dates for goods being traded. These resembled futures contracts are thought to be the first example of financial derivatives.

We continue around 600 BCE in ancient Greece, when philosopher Thales of Miletus[1] became the world's first olive oil derivatives trader. What Thales did was to exploit his knowledge of astronomy to predict a bumper season and position himself to profit from the rising price of oil by negotiating what were effectively call options on olive oil presses for delivery in the spring. Similarly, the Athenians used shipping contracts called Commandas that stipulated pricing, commodity type, volume and time considerations, hence resembled forward contracts. Italians issued another type of derivatives, the Monti shares. These shares were promises by the governments to repay debts in the future.

In 1515 Antwerp opened its Bourse, a building where traders could congregate to do business. By this time, traders were no longer purchasing commodities directly. They were buying and selling forward contracts. For the next two hundred years forward contracts were the main way commodities were traded, more akin to OTC derivatives than exchange-traded options.

In 1585, international trade moved to Amsterdam where one of the most significant developments in derivatives occurred with underline stocks. In need of funds to finance maritime trade, companies of Amsterdam merchants issued shares to create in 1602 the Dutch East India Company, a joint stock company.

In 1608, Isaac le Maire, an Antwerp merchant formed a syndicate and organized a first short-selling attack with a view to depressing the value of the company. The syndicate borrowed shares and then sold them but traders who engaged to speculate on their own account went bankrupt as they had to buy shares at prices much higher than the ones they negotiated for future delivery so short selling banned in 1610.

[1] Ancient Greek city on the western coast of Anatolia

In 17th Century in Japan, the first secondary market for commodity derivatives - Dojima Rice Exchange - was born. It was the first truly modern futures market worked like today, transactions were executed through a clearing house, which acting as an intermediary and guaranteed payments. Transferable rice vouchers actively traded and could be settled for cash. At that time rice played an important role in the economy, as rice was the main agricultural commodity and was the basis of national income. It was sold by way of auctions and once deals were done, the sellers issued a certificate of title – rice bill - in exchange for money. Merchants could hold the bills or could sell them in the hope of a quick profit within the defined period. However, as the market developed the deposits shrank and the delivery dates extended. The rice bills represented the right to take up delivery of an agreed quantity of rice at a future date but at a current price. The whole procedure looks like one of the most known derivatives, the forward contract.

1.2 USA & Derivatives "Love Story"

This new approach to trading soon crossed over the Pacific to North America where has been the cradle of innovation in derivatives. The development of computers and their growing use in finance, which allowed complex models and computations to be quickly solved, but also the lenient regulatory regime constituted key elements for innovation. Financial innovations were first introduced by exchanges.

In 1848, the Chicago Board of Trade (CBOT) was founded, which is the oldest organized futures market and still operating in the world. However, it merged with the Chicago Mercantile Exchange in 2007 to become the CME Group. Chicago, thanks to the Midwestern grain and its strategic location, was developing as a major center for the storage, sale and distribution of grain with forward contracts called "to-arrive" contracts. It allowed farmers to lock in the price and later deliver the crop. Due to the seasonality of grain, prices of grain were very volatile and it appeared that when fluctuations were too great, parties to deals backed out. The counterparty risks were significant.

From 1865, the CBOT made three important changes to the structure of its trading market. Contracts were standardized in terms of quality, quantity, and time and place of delivery. This change was later accompanied by the introduction of a clearinghouse that reduced the counterparty risk that had plagued OTC trading. The third change was the introduction of a margining system. In 1975, the CBOT introduced the first interest rate futures contracts,

called swaps. The birth of the OTC currency (ccy) swap negotiated between IBM[2] and the World Bank in 1981. The World Bank had borrowings denominated in U.S. dollars while IBM had borrowings denominated in German deutsche marks and Swiss francs. The World Bank agreed to make interest payments on IBM's borrowings while IBM in return agreed to make interest payments on the World Bank's borrowings. Since that first transaction in 1981, the swap market has seen phenomenal growth. Then, the first CDOs were issued by a Wall Street investment bank. However, derivatives trading still mainly took place on exchanges, but not for long. Already in 1991, the notional amount of OTC derivatives trading surpassed exchanged-traded derivatives. The nineties saw, among other things, the emergence of modern CDS and then about a decade later came the subprime crisis which will undoubtedly leave a permanent trace in the history of derivatives.

1.3 What about Regulation?

By spring of 1998, the chairman of Federal Reserve System[3] Alan Greenspan said that the current economic performance was as impressive as any he had witnessed in his near half century. In Washington, though, there was one agency that looked at the bull market with some skepticism, buried deep in the bureaucracy, the Commodities Future Trading Commission (CFTC) the agency who is authorized to regulate agriculture futures and to oversee derivatives. The CFTC started getting in the way in 1996 when a new chairperson, Brooksley Born, took over. An experienced financial litigator who'd seen the worst of the markets, Born was a believer in government regulation. She was determined that her agency would investigate fraud and the area that caught her attention was a new highly lucrative market: over-the-counter (OTC) derivatives.

1.4 The Chaos & the Scam

Born starts to realize that there's a whole world out there of OTC derivatives that are essentially unregulated and the government doesn't even know what's going on. On Wall Street they described it as black box. It was a $27T market happening out of sight, inside this black box. It had all happened in secret. The contracts aren't traded on exchanges. Only the

[2] IBM(International Business Machines Corporation) is an American multinational information technology company headquartered in Armonk, New York, with operations in over 170 countries. *Source:* https://www.ibm.com/gr-en
[3] Federal Reserve System is the Central Bank of United Stated of America.

parties involved in a deal knew what was happening. The derivatives market was a market that was not well understood, was growing rapidly, that had a few really smart, aggressive, innovative players. Trillions of dollars and the biggest banks of USA operating in secret. If something went terribly wrong, the high-stakes derivatives market could take down the entire financial system. Consider one big institution fails, it can't pay its obligations, so it forces somebody else into a dangerous territory who can't pay their obligations. Pretty soon, it's a falling domino effect through the economy. Anyone didn't know the dangers of the market because it was a dark market with no transparency. The conditions were favorable for things to go wrong.

In 1993, Bankers Trust, one of the largest banks in the United States (US) at the time, had sold derivatives to Proctor & Gamble(P&G)[4]. P&G sued Bankers Trust claiming that had been sold products that they didn't really understand. It opened a window onto what was really going on in the derivatives market. Bankers Trust employees took advantage of the fact that derivatives were too complicated to understand. But P&G discovered secret audio tape recordings of telephone calls among Bankers Trust brokers. A Bankers Trust employee said "We set 'em up."

Even this blatant scam may never have been discovered by the government. Looking inside Wall Street's black box was impossible for any government regulator. There was no record keeping requirement imposed on participants in the market. There was no reporting(!). No one knew how many of these were out there, how big this market it was, who owned them and who owed who money because it was just a bunch of contracts in file cabinets in the lawyers' offices of banks and hedge funds all over the world.

1.5 The warning

At Treasury, things were about to change. Brooksley Born was contemplating the regulation of OTC derivatives. Larry Summers[5], Bob Rubin[6] and Alan Greenspan tried to stop her, they

[4] P&G is an American multinational consumer goods corporation headquartered in Cincinnati, Ohio. It specializes in a wide range of personal care and hygiene products. *Source:* https://en.wikipedia.org/wiki/Procter_%26_Gamble

[5] Lawrence Henry Summers (1954) is an American economist, former Vice President of Development Economics and Chief Economist of the World Bank until 1993, senior U.S. Treasury Department official throughout President Clinton's administration until 2001 and former director of the National Economic Council for President Obama (2009–2010). *Source:* https://en.wikipedia.org/wiki/Lawrence_Summers

[6] Robert Edward Rubin (1938) is an American lawyer. He served as the 70th United States Secretary of the Treasury during the Clinton administration. Before his government service, he spent 26 years at Goldman Sachs, eventually serving as a member of the board and co-chairman from 1990 to 1992. *Source:* https://en.wikipedia.org/wiki/Robert_Rubin

were totally opposed to it. That puzzled her. What was in this market that had to be hidden? So, Born designed a document known as a concept release to regulate the OTC derivatives. To stop her, Rubin would call upon his allies who sat with him on the secretive council known as the President's Working Group, the most influential White House body on financial policy. The clear mission of the meeting was to convince Born that the concept release should not be issued with an argument that this deregulated market was part of what's brought them in the boom times. Markets will take care of everything and if they interfere it would be counterproductive. This tight-knit group tried to persuade her that they really would face a situation of financial turmoil if they undo these existing contracts.

But two weeks later, the concept release was published. The response of the Working Group was immediate and unprecedented. Rubin, Greenspan and Levitt[7] put out a statement saying "We have grave concerns about this action and its possible consequences. We are prepared to pursue, as appropriate, legislation that would provide greater certainty concerning the legal status of OTC. derivatives." But only Congress had the legal authority to stop Born. The 90% of the members of Congress couldn't have told you what a derivative was. All they knew was that the bankers on Wall Street some of whom make big campaign contributions, many of whom seem very smart and consider that if they go against them, it will devastate the economy. Born had no support anywhere. She had no political capital. She had no chance.

1.6 It's happening

Six weeks later, Born's warning became a prophecy. The hedge fund, Long Term Capital Management (LTCM), was melting down. It was run by John Meriwether, ex-Salomon Brothers. He's considered one of the great geniuses of the bond market. David Mullins[8] and John Meriwether operated LTCM outside government regulations. They were the personification or the embodiment of Alan's Greenspan's credo. Credo was, markets get it right. LTCM invented complex mathematical formulas and used derivatives to place their bets. Neither the government nor investors knew anything about how they worked. It was a

[7] Arthur Levitt Jr. (1931) is the former Chairman of the United States Securities and Exchange Commission (SEC). He previously served as a policy advisor to Goldman Sachs and is a Director of Bloomberg LP, parent of Bloomberg News. *Source:* https://en.wikipedia.org/wiki/Arthur_Levitt

[8] David Wiley Mullins Jr. (1946 -2018) was an American economist and former vice-chairman of the Federal Reserve. He also served as an assistant Secretary of the Treasury for domestic finance in the administration of United States President George H. W. Bush. He was in private finance of Long Term Capital Management and remained in following its collapse in 1998. *Source:* https://en.wikipedia.org/wiki/David_W._Mullins_Jr.

completely secret process. It was a black box with returns like 46%, 40% and 20% with people fighting to get in to invest, fighting to lend money. LTCM did business with 15 of Wall Street's biggest banks which hadn't done their homework. They didn't even know the extent of LTCM's exposures in the market. A quiet panic had begun. LTCM's complicated computer models were failing.

On 17 August 1998 in Russia, the financial markets were hit hard. A grave financial situation grew and the side effects of the crisis were evident everywhere. Credit markets around the world shut down. LTCM had all sorts of models that said, no matter what happened, based on history, they could not lose more than $35M a day. They started dropping $300M, $400M, $500M every day. Many banks had invested in LTCM's derivatives believing they alone were in a deal. They weren't. When LTCM started to get stressed, and wanted to collect their collateral, they all discovered that a lot of other parties had the same claims on it. With Wall Street's banks in a panic, LTCM was perilously close to collapse. And that's when Washington first heard about the problem. The members of the Working Group were told the entire American economy was hanging in the balance. The question was, if it came down how would that affect the American public? The fear was that if it went down, it would prevent what they call a systemic risk, something that could unwind the entire financial system.

1.7 Action & Reaction

After four days, the Federal Reserve acted, but not directly. The Wall Street banks were pressured to bail out LTCM themselves. The government became aware that financial stability was in jeopardy and the way to solve this problem was for each bank to pony up $400M and buy the fund, preventing it from collapsing. So, 14 banks agreed to put up a few hundred million each, about $3.5B. It worked and crisis passed. But yet again it was an unregulated market. Born resigned. OTC derivatives were off-limits. Banks were free to make riskier investments. Wall Street was largely left to regulate itself.

By 2007, the OTC derivatives market had grown to $595T. The hands-off approach seemed to be working. Wall Street had bet heavily on the real estate boom. Those derivatives were the heart of that strategy. People had derivatives insuring derivatives which in turn were also based on derivatives (!). What, in fact, people essentially had was a big, creaking time bomb that needed some sort of event to disrupt all of the assumptions everyone had. The time bomb exploded almost exactly ten years after the collapse of LTCM. Investors were shaken by

Leyhman Brothers bankruptcy filing and at the same time American International Group (AIG)[9] plunging. It was the rawest panic of the economy and financial markets since the 1930s. The answer was given by European Union (EU) and it's called Markets in Financial Instruments Directive (MiFID). MiFID is a regulation that increases the transparency across the financial markets, implements new measures, such as pre- and post-trade transparency requirements and set out the conduct standards for financial firms. The stated aim of the MiFID is for all EU members to share a common, robust regulatory framework that protects investors. MiFID came into effect a year before the 2008 financial crisis, but changes were made in light of the crisis.

Three years after the financial crisis fueled in part by a tangled web of derivatives, regulators still have an incomplete picture of who holds what in this $595T market. President Barack Obama[10] introduced a proposal for a "sweeping overhaul of the US financial regulatory system, a transformation on a scale not seen since the reforms that followed the Great Depression[11]". The 2010 Dodd–Frank Wall Street Reform and Consumer Protection Act[12] was supposed to improve regulators' ability to monitor derivatives. American banks had to start reporting specifics about their trades, including whom they traded with, to the CFTC. But the Dodd-Frank Act contained a big gap: Banks did not have to disclose to American regulators their holdings of derivatives housed in certain offshore entities. One consequence is that US regulators were unable to grasp the full exposure of American banks to their foreign rivals. Germany's troubled Deutsche Bank[13], for example, is one of the largest players in the derivatives market, and much of its derivatives trading occurs in foreign markets that are outside the purview of American regulators. That means they had limited visibility into US banks' connections to Deutsche Bank. Other countries' regulators could seek information about those holdings, but they generally did not collect the same data that was reported to American regulators. Goldman Sachs, for example, reported its total exposure to the derivatives market as a single number: The bank had $45B in OTC derivatives alone on its balance sheet at the end of 2017. Because of the trading in its Goldman Sachs International

[9] American International Group, Inc., also known as AIG, is an American multinational finance and insurance corporation with operations in more than 80 countries and jurisdictions. *Source:https://en.wikipedia.org/wiki/American_International_Group*

[10] Barack Hussein Obama (1961) is an American attorney and politician who served as the 44th president of the United States from 2009 to 201

[11] The Great Depression was a severe worldwide economic depression that took place mostly during the 1930s, beginning in the United States.

[12] The Dodd–Frank Wall Street Reform and Consumer Protection Act (commonly referred to as Dodd–Frank) is a United States federal law that was enacted on July 21, 2010. The law overhauled financial regulation in the aftermath of the financial crisis of 2007–2008, and it made changes affecting all federal financial regulatory agencies and almost every part of the nation's financial services industry. *Source: https://en.wikipedia.org/wiki/American_International_Group*

[13] Central Bank of Germany.

Bank unit and other foreign subsidiaries, a certain amount of those trades was invisible to American regulators. A Goldman spokesman said less than 1% of the bank's global derivatives activity wasn't visible to the CFTC, but he declined to comment further.

1.8 MIFIR - MIFID II: Everything is set now

After the original MiFID who went into effect in November 2007, the onset of the subsequent global financial crisis exposed some weaknesses in its provisions. It focused too narrowly on stocks, ignoring fixed-income assets, derivatives, currencies, and other assets and did not address dealings with firms or products outside the EU, leaving the rules about those dealings to be decided by individual members. This meant some firms outside the EU could have a competitive advantage over firms inside the union because of the easier regulatory oversight. This issue was addressed through MiFID II, which was implemented in January 2018 and harmonized the rules for all firms with EU clients. It was the largest and most sweeping regulatory regime in a generation. MiFID II which works in conjunction with Markets in Financial Instruments Regulation (MiFIR) usher in a new global era as it changed market structure, influenced investment behavior, created new technological infrastructure, and required extensive regulatory compliance, reporting, record keeping and storage. It affected everyone from banks and fund managers to brokers and pension funds. In particular:

I. It imposes more reporting requirements and tests in order to increase transparency and reduce the use of dark pools (private financial exchanges that allow investors to trade without revealing their identities) and OTC trading. Brokers will have to provide more detailed reporting on their trades—50 more pieces of data, in fact— including price and volume information. They will have to store all communications, including phone conversations; electronic trading is encouraged since it is easier to record and track.
II. The new regulations also target high-frequency trading. Algorithms used for automated trading have to be registered, tested and have circuit breakers included.
III. It extends the scope of requirements under MiFID to more financial instruments. Equities, commodities, debt instruments, futures and options, exchange-traded funds, and currencies all fall under its purview. If a product is available in an EU nation, it is covered by MiFID II—even if, say, the trader wishing to buy it is located outside the EU.
IV. Bankers, traders, fund managers, exchange officials, and brokers—and their firms—all have to abide by its regulations. So do institutional and retail investors.

Logic suggests that greater transparency in financial markets means greater liquidity. However, manually repapering, amending or remediating the hundreds of thousands of OTC derivatives contracts to comply with MiFID II can actually reduce overall market liquidity. In the highly competitive and complex world of global financial derivatives, how well you understand your contractual book of business can tip the balance between success and failure. An intuitive smart document platform is not only a tool for proving compliance, it streamlines complex workflows, saves time and resources, removes human errors, uncover hidden risks and provides better insight for senior management. In an age of overwhelming regulation, smart document management could make that difference.

1.9 Last but not Least: ISDA Master Agreement

An ISDA Master Agreement is the standard document that is regularly used to govern OTC derivatives transactions. The Agreement, which is published by the International Swaps and Derivatives Association (ISDA), outlines the terms to be applied to a derivatives transaction between two parties, typically a derivatives dealer and a counterparty. The Master Agreement, known as a confirmation itself, is standard, but it is accompanied by a customized schedule, defining in some detail the payments required by the two sides, what happens in the event of default by either side, collateral requirements and so on.

CHAPTER B: INTRODUCTION

2.1 Derivatives Breaking Down

When a derivative is traded, the buyer agrees to purchase the asset on a specific date (or dates) at a specific price and its value comes from the fluctuations of the values of the underlying asset. The contract's seller is not obligated to own the underlying asset. He can execute the contract by giving the buyer enough money to buy the asset at the prevailing price or give the buyer another derivative contract that offsets the value of the first. This makes derivatives much easier and attractive than trade the asset itself.

On the downside, derivatives are difficult to value because, as it is already mentioned, they are based on the price of another asset. Besides that, they are also sensitive to changes in the amount of time to expiration, the cost of holding the underlying asset, and interest rates. Regardless of what is happening with the price of the underlying asset, supply and demand factors to cause a derivative's price and its liquidity to rise and fall. Also, since the derivative itself has no intrinsic value [41] is vulnerable to market sentiment and market risk.

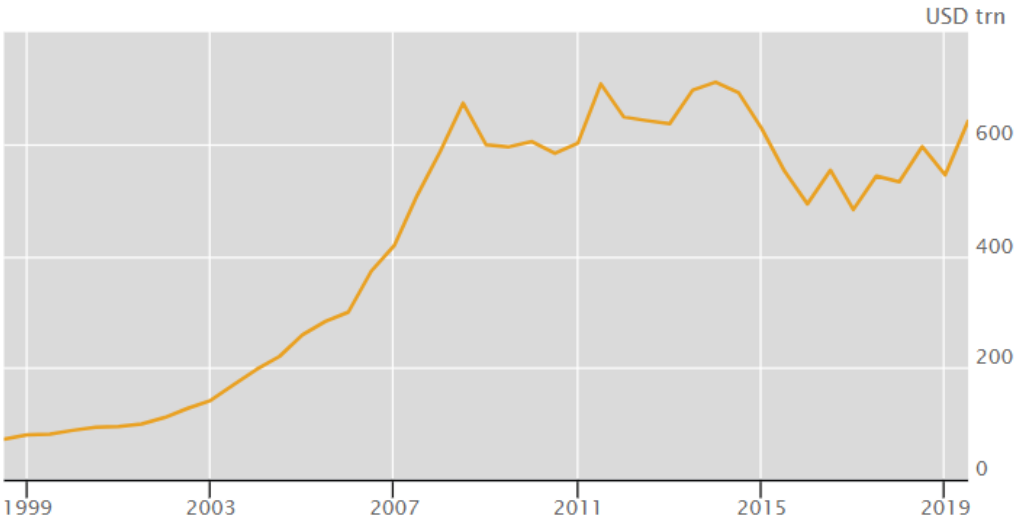
Derivatives can trade over-the-counter (OTC) or on an exchange. OTC refers to the process of how securities are traded for companies that are not listed on a formal exchange. Securities that are traded over-the-counter are traded via a broker-dealer network as opposed to on a centralized exchange. These securities do not meet the requirements to have a listing on a standard market exchange whose contracts are standardized and traded by individuals. They specify the premiums or discounts on the contract price. This standardization improves the liquidity of derivatives, thus making them more useful for hedging. But not all derivatives trading is on exchanges, just a small percentage. Banks, other large financial institutions, fund managers, and corporations are the main participants in OTC markets where there is a great possibility of counterparty risk. On the contrary, once two traders have agreed on a trade on the exchange market, it is handled by the exchange clearing house. The clearing house takes care of credit risk by requiring each of the two traders to deposit funds, known as margin, with the clearing house to ensure that they will live up to their obligations.

Derivatives can be used to hedge a position or speculate on the directional movement of an underlying asset. They can make future cash flows more predictable. They allow companies to forecast their earnings more accurately. That predictability boosts the economy because businesses need less cash on hand to cover emergencies so they man reinvest more into their business.

2.2 Market Size

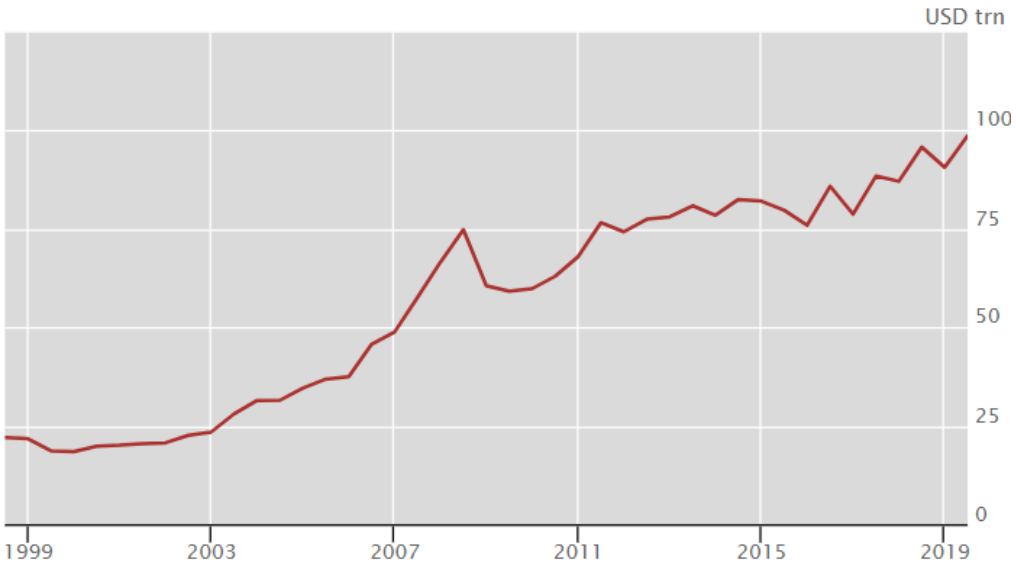
The Bank for International Settlements (BIS) started collecting statistics on the markets in 1998. In the title of this dissertation, the word "trend" has been chosen. The reason is noticeable in the charts below.

Figure 2. 1: Outstanding – Notional Amount of Derivatives



Source: BIS

Figure 2. 2: Outstanding – Notional Amount of Foreign Exchange Derivatives



Source: BIS

Figure 2.1 capture the outstanding positions of derivatives dealers, mainly banks. They cover the outstanding notional value, market value and credit exposure of OTC FX, interest rate, equity, commodity and credit derivatives. The data reported every six months by dealers in 12 jurisdictions (Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the US) plus data reported every three years by dealers in more than 30 additional jurisdictions.

2.3 Foreign Exchange

The FX market is a worldwide marketplace for trading currencies. In FX transactions, one currency is exchanged for another. Currencies are symbolized with a three-letter code and currency pairs are written CCY_1/CCY_2 where the exchange rate for the currency pair is the number of CCY_2 it costs to buy one CCY_1. For example, trading EUR/USD means exchanging amounts of EUR and USD. If the FX rate goes:

I. higher, EUR is getting relatively stronger against USD since it will cost more USD to buy one EUR.
II. lower, EUR is getting relatively weaker against USD because one EUR will buy fewer USD.

The most commonly quoted FX rate is the spot rate. For example, if the EUR/USD spot rate is 1.1000, EUR 1,000,000 (1M) would be exchanged for USD 1.1M. When a spot trade is occurred, the settlement is usually two business days after the transaction is agreed which is called T+2 settlement. However, in some currency pairs, for example, USD/CAD and AUD/NZD, the spot date is only one day after the transaction date (T+1).

Table 2. 1: G10 Currencies

CCY CODE	FULL NAME
AUD	Australian dollar
CAD	Canadian dollar
CHF	Swiss franc
EUR	Euro
GBP	Great British pound
JPY	Japanese yen
NOK	Norwegian krone
NZD	New Zealand dollar
SEK	Swedish krona
USD	United States Dollar

If a currency pair has both elements from the list above, it is described as a G10 currency pair. In G10 pairs, the market convention for quoting a currency pair can be deduced from this ordering:

EUR > GBP > AUD > NZD > USD > CAD > CHF > NOK > SEK > JPY

For example, the CAD against USD FX rate is quoted in the market as USD/CAD. The USD is by far the most frequently traded currency as either CCY_1 or CCY_2. EUR/USD is the most traded currency pair, followed by USD/JPY and then GBP/USD. FX traders draw a distinction between major currency pairs which means the most commonly traded currency pairs, and cross currency pairs. For example, EUR/USD and AUD/USD are majors while EUR/AUD is a cross. There are also triangular relationships. For example, if EUR/USD rises, then either USD/CNY must fall, or EUR/CNY rise by at least as much as EUR/USD does. The FX market is highly efficient so if EUR/USD spot is trading at 1.1000 and AUD/USD spot is trading at 0.6600, EUR/AUD spot will certainly be trading at 1.6600 (1.1/0.66).

Table 2. 2: Top 6 Most Tradable Currency Pairs

Ticker	Bid (BGNE)	Ask (BGNE)	High	Low
EURUSD	1.1084	1.1085	1.1089	1.1071
USDJPY	108.6130	108.6150	108.67	108.28
GBPUSD	1.2947	1.2948	1.2949	1.2916
USDCAD	1.3297	1.3297	1.3322	1.3295
USDCHF	.9908	.9909	.9916	.9891
AUDUSD	.6808	.6809	.6811	.6786

Source: Bloomberg Snapshot 21/11/19 11:00

The table above is a snapshot of a market-data tool showing live spot rates in major G10 currency pairs. In practice these rates change (tick) many times a second. The bid price represents the price that a buyer has to pay for the CCY. The ask price represents the minimum price that a seller is willing to take for the CCY. Columns high and low represent the maximum and the minimum rate of the day.

2.4 FX Market Outlook

There are many factors that affect the FX rates: Interest Rates, Consumer Price Index (CPI), Gross Domestic Product (GDP), Current Account and Sovereign Bonds. In recent years, there has been a special interest in the link between exchange rates and interest rates in both advanced and developing countries.

Figure 2. 3: 3 Month Euribor vs EUR Currency

Source: Bloomberg

In the figure above is exhibited how 3 Month Euribor rate and EUR currency index moved from 2010 since today. The 3 Month Euribor interest rate is the interest rate at which a selection of European banks lend one another funds denominated in EUR whereby the loans have a maturity of 3 months. The Euribor interest rates are the most important European interbank interest rates. It is common knowledge that Central Bank's announcement, news or even a terrorist attack make the spot volatile[45]**.** For example, if monetary authorities begin a program of expansionary monetary policy[14]:

I. The reduction in domestic investment by foreigners and the country's citizens will decrease the demand for the nation's currency and increase the demand for the currency of foreign countries. The exchange rate of the nation's currency will tend to decline.

II. With no government intervention, the financial account and the current account must sum to zero. As the financial account declines, the current account will be expected to improve by an equal amount. In other words, the balance of trade should improve. The country's export will have become relatively cheaper and imports will be relatively more expensive.

III. The increase in imports purchased will increase the need to convert domestic to foreign currency. As a result, the exchange rate of the domestic currency will decrease.

A restrictive monetary policy would be expected to result in the opposite. A higher exchange rate, a stronger financial account and a weaker current account. An unanticipated increase in the money supply will cause the exchange rate to go down, the financial account to weaken

[14] Expansionary policy is a form of macroeconomic policy that seeks to encourage economic growth.

and current account to gain strength. Over time, the income effect will come into play. A rising GDP will cause both the trade balance and financial account to weaken.

Figure 2. 4: Germany Rates vs EUR Currency

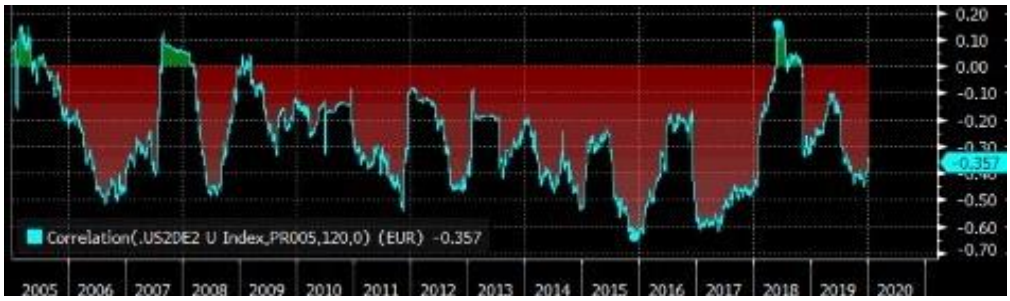
Source: Bloomberg

Figure 2. 5: Correlation between EUR currency – Germany 2Y Rates

Source: Bloomberg

As Germany has the biggest national economy in Europe, the influence in the EUR currency is obvious. In fact, there has been a reasonably strong relationship between the difference in German and American sovereign borrowing costs and the EURUSD rate, where an increase in relative yields goes hand in hand with an increase in the relative value of the dollar.

Figure 2. 6: Correlation between EURUSD – spread of US and Germany Rates



Source: Bloomberg

The reason that the correlation is negative is that the spread is calculated as US Rates – Germany Rates and the base currency is EUR.

Banks such as Societe General (SG)[15] creates forecasts depended on the market overview.

Table 2. 3: Market Overview

	GDP			CPI			INTEREST RATES			10Y BONDS		
	2018	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
US	2.9	2.3	0.7	2.4	1.8	1.9	1.92	2.13	1.02	2.86	2.07	1.38
EURO	1.9	1.2	0.9	1.8	1.2	1.2	0.00	0.00	0.00	0.40	-0.27	-0.48
UK	1.4	1.2	0.7	2.5	1.8	2.1	0.58	0.6	0.75	1.36	0.83	0.48
CHINA	6.6	6.1	5.8	2.1	2.8	1.2	2.55	2.35	2.54	3.65	3.22	2.87
JAPAN[16]	0.8	1	0.9	1	0.5	1.5	-0.10	-0.10	-0.10	0.07	-0.08	-0.14

Source: SG Cross Asset Research/Forex

Table 2. 4: FX Forecast

FX	2018	2019	2020
EUR/USD	1.18	1.12	1.18
EUR/GBP	0.89	0.89	0.85
GBP/USD	1.33	1.27	1.36
USD/CNY	6.59	6.89	7.14
USD/JPY	110.5	108.8	101.8

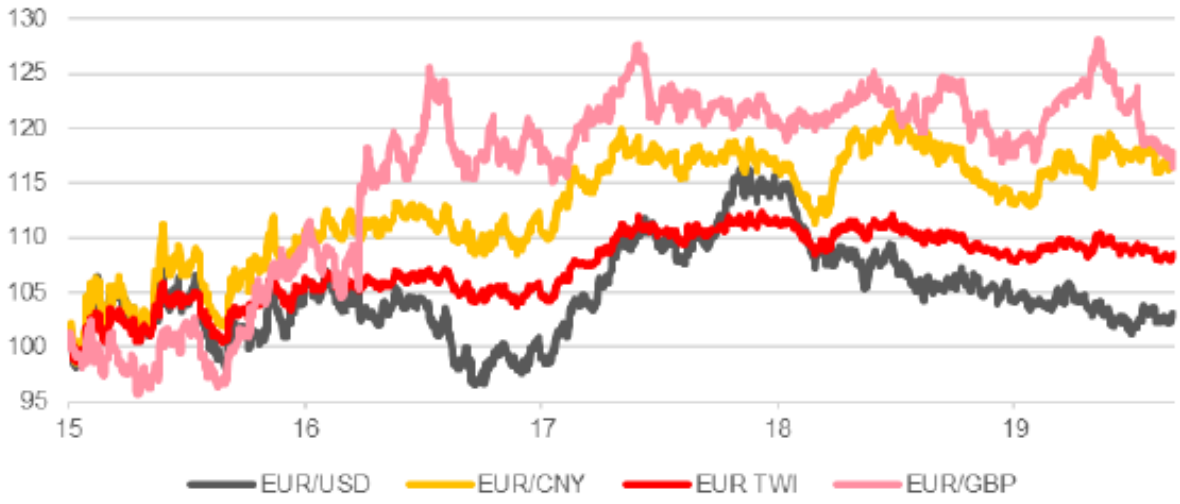
Source: SG Cross Asset Research/Forex

[15] Société Générale S.A. is a French multinational investment bank and financial services company headquartered in Paris.

[16] While seemingly inconceivable, there may be times when central banks run out of policy options to stimulate the economy and turn to the desperate measure of negative interest rates. Negative interest rates are an unconventional monetary policy tool that shows that policymakers are at risk of falling into a deflationary spiral. In harsh economic times, people and businesses tend to hold on to their cash while they wait for the economy to improve. By charging banks to hold reserves at the central bank, they hope to encourage banks to lend more. This means that deposit holders would also be charged for parking their money at their local bank while some borrowers enjoy the privilege of actually earning money by taking out a loan.

EUR: The euro is very undervalued relative to the dollar, and there is a huge amount of negative sentiment in the current price. The European Central Bank (ECB) has done almost everything that it can to revive growth, and yet we still see Germany slipping into recession in 2020.

Figure 2. 7: Euro moves since financial crisis



Source: SG Cross Asset Research/Forex

A simple way to see this is by looking at what happened in 2005-2008 as the euro rallied ahead of the financial crisis. EUR/USD rose by 33%, and USD/CNY fell by 13%. The result of that was a 12% appreciation in the traded-weighted euro's (EUR TWI) value which is bad enough for a major exporting nation. Needless to say, a 20% rise in EUR/GBP did not make a difference, either.

USD: President Trump[17] would rather see a weaker currency and lower rates. This administration believes that a strong dollar is costing Americans jobs, that the global trading system works to America's disadvantage and moreover that the US has had to wage currency war to prevent devaluation policy by others. As long as US growth and US interest rates hold up, then no change could be visible. Finally, the U.S.-China trade war may be on the road to resolution.

[17] Donald John Trump (1946) is the 45th and current president of the United States. Before entering politics, he was a businessman and television personality. *Source:* https://en.wikipedia.org/wiki/Donald_Trump

Figure 2. 8: USD moves in 2019

Source: SG Cross Asset Research/Forex

In real trade-weighted terms, the dollar is almost exactly where it was at the start of 2019. Over the past year, the dollar has risen against the Chinese yuan and the euro, fallen against the Canadian dollar and barely moved against the Mexican peso. The net result is that in real effective terms, it is virtually unchanged.

GBP: Sterling has been the pick of the G10 currencies in 2019 even though it hasn't actually done as well as the consensus expected a year ago. Even if current opinion polls are a good guide and the UK finally leaves the EU in January 2020, the saga will go on, with at least 11 months of EU/UK trade negotiations ahead.

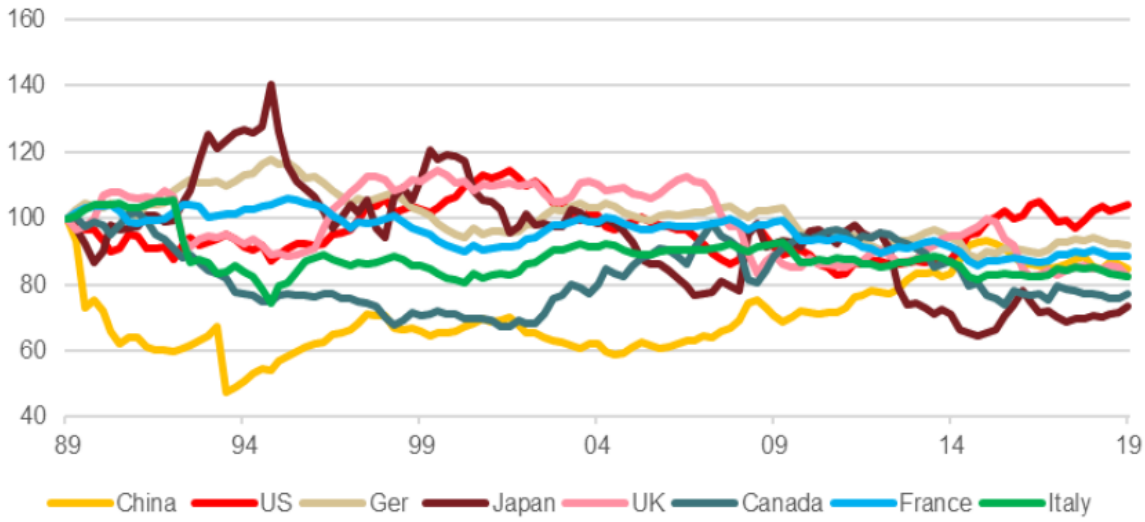
CHF: The Swiss franc is arguably the most expensive currency in G10. But this is not new, the currency is indeed very close to its average of the past decade. Over the medium run, the CHF Real Effective Exchange Rate (REER) is also strongly linked to domestic inflation. The CPI has fallen into negative territory, suggesting that Switzerland is threatened by deflation, and historically this has had a positive effect on the currency, though sometimes with a lag.

AUD: The Australian dollar has stayed on the weak side in the second half of 2019, establishing itself below 70 cents for the first time since the financial crisis. The break below 70 cents happened just when USD/CNY broke above 7.0. This year has seen the Reserve Bank of Australia cash rate halved to 75bp.

CNY: FX markets are no longer a bipolar world where the US dollar and euro dominate international trade and capital markets. Currencies now also strongly feel the yuan's gravitational pull, so understanding market dynamics has switched from being a two- to a three-body problem. It's been discussed a lot about the significance of moving to a tri-polar

global currency system. China is slowing, the People's Bank of China (PBoC)[18] is easing, and the yuan is pricing in some roll-back of US import tariffs. The evolution of the US-China trade war and the direction of global growth momentum remain the primary factors affecting the CNY. The less the US rescinds import tariffs on Chinese goods, the more USD/CNY can rise.

Figure 2. 9: REER rebased to 1989



Source: SG Cross Asset Research/Forex

A chart of G7[19] countries' currencies, plus China, shows that the strongest currency of the early 1990s, the JPY, has become the cheapest, while the one which started the 1990s falling, the CNY, has recovered. By and large, real values have converged, but they've all fallen with the exception of the dollar, which has clearly diverged from the pack, irking the President.

JPY: For years, the Japanese yen was an expensive currency, and then along came Abenomics[20] and aggressive monetary easing drove it down. The Bank of Japan (BoJ) has run out of room to ease, and Japan's investors will need to reduce foreign currency exposure.

[18] The People's Bank of China is the central bank of the People's Republic of China and is located in Beijing. Since July 2017, the PBOC has had the largest financial asset holdings of any central bank in the world. *Source:* https://www.investopedia.com/terms/p/peoples-bank-china-pboc.asp

[19] The Group of Seven (G-7) is a forum of the seven countries with the world's largest developed economies—France, Germany, Italy, Japan, the United States, the United Kingdom, and Canada—whose government leaders meet annually on international economic and monetary issues. *Source:* https://www.investopedia.com/terms/g/g7.asp

[20] Abenomics refers to economic policies enacted by Japanese Prime Minister Shinzō Abe at the outset of his second term. Abenomics involves increasing the nation's money supply, boosting government spending, and enacting reforms to make the Japanese economy more competitive. *Source:*https://www.investopedia.com/terms/a/abenomics.asp

CHAPTER C: FORWARD, VANILLA OPTIONS & CURRENCY SWAP

3.1 Forwards

One of the most commonly traded FX contracts is a forward or forward outright. Forward contracts on FX are very popular. Most large banks employ both spot and forward FX traders. Within a forward transaction, the cash flows settle on some future date other than the spot date. The maturity, or even better tenor of the contract must also be specified when rates are quoted on forwards. For example, if the EUR/USD one year forward FX rate is 1.1200, by transacting this contract in €10M notional, each EUR will be exchanged for 1.1200 USD. In a given currency pair, the spot rate and forward rates are linked by the respective interest rates in each currency. The difference between those two, called swap points or forward points.

For example, if EUR/USD spot is 1.1000 and the EUR/USD 1 year forward is 1.1200, the EUR/USD 1 year swap points are 0.0200. In the market, swap points are quoted as a number of pips. Pips are the smallest increment in the FX rate usually quoted for a particular currency pair. In EUR/USD, where FX rates are usually quoted to four decimal places, a pip is 0.0001. In the above example, an FX swaps trader would say that EUR/USD 1yr pips are 200. Another term used to describe spot moves is figure, meaning one hundred pips. For example, if the USD/JPY spot rate moves from 101.20 to 100.20, it is said that 'USD/JPY has dropped a figure'. In the exhibit below the quote is for EUR/USD.

Figure 3. 1: Forward EUR/USD Calculator

Source: Bloomberg 21/11/19

On the top there is the spot price, and on the left list there are pips on indicative dates. On the right list, it is possible to calculate the pips and the forward price for a preferable date.

But if Bloomberg is not an option, how the forward price is calculated?

We assume that the domestic currency is EUR. The underlying asset is USD. We will therefore define the variable S_0 as the current spot price in EUR of one unit of USD and F_0 as the forward price in EUR of one unit of USD. The holder of the currency can earn interest at the risk-free interest rate either in EUR or USD. We define r_f as the value of the foreign risk-free interest rate when money is invested for time T. The variable r_d is the domestic risk-free rate when money is invested for this period.

The relationship between F_0 and S_0 is:

$$F_0 = S_0 e^{(r_d - r_f)T} \tag{3.1}$$

This is the well-known interest rate parity relationship from international finance. Suppose that an individual start with $100. There are two ways it can be converted to EUR at time T:

I. By investing it for T years at r_f and entering into a forward contract to sell the proceeds for EUR at time T. This generates EUR $100e^{r_f T}F_0$.

II. By exchanging the USD for EUR in the spot market and investing the proceeds for T years at rate. This generates $100S_0e^{r_dT}$ EUR. In the absence of arbitrage opportunities, the two strategies must give the same result. Hence,

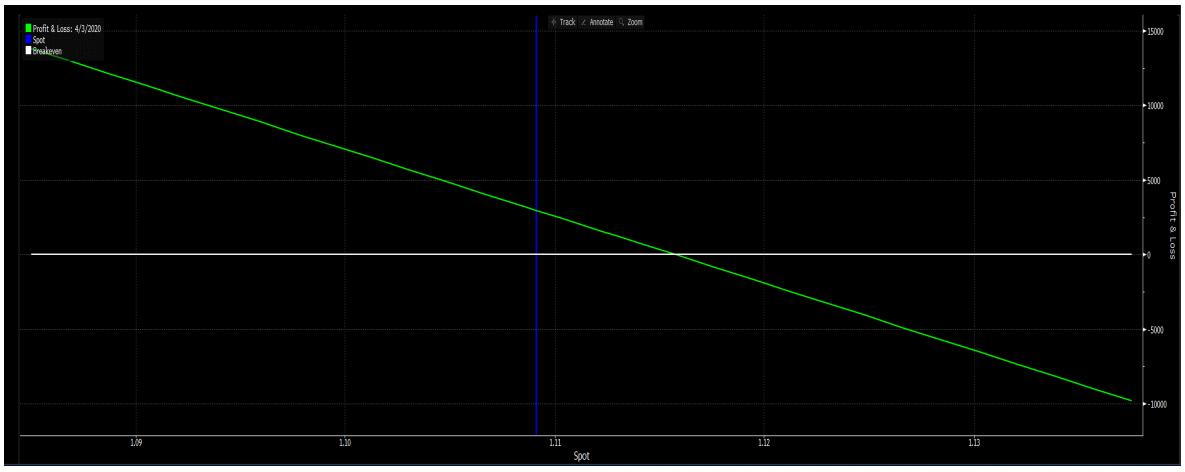
$$100e^{r_fT}F_0 = 100S_0e^{r_dT} \quad (3.2)$$

$$F_0 = S_0\, e^{(r_d - r_f)T} \quad (3.3)$$

3.1.1 Illustration

Consider a Greek corporation who imports its products in USD and knows that will pay $1M in 1 month. A useful comment in this situation is that this company needs to buy USD and sell as less EUR is possible. That means a high EUR/USD strike The corporation wants to hedge against exchange rate moves. The treasurer can agree to buy $1M 1 month forward at an exchange rate of 1.1130. The corporation then has a short forward contract on EUR. It has agreed that i.e. on 23/12/19 it will buy $1M from the bank for € 898.472,59. The bank has a long forward contract on EUR. Both sides have made a binding commitment. If the spot exchange rate rose to, say, 1.1200, at the end of 1 month, it would enable $1M to be purchased at an exchange rate of 1.1130 rather than 1.1200 and the forward contract would have a negative value to the corporation. Similarly, if the spot exchange rate fell to 1.1000 at the end of 1 month, the forward contract would have a positive value to the corporation of because it would lead to the corporation paying € 10.618,31 less than the market price. Because it costs nothing to enter into a forward contract, the payoff from the contract is also the trader's total profit or loss (P&L) from the contract. They are illustrated in Figure 3.2.

Figure 3. 2: P&L of the contract



Source: Bloomberg

3.2 FX Swap

The FX swap quoted by two FX deals in opposite directions. Most often one deal is a spot trade and the other deal is a forward trade to a specific maturity. The two trades are called the legs of the transaction and the notionals of the two legs of the FX swap are often equal in CCY_2 terms. An example here is necessary. Consider a trader who buys $10M USD/CAD spot at a rate of 1.3300. This means buying $10M and simultaneously selling CAD13.3M. This position is described as ‘‘long ten dollar-cad’’. A long position in a financial instrument makes money if the price of the instrument rises and loses money if the price falls(there is no domestic currency here as in 3.1). The concept of selling something you don’t initially own is a strange one in the real world, but it quickly becomes normal in financial markets where trading positions between long and short can flip often. So, USD/CAD spot jumps up to 1.3400. Time to sell USD/CAD spot and lock in the profit. Selling $10M USD/CAD spot at 1.3400 results in selling $10M against buying CAD13.4M. A CAD 0.12M profit occurred. Therefore, FX transactions and positions are usually quoted in CCY_1 while the P&L from the trade is naturally generated in CCY_2.

3.3 Roll Forward

Roll forward refers to extending the expiration or maturity of a forward by closing the initial contract and opening a new longer term contract for the same underlying asset at the (future) current market price. A roll forward enables the trader to maintain the position beyond the initial expiration of the contract, since it has finite expiration dates. It is usually carried out shortly before expiration of the initial contract and requires that the PnL on the original contract be settled. The steps are two.

I. The initial contract is exited.
II. A new position with a later expiry is initiated.

For example, if an investor has bought EUR/USD at 1.1000 for value on 30/06/20, the contract would be rolled on 28/06/20 by entering into a swap, if the spot rate in the market is 1.1100. The investor would sell the same number of EUR at that rate and receive the profit in USD on 30/06/20. The EUR would net to zero with no movement of funds. The investor would simultaneously enter into a new forward contract to buy the same number of EUR for the new forward value date; the rate would be the same 1.1100 spot rate plus or minus the forward points to the new value date.

3.4 Currency Swap

A swap is an OTC derivatives agreement between two companies to exchange cash flows in the future. The agreement defines the dates when the cash flows are to be paid and the way in which they are to be calculated. Usually the calculation of the cash flows involves the future value of an interest rate, an exchange rate, or other market variable but our focus in this chapter is fixed-for-fixed currency swap. It contains exchanging principal and interest payments at a fixed rate in one currency for principal and interest payments at a fixed rate in another currency. Two other popular currency swaps are:

I. Fixed-for-floating where a floating interest rate in one currency is exchanged for a fixed interest rate in another currency.
II. Floating-for-floating where a floating interest rate in one currency is exchanged for a floating interest rate in another currency.

A currency swap agreement requires the principal to be specified in each of the two currencies. The principal amounts in each currency are usually exchanged at the end of the life of the swap. Usually the principal amounts are chosen to be approximately equivalent using the exchange rate at the swap's initiation but when they are exchanged at the end of the life of the swap, their values may be quite different.

A forward contract can be viewed as a simple example of a swap. Whereas a forward contract is equivalent to the exchange of cash flows on just one future date, swaps typically lead to cash-flow exchanges taking place on several future dates. A fixed-for-fixed currency swap can therefore be valued assuming that forward rates are realized.

3.4.1 Illustration

Consider a three-year currency swap agreement between Aegean Airlines and Barclays entered into on 2017. We suppose that Aegean Airlines pays a fixed rate of interest of 3% in USD to Barclays and receives a fixed rate of interest of 1% in EUR from Barclays. Interest rate payments are made once a year and the principal amounts are $10M and €15M. This is termed a fixed-for-fixed currency swap because the interest rate in both currencies is fixed. Barclays is more creditworthy than Aegean Airlines, hence, there is a difference between the rates. Thus, at the outset of the swap, Aegean Airlines pays $10 million and receives €15 million. Each year during the life of the swap contract, Aegean Airlines receives €0.1M and pays $0.3M. At the end of the life of the swap, it pays $10M and receives €15M. The cash

flows to Barclays are the opposite. Suppose that the term structure of risk-free interest rates is flat in both Greece and the United States. The Greek rate is 0% per annum and the U.S. rate is 1.75% per annum (both with continuous compounding). The current FX rate is 1.1000. The calculations for valuing the swap as the sum of forward FX contracts by the side of Aegean Airlines are summarized in the following table (all amounts are in millions):

Table 3. 1: Total value of forward contracts

YEARS	EUR CASH FLOW	USD CASH FLOW	FORWARD FX RATE	USD VALUE OF EUR CASH FLOW	NET CASH FLOW	PRESENT VALUE
1	+0.15	-0.3	1.1194	+0.16	-0.14	-0.13
2	+0.15	-0.3	1.1391	+0.17	-0.15	-0.14
3	+15.15	-10.3	1.1592	+17.56	+7.26	+6.88
Total						+6.61

The swap can be used to transform the nature of assets. Suppose that Aegean Airlines can invest €15 million to earn 1% in EUR for the next three years but feels that EUR will strengthen (or at least not depreciate) against the USD and prefers a EUR denominated investment. The swap has the effect of transforming the USD investment into a €10M investment yielding 1%.

3.5 Options

Vanilla FX call option contracts give the right to buy spot on a specific date in the future while vanilla FX put option contracts give the right to sell spot on a specific date in the future. The term vanilla is used because calls and puts are the standard contract in FX derivatives. Approximately 90% of derivative transactions executed by an FX derivatives trading desk are vanilla contracts as opposed to exotic contracts. Exotic FX derivatives have additional features i.e. more complex payoffs, barriers & averages.

There are two main kinds of vanilla option:

I. European vanilla can be exercised only at the option maturity.
II. American vanilla can be exercised at any time before the option maturity.

European vanilla options are the standard product in the FX derivatives market because they are easier to risk manage and mathematically simpler to value. **Henceforth, any mention of a vanilla option means a European-style contract.**

To describe a vanilla FX option contract are required:

I. *Currency pair*. The spot FX rate in this currency pair is the reference rate against which the value of the vanilla option will be calculated at maturity.

II. *Call or put*. FX transactions exchange two currencies: one that is bought and one that is sold. Therefore, vanilla options are simultaneously a call on CCY_1 and a put on CCY_2 or vice-versa. Most often only the CCY_1 direction is specified when describing the contract, so, for example, a EUR/USD call option is a EUR call and a USD put.

III. *Maturity/expiry*. The date on which the owner of the option decides whether to exercise their option or let it expire.

IV. *Strike*. The rate at which the owner of the option has the right to exchange CCY_1 and CCY_2 at maturity.

V. *Notional***.** The amount of cash that can be exchanged at maturity.

VI. *Cut.* The exact time on the expiry date at which the option matures. The two most common cuts in G10 currency pairs are:

i. New York (NY): 10 A.M .New York time,

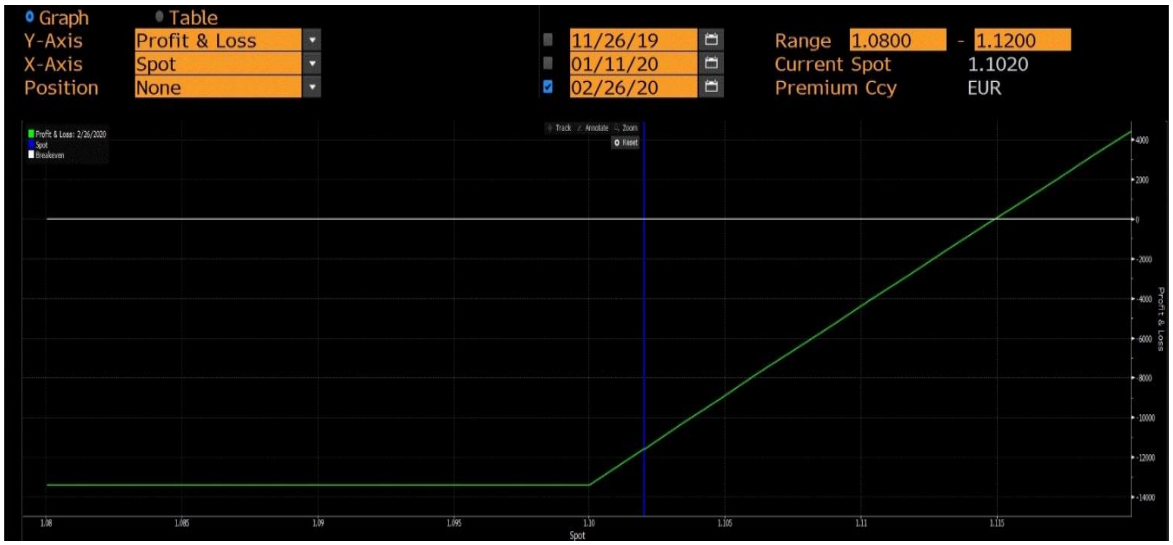
ii. Tokyo (TOK): 3 P.M.

Table 3. 2: FX derivatives pricing tool in EUR/USD call vanilla contract

TS Description			EUR/USD Vanilla 20200226
Price Date			11/26/19 12:40
Asset			EURUSD
Spot		Mid	1.1020
Style		European	Vanilla
Direction		Client buys	Physical
Call/Put		EUR	Call
Expiry		3 months	02/26/20
Delivery		NY 10:00	02/28/20
Strike		1.1000	0.80% ITMF
Notional		EUR	1,000,000.00
Model			Black-Scholes
Vol	BGN		4.296%/4.526%
More Market Data			
Points	BGN	Mid	68.55
Forward		Mid	1.1089...
EUR Depo	Implied	Mid	-0.961...%
USD Depo	USD OIS	Mid	1.494...%
Spread Data			
Greeks			
Advanced Greeks			
Results			
Price	% EUR		1.3612% P
Premium	EUR		13,611.63 P
Prem Date			11/29/19
T.V.			1.3464% P
Delta	Spot		63.3644%
Sticky Delta			63.4137%
Hedge			-633,644.14

Source: Bloomberg

Figure 3. 3: Net Profit from long call option



Source: Bloomberg

On the expiry date, the owner (buyer) of this European style vanilla option will contact the writer (seller) of the option to inform them if they want to exercise the option. If the spot rate at maturity is above the strike 1.1000, the option is said to be in-the-money (ITM). In this case the option will be exercised because the option gives its owner the right to transact at a better rate than the spot level. If the option is exercised, on the delivery date, the option owner will get longer €1M versus shorter $1.1M while the option writer will get the opposite position.

If the spot rate at maturity is below the strike, the option is said to be out-of-the-money (OTM). The option owner should let the option expire because EUR/USD spot can be bought more cheaply in the market. Note that for a put option with all other contract details the same, the ITM and OTM sides flip: the ITM side is below the strike and the OTM side is above the strike. The value of a vanilla option can be decomposed into intrinsic value plus time value:

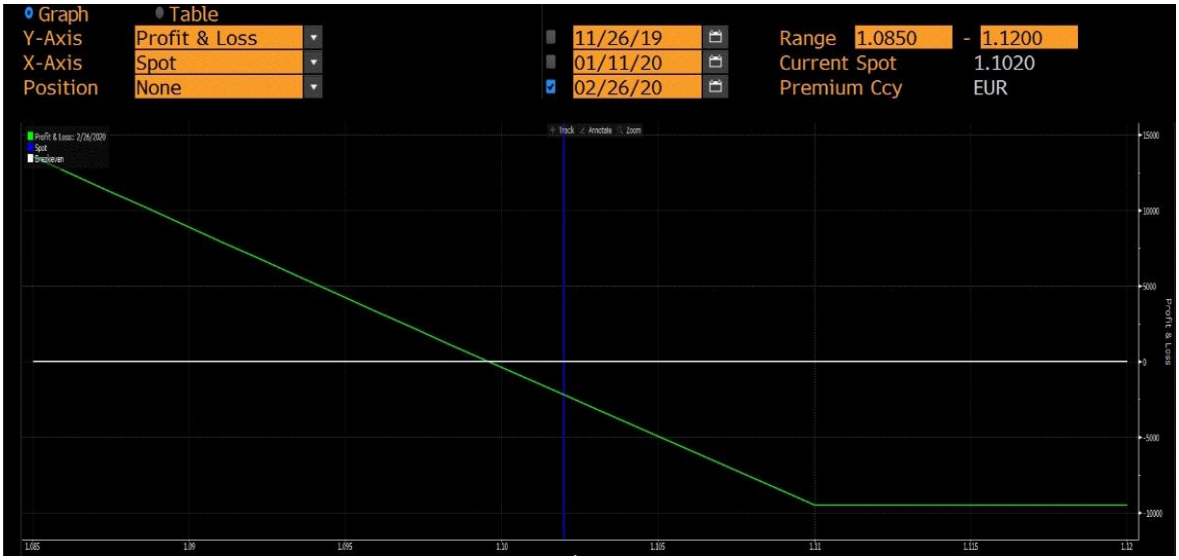
I. Intrinsic value is the option payoff at maturity.
II. Time value is the value expected to be generated from the remaining optionality in the contract.

Table 3. 3: FX derivatives pricing tool in EUR/USD put vanilla contract

TS Description		EUR/USD Vanilla 20200226	
Price Date		11/26/19	12:40
Asset		EURUSD	
Spot		Mid	1.1020
Style		European	Vanilla
Direction		Client buys	Physical
Call/Put		EUR	Put
Expiry		3 months	02/26/20
Delivery		NY 10:00	02/28/20
Strike		1.1100	0.10% ITMF
Notional		EUR	1,000,000.00
Model		Black-Scholes	
Vol	BGN	4.349%/4.564%	
More Market Data			
Points	BGN	Mid	68.55
Forward		Mid	1.1089...
EUR Depo	Implied	Mid	-0.961...%
USD Depo	USD OIS	Mid	1.494...%
Spread Data			
Greeks			
Advanced Greeks			
Results			
Price	% EUR	0.9695% P	
Premium	EUR	9,694.85 P	
Prem Date		11/29/19	
T.V.		0.9461% P	
Delta	Spot	-52.4668%	
Sticky Delta		-54.8423%	
Hedge		524,667.70	

Source: Bloomberg

Figure 3. 4: Net Profit from long put option



Source: Bloomberg

Within the pricing tool, both volatility and premium prices are shown for the contract. Some market participants want prices quoted in volatility terms while others want prices quoted in premium terms. The Black-Scholes formula provides the link between volatility and premium. A two-way volatility is given, and the Black-Scholes formula is used to calculate

an equivalent two-way premium. It may seem strange that a price would be quoted in volatility terms, but this is exactly how the FX derivatives market works.

CHAPTER D: Pricing formulas, Volatility & Greeks

4.1 Black and Scholes Formula

In the early 1970s, Fischer Black, Myron Scholes, and Robert Merton achieved a breakthrough in the pricing of European stock options and has become known as the Black–Scholes–Merton (or Black–Scholes) model. The model has had a huge influence on the way that traders price and hedge derivatives. The Black-Scholes (BS) framework implies that the price of the underlying, in this case the FX spot rate follows a geometric Brownian motion[21] and the FX rate at some future time, given its price today, is lognormal. The change in *ln S* between time *0* and some future time *T* is therefore normally distributed with mean $(\mu - \sigma^2/2)T$ and variance $\sigma^2 T$. That means:

$$lnS_T \sim \varphi[lnS_0 + (\mu - \frac{\sigma^2}{2})T, \sigma^2 T] \tag{4.1}$$

where μ is the expected return in a short period of time (annualized), σ is the volatility of the FX rate, S_T is the FX rate at time *T*, S_0 is spot and $\varphi(m, u)$ denotes a normal distribution with mean *m* and variance *u*.

The formula that gives prices for European vanilla calls and puts is:

$$Price_{call} = P_{call} = Se^{-r_f \cdot T}N(d_1) - Ke^{-r_d \cdot T}N(d_2) \tag{4.2}$$

$$Price_{put} = P_{put} = Ke^{-r_d \cdot T}N(-d_2) - Se^{-r_f \cdot T}N(-d_1) \tag{4.3}$$

$$d_1 = \frac{ln\left(\frac{S}{K}\right) + (r_d - r_f + \frac{1}{2}\sigma^2) \cdot T}{\sigma\sqrt{T}} \tag{4.4}$$

$$d_2 = d_1 - \sigma\sqrt{T} = \frac{ln\left(\frac{S}{K}\right) + (r_d - r_f - \frac{1}{2}\sigma^2) \cdot T}{\sigma\sqrt{T}} \tag{4.5}$$

where *S* is spot at time *T*, r_d and r_f are continuously compounded interest rates respectively, σ is the volatility of the underlying's returns, *K* is the strike price and *T* is the time to maturity

[21]The Brownian motion process, sometimes called the Wiener process, is one of the most useful stochastic processes in applied probability theory. A stochastic process [X(t),t≥0] is said to be a Brownian motion process if

i. X(0)=0,
ii. {X(t),t≥0} has stationary independent increments,
iii. For every t>0, X(t) is normally distributed with mean 0 and variance c^2t. (Ross, 1996)

of the option. The function *N(x)* is the cumulative probability distribution function for a variable with a standard normal distribution. In other words, it is the probability that a variable with a standard normal distribution will be less than x. The terms $N(d_1)$ and $N(d_2)$ in equation has a simple interpretation. $N(d_2)$ shows the possibility if the option is ITM and $N(d_1)$ shows how ITM the option is.

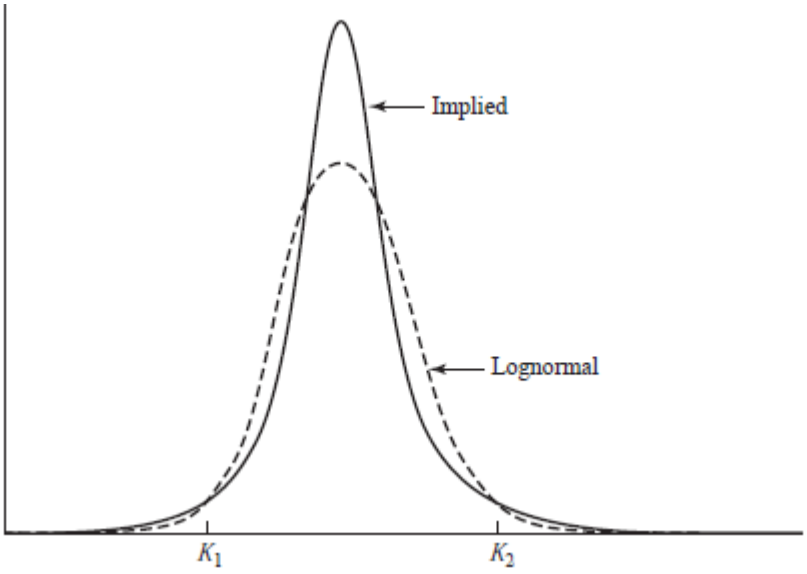
The equation does not involve any variables that are affected by the risk preferences of investors. If CCY_1 and CCY_2 interest rates both move higher to the same level, the forward will be unchanged but both call and put option prices decrease due to increased discounting. If the forward to maturity is far above or below the strike, the optionality has minimal value since there is little chance of spot going through the strike before maturity. FX derivatives traders typically quote prices in volatility terms because this makes the price making process easier. For a vanilla contract with a fixed maturity and strike, each time the spot rate changes, the option premium changes. However, the implied volatility quoted for a given contract can stay stable for longer, perhaps up to a few minutes in normal market conditions.

4.2 Implied Volatility

Volatility is a measurement of an asset tendency to move up or down in price. It is a function of uncertainty between the price and time to maturity, specifically, the more time until the expiration, the more uncertainty about the price at the expiration. Intuitively, if spot is more volatile, it will have more chances to go through the strike. There are times when the currency price stands still or moves within a very narrow range. In this case, we talk about the low volatility in the market. On the other hand, when key economic data are published or officials make a speech, the market price makes sharp and strong movements. So, here we can see an increase or even a spike of volatility.

The volatility of the FX rates cannot be directly observed. Although it can be estimated using historical data known as historical volatility, traders usually work with *implied volatilities* because are forward looking. These are the volatilities implied by option prices observed in the market and are used to monitor the market's expectation of future movement of the FX rate. To understand how implied volatilities are calculated, suppose that the market price of a European call option 0.0073 when S=1.1020, K=1.1000, rCCY_1 =1.49%, rCCY_2 =-0.96% and T=0.25. The implied volatility is the value of σ that, when substituted in the equation (4.2) gives c=0.0073. Usually, currency pairs with high liquidity tend to have less volatility. And, the lower the volatility of the currency pair is, the lower the risk is.

Figure 4. 1: Implied and lognormal distribution for foreign currency options



Implied distribution is also called risk-neutral distribution. It can be seen that implied distribution has heavier tails than the lognormal distribution. One way is to buy deep OTM call and put options on a variety of different currencies and wait. These options will be relatively inexpensive and more of them will close in the money than the lognormal model predicts[22]. BS formula assumes that the underlying asset price has a lognormal distribution at future times. Two of the conditions for an asset price to have a lognormal distribution are:

I. The volatility of the asset is constant.
II. The price of the asset changes smoothly with no jumps.

In practice, neither of these conditions is satisfied for an FX rate. The volatility of an FX rate is far from constant, and FX rates frequently exhibit jumps, sometimes in response to the actions of central banks. It turns out that both a nonconstant volatility and jumps will have the effect of making extreme outcomes more likely. The impact of jumps and nonconstant volatility depends on the option maturity. As the maturity of the option is increased, the percentage impact of a nonconstant volatility on prices becomes more pronounced, but its percentage impact on implied volatility usually becomes less pronounced.

There are two constructions of the volatility surface: **volatility smile** and **ATM curve.** Volatility smile defines the implied volatility for strikes away from the ATM strike. The other is **ATM curve** who forms the backbone of the volatility surface along different expiry dates.

[22] In the mid-1980s, a few traders knew about the heavy tails of foreign exchange probability distributions. Everyone else thought that the lognormal assumption of Black–Scholes–Merton was reasonable. The few traders who were well informed followed the strategy we have described—and made lots of money. By the late 1980s everyone realized that foreign currency options should be priced with a volatility smile, so Vanna-Volga adjustment gave the solution.(Hull, 2018)

To quote consistent vanilla option prices for any expiry date and strike, traders keep a volatility surface updated in each currency pair.

4.2.1 ATM Curve

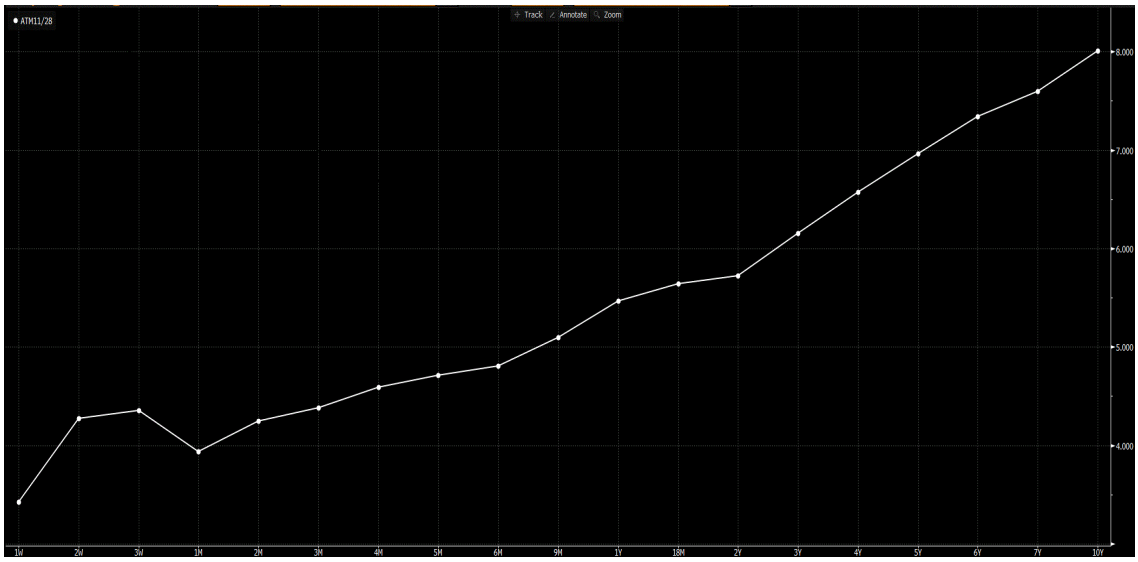
ATM contracts are vanilla contracts quoted to a specific maturity and they have a strike at the spot or forward to the same maturity. The table below shows the best bid and best offer for an ATM contract at each tenor. In the table below there are tradable rates that have been contributed by other banks. The EUR/USD 1month ATM two-way implied volatility price is 4.01%/4.31%: The contract will cost 4.01% volatility to buy while selling it will earn 4.31% volatility.

Table 4. 1: ATM EUR/USD Volatility

	ATM
Exp	Bid / Ask
1D	1.315 / 4.690
1W	2.685 / 4.010
2W	3.280 / 4.380
3W	3.710 / 4.410
1M	4.010 / 4.310
2M	4.360 / 4.660
3M	4.690 / 4.990
4M	4.815 / 5.115
5M	4.907 / 5.206
6M	4.975 / 5.275
9M	5.170 / 5.470
1Y	5.485 / 5.785
18M	5.670 / 5.985
2Y	5.760 / 6.090
3Y	6.175 / 6.505
4Y	6.570 / 6.915

Source: Snapshot Bloomberg – 27/12/19 11:47

Figure 4. 2: EUR/USD ATM Curve



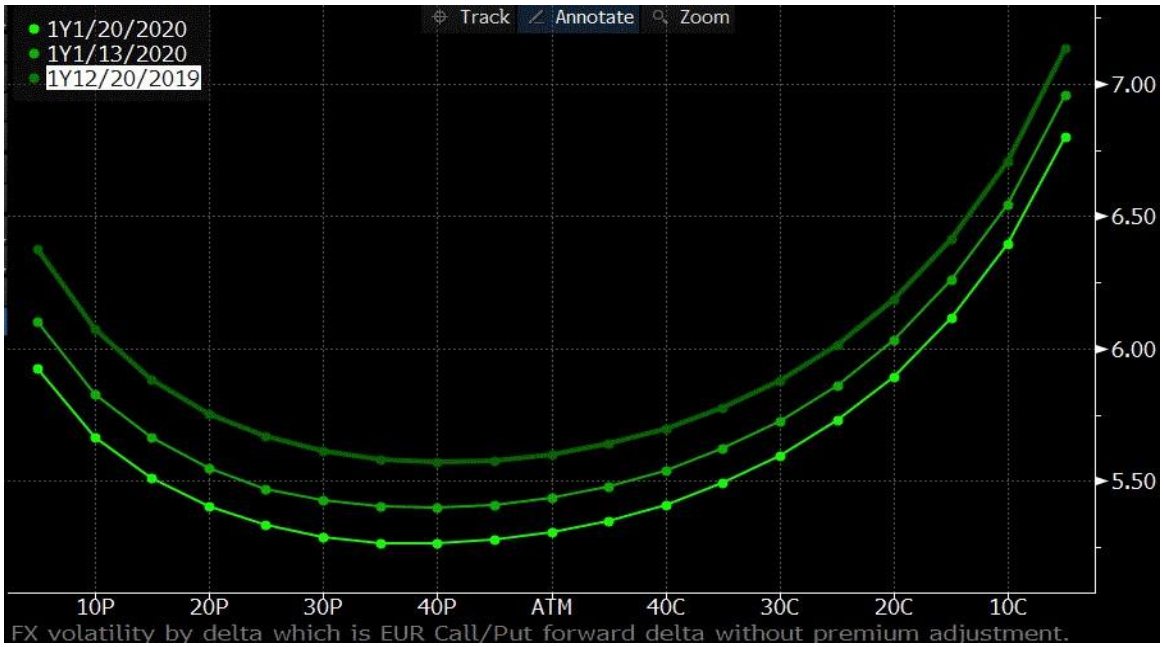
Source: Bloomberg

ATM curves are described as upward sloping if back-end (e.g., 1 year) ATM volatility is higher than front-end (e.g., 1 month) ATM volatility and as downward sloping if front end ATM volatility is higher than back-end ATM volatility. In quiet markets, backend ATM volatility tends to be higher than front-end ATM volatility as the figure above.

4.2.2 Volatility Smile

The history has proved that downside movements have been much greater and faster than movements to the upside. This means, that the tendency to purchase downside protection when markets move down is much greater than the tendency to purchase upside calls when the market moves up. This creates a volatility smile, a graphic representation of the implied volatilities of an option in vertical axis and the strike price or deltas on horizontal axis. They define how low strikes away from the ATM strike are priced relative to the ATM implied volatility at a given tenor. The implied volatility is relatively low for ATM options. It becomes progressively higher as an option moves either ITM or OTM. Volatility smiles exist due to the inaccuracy of the pricing models. If the assumption were accurate, then the implied volatilities of all options on the same underlying FX rates with the same maturities would have the same value.

Figure 4. 3: EUR/USD Volatility Smile 1 Year



Source: Bloomberg Snapshot – 20/01/20 11:54

The skew has the shape of "U", thus the name smile. The bottom point of the smile is where ATM strike falls and the upward curve on both sides of the smile is caused by the tendency for far OTM options to have higher implied volatilities. To conclude, the "U" graph explains that the further away an option's strike price is from the actual market price of the underlying, the higher the option volatility.

At each market tenor, three market instruments define the volatility smile:

I. *ATM* contracts define the implied volatility for a specific strike close to the forward for the given tenor.
II. *Butterfly (BF)* contracts define the implied volatility differential between the wings of the volatility smile and the ATM—a measure of the height of the wings of the volatility smile.
III. *Risk reversal (RR)* contracts define the implied volatility differential between strikes above and below the ATM—a measure of how skewed or tilted the volatility smile is.

Technically, the ATM represents the central reference point, the butterfly lifts the wings symmetrically higher on both sides, and the risk reversal tilts the smile one way or the other. Butterfly and risk reversal contracts are most often quoted at 25 delta (25D) and 10 delta (10D) strikes. An example run of market instruments at market tenors is shown below.

Table 4. 2: EUR/USD Volatility table

	ATM	25D RR	25D BF	10D RR	10D BF
Exp	Bid / Ask	Bid / Ask	Bid / Ask	Bid / Ask	Bid / Ask
1D	1.315 / 4.690	-1.080 / 1.280	-0.710 / 0.980	-1.855 / 2.195	-1.000 / 1.700
1W	2.685 / 4.010	-0.330 / 0.595	-0.230 / 0.435	-0.575 / 1.015	-0.265 / 0.795
2W	3.280 / 4.380	-0.220 / 0.550	-0.155 / 0.395	-0.380 / 0.940	-0.130 / 0.750
3W	3.710 / 4.410	-0.060 / 0.430	-0.050 / 0.300	-0.120 / 0.725	0.035 / 0.595
1M	4.010 / 4.310	0.090 / 0.300	0.055 / 0.205	0.150 / 0.510	0.230 / 0.470
2M	4.360 / 4.660	0.125 / 0.335	0.075 / 0.225	0.205 / 0.565	0.295 / 0.535
3M	4.690 / 4.990	0.175 / 0.385	0.095 / 0.245	0.290 / 0.650	0.360 / 0.600
4M	4.815 / 5.115	0.180 / 0.390	0.105 / 0.250	0.305 / 0.660	0.395 / 0.630
5M	4.907 / 5.206	0.194 / 0.403	0.118 / 0.265	0.348 / 0.704	0.459 / 0.696
6M	4.975 / 5.275	0.210 / 0.420	0.130 / 0.280	0.365 / 0.725	0.495 / 0.735
9M	5.170 / 5.470	0.230 / 0.440	0.150 / 0.300	0.415 / 0.775	0.580 / 0.820
1Y	5.485 / 5.785	0.255 / 0.465	0.165 / 0.315	0.465 / 0.825	0.685 / 0.925
18M	5.670 / 5.985	0.185 / 0.405	0.170 / 0.330	0.340 / 0.715	0.695 / 0.950
2Y	5.760 / 6.090	0.150 / 0.380	0.180 / 0.345	0.285 / 0.685	0.760 / 1.020
3Y	6.175 / 6.505	0.070 / 0.300	0.185 / 0.350	0.135 / 0.530	0.775 / 1.040
4Y	6.570 / 6.915	-0.005 / 0.235	0.185 / 0.360	-0.005 / 0.410	0.785 / 1.060

Source: Snapshot Bloomberg – 27/12/19 11:47

The following approximations link the ATM, 25D BF, and 25D RR instruments with the implied volatilities for the outright 25D call and put options at a given tenor:

$$\sigma_{Call25D} = \sigma_{ATM} + \sigma_{BF25D} + \frac{1}{2}\sigma_{RR25D} \quad (4.6)$$

$$\sigma_{Put25D} = \sigma_{ATM} + \sigma_{BF25D} - \frac{1}{2}\sigma_{RR25D} \quad (4.7)$$

Therefore,

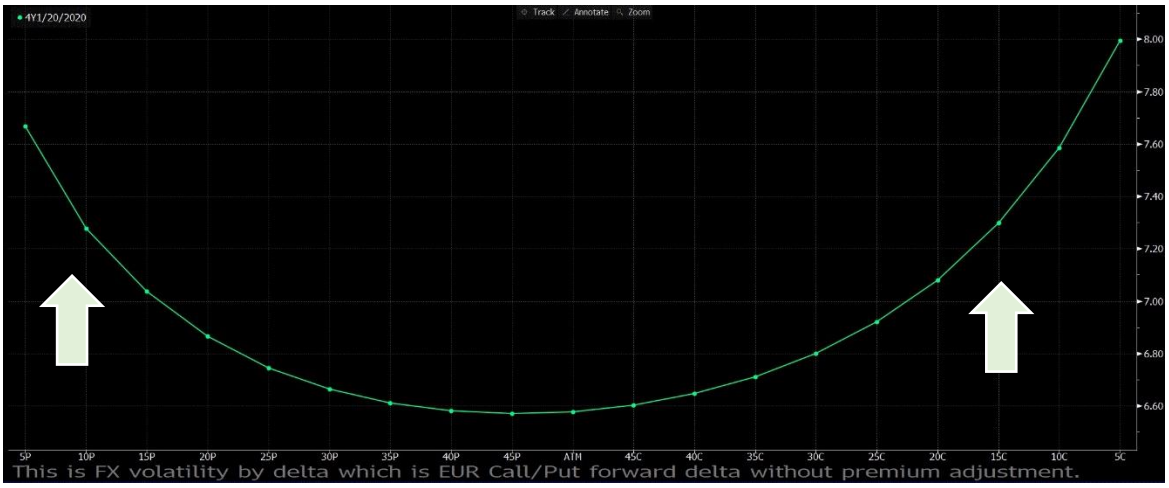
$$\sigma_{RR25D} = \sigma_{Call25D} - \sigma_{Put25D} \quad (4.8)$$

These approximations were generalized into a single formula for any delta by Allan M. Malz in 1997:

$$\sigma_{X\ Delta\ Put} = \sigma_{ATM} + 2\sigma_{RR25D} \cdot (X - 50\%) + 16\sigma_{BF25D} \cdot (X - 50\%)^2 \qquad (4.10)$$

If the butterfly increases, the wings of the volatility smile rise symmetrically as shown in Exhibit.

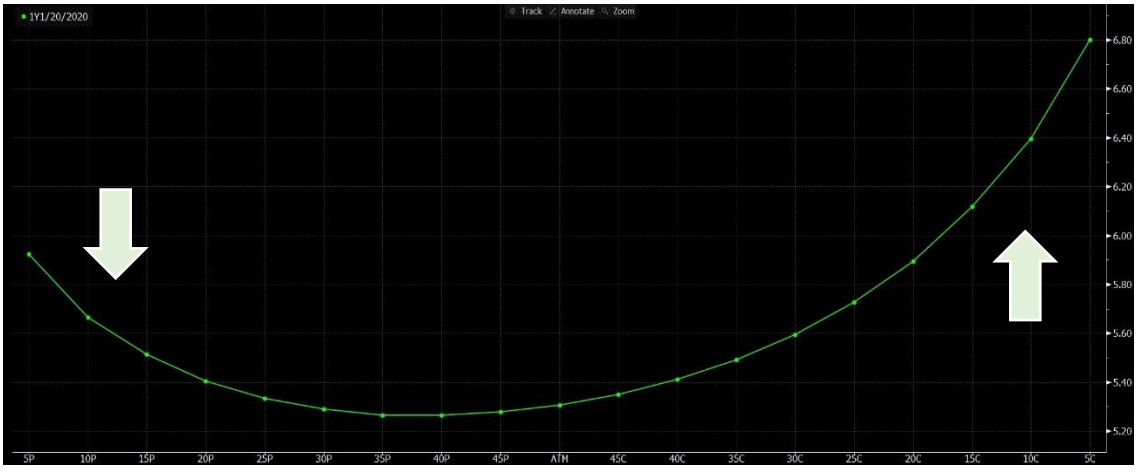
Figure 4. 4: Volatility smile rise symmetrically



Source: Bloomberg

With a positive risk reversal, strikes above the ATM have a higher implied volatility than the equivalent delta strikes below the ATM.

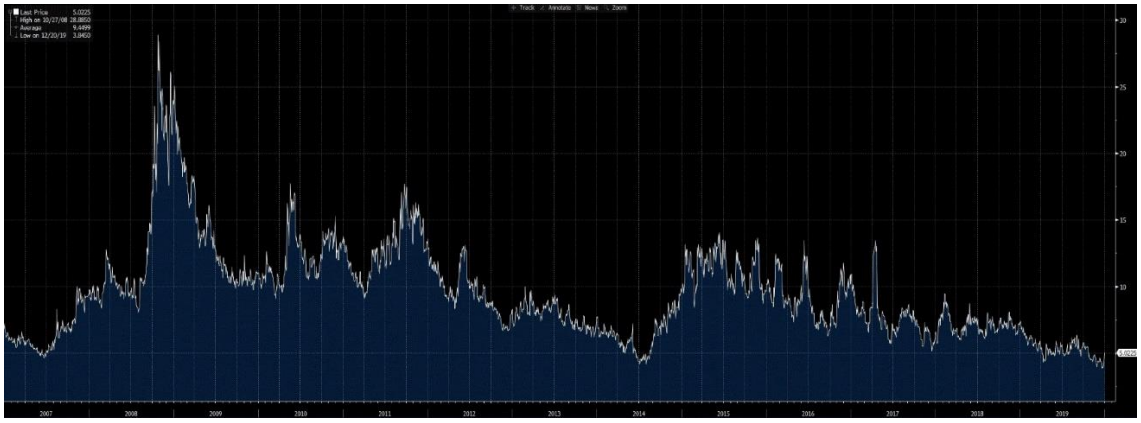
Figure 4. 5: Volatility smile rise asymmetrically



Source: Bloomberg

4.2.3 Volatility Market Outlook

Figure 4. 6: EUR/USD ATM 1 month Volatility



Source: Bloomberg Snapshot – 9/1/20 14:33

There's no doubt about it – volatility in the FX markets has been falling recently. As daily price swings have narrowed, expectations of future currency market moves have also dropped.

Table 4. 3: Volatile currency pairs

MOST VOLATILE CCY PAIRS	LEAST VOLATILE CCY PAIRS
AUD/JPY	EUR/GBP
NZD/JPY	USD/CHF
GBP/AUD	EUR/USD
AUD/USD	NZD/USD

While lower volatility makes it hard for traders to make money, in fact it's something to be celebrated. But why the FX volatility is so low?

I. The dispersion of current accounts among countries is falling. That means less reason for money to flow from one part of the world to another. Currencies often act as the "balancing item" between countries. Changes in currency values are the way that these imbalances get rectified. With fewer imbalances, there are fewer opportunities to profit from eventual policy changes in one country or another.

II. Policy makers have succeeded in bringing inflation down around the world. Years ago, there was a very wide dispersion of inflation rates; now they are all converging. Furthermore, they're converging mostly below 2%, the rate that most major central banks have chosen as their target. Below-target inflation is causing them to cut their interest rates. This too is dampening volatility, for two reasons.

i. First off, there's less opportunity to profit from central bank moves. No one is hiking rates, so while there may be reasons to leave a currency, there's less reason to buy a currency.
ii. Secondly, countries can only cut so far. Switzerland, with its -0.75% policy rate, has the lowest interest rates in recorded history. As interest rates get lower and lower, once again the divergence among countries falls, meaning there's less reason to move money from one country to another.
III. In this low inflation, low-interest-rate environment, carry trades – a major strategy for FX investors – haven't proved very profitable. That's because with a narrower spread between different interest rates, there's less money to be made borrowing in a low-interest-rate currency and lending in a high-interest-rate currency.

4.3 Greeks

To risk manage derivatives positions traders use Greeks; the exposures of the position to market changes. Greeks are calculated on each deal in the portfolio and then aggregated together. Each Greek letter -delta, gamma, vega, rho, theta- measures a different dimension to the risk in an option position. In order to calculate a Greek letter, it is necessary to assume an option pricing model. Traders usually assume the BS model and set the volatility equal to the current implied volatility. A trader naturally feels confident if the risks of changes in all these variables have been adequately hedged and the procedure is known as delta hedging.

4.3.1 Delta

The most important "Greek" is delta which is the exposure of the option value to the spot rate. Mathematically, is the first derivative of an option value with respect to spot.

$$Delta(\Delta) = \frac{\partial P}{\partial S} \tag{4.11}$$

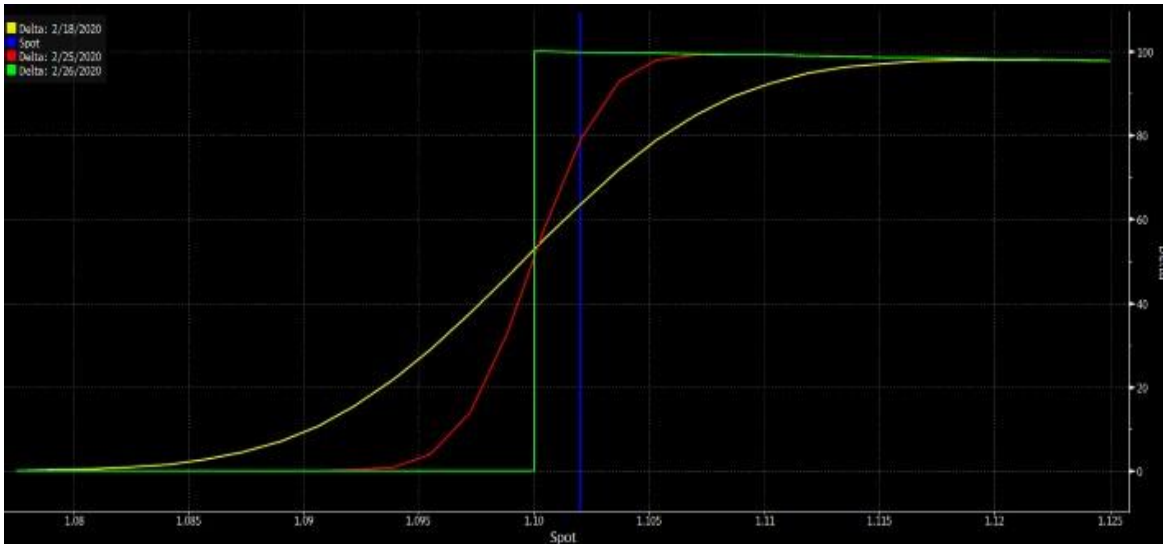
where P is the option price and S is spot rate. It can also be considered as the % chance of ending up ITM at maturity. Call options with strikes close to spot have a delta of approximately 50%. As spot goes lower, the call option delta reduces as does the chance of ending up ITM. The delta of a call option is positive because the value of a call option increases with a spot higher in a long position, whereas the delta of a put option is negative.It must be mentioned that

$$\Delta(call) = N(d_1) \tag{4.12}$$

where d_1 *and* $N(x)$ are defined in equation (4.4). The formula gives the delta of a long position in one call option. The delta of a short position in one call option is - $N(d_1)$. Using delta hedging for a short position in a European call option involves maintaining a long position of $N(d_1)$ for each option sold. Similarly, using delta hedging for a long position in a European call option involves maintaining a short position of $N(d_1)$ for each option purchased.

For example, if an AUD/USD put option has –10% spot delta and AUD80m of the contract is bought, AUD8m AUD/USD spot must be bought on the hedge in order to leave delta in the trading position unchanged. If the option was sold instead, spot must be sold on the hedge.

Figure 4. 7: Delta Exposure in a long call EUR/USD



Source: Bloomberg

Figure 4.7 shows the delta of a long vanilla call option with a 1.1000 strike. At maturity, there is a discontinuity in delta from 0% below the strike to 100% above caused by either expiring the option above the strike hence having no position or exercising the option below the strike hence buying spot in the full notional amount. Prior to maturity, the delta still goes from 0% to 100% but the change occurs over a wider spot range.

4.3.1.1 Delta Hedging Simulation

Consider a 1 month EUR 1M call at 1.1000 priced at 27/11/19. The historical prices of EUR/USD are exhibited below.

Table 4. 4: EUR/USD Historical Prices

Date	Last Price	Date	Last Price	Date	Last Price
Fr 01/17/20		Fr 12/27/19	1.1177	Fr 12/06/19	1.1060
Th 01/16/20		Th 12/26/19	1.1098	Th 12/05/19	1.1104
We 01/15/20	1.1127	We 12/25/19	1.1093	We 12/04/19	1.1078
Tu 01/14/20	1.1128	Tu 12/24/19	1.1089	Tu 12/03/19	1.1082
Mo 01/13/20	1.1134	Mo 12/23/19	1.1089	Mo 12/02/19	1.1079
Fr 01/10/20	1.1121	Fr 12/20/19	1.1079	Fr 11/29/19	1.1018
Th 01/09/20	1.1106	Th 12/19/19	1.1122	Th 11/28/19	1.1009
We 01/08/20	1.1105	We 12/18/19	1.1114	We 11/27/19	1.0999
Tu 01/07/20	1.1153	Tu 12/17/19	1.1150	Tu 11/26/19	1.1021
Mo 01/06/20	1.1197	Mo 12/16/19	1.1144	Mo 11/25/19	1.1014
Fr 01/03/20	1.1161	Fr 12/13/19	1.1121	Fr 11/22/19	1.1021
Th 01/02/20	1.1172	Th 12/12/19	1.1130	Th 11/21/19	1.1059
We 01/01/20	1.1212	We 12/11/19	1.1130	We 11/20/19	1.1073
Tu 12/31/19	1.1213	Tu 12/10/19	1.1092	Tu 11/19/19	1.1078
Mo 12/30/19	1.1199	Mo 12/09/19	1.1064	Mo 11/18/19	1.1072

Source: Bloomberg 15/1/20 – 11:06

The delta exposure at the end of each week is exhibited in the table below:

Table 4. 5: Delta exposure

DATE	SPOT	DELTA (%)	DELTA NOTIONAL (€)	EUR DEPO (%)	FWD	IMPLIED VOLATILITY (%)
27/11	1.0999					
29/11	1.1018	62.98	620,983.38	-1.37	1.1042	4.123/4.434
06/12	1.1060	70.35	703,543.01	-0.91	1.1074	4.909/5.254
13/12	1.1121	89.96	899,685.52	-1.06	1.1131	3.636/5.335
20/12	1.1079	94.29	942,935.98	-0.97	1.1084	1.371/5.287
27/12	1.1135	**98.78**	987,876.07	-3.16	1.1135	**0.000**/5.340

Source: Bloomberg

It is obvious that it's an ITM contract. That means that as it comes to maturity and spot increases, delta increases too. Remember that delta describes the possibility of how ITM the contract is. At maturity there is almost 100% possibility to end ITM. As for the delta notional, it can also be referred as hedging: the position in this contract is long so it is essential to short this amount each week to be delta-hedged. When a position is delta neutral, no P&L change results from spot moving higher or lower. However, this only works for small moves in spot if the second derivative (gamma) is non-zero.

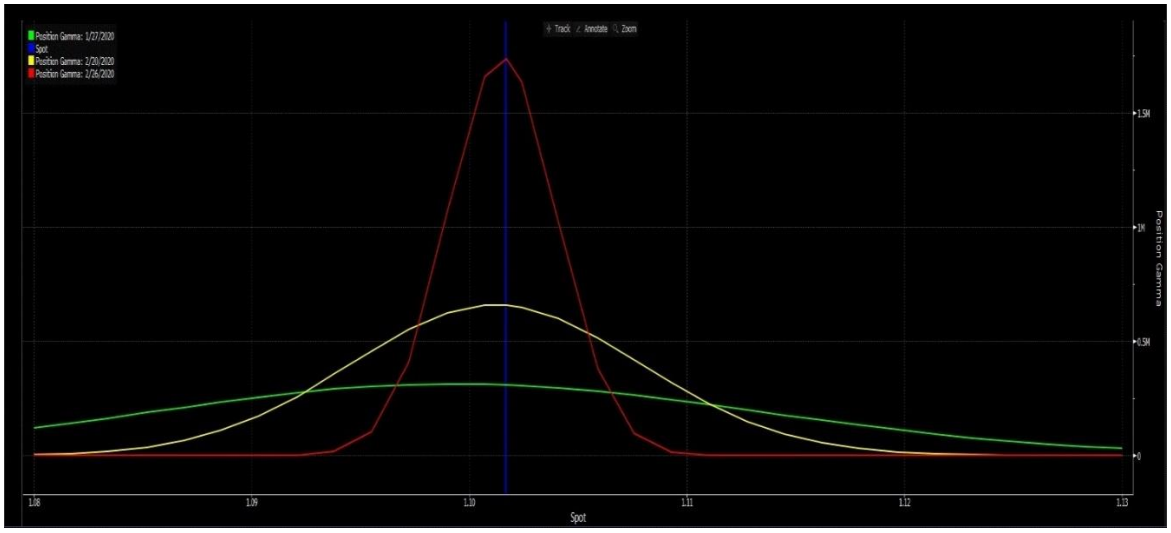
4.3.2 Gamma

Taking the first derivative of delta (or the second derivative of option price) with respect to spot gives another important Greek: Gamma. In symbols:

$$Gamma(\Gamma) = \frac{\partial \Delta}{\partial S} = \frac{\partial^2 P}{\partial S^2} \quad (4.13)$$

It describes how delta changes with respect to a 1 basis[23] point change in spot. Call and put options with the same strike and maturity have the same gamma profile. If gamma is small, delta changes slowly, and adjustments to keep a portfolio delta neutral need to be made only relatively infrequently. However, if gamma is highly negative or highly positive, delta is very sensitive to the price of the underlying asset. It is then quite risky to leave a delta-neutral portfolio unchanged for any length of time.

Figure 4. 8: Gamma Exposure in a long call EUR/USD



Source: Bloomberg

As time moves toward the option maturity, gamma increases and concentrates around the strike. Gamma at maturity is not shown on the graph because the discontinuity in delta cannot be neatly differentiated. At longer maturities, when there is a wider spot distribution, delta changes slowly as spot moves, hence low gamma. At shorter maturities, when there is a tighter spot distribution, delta changes quickly as spot moves, hence high gamma. Generally:

I. ITM options right before expiration have deltas of 100 and no gamma.
II. OTM options have no deltas and no gamma right before the expiration.
III. ATM options have the greatest gamma.

For a European call or put option, the gamma given by the BS model is:

$$\Gamma = \frac{N'(d_1)}{S\sigma\sqrt{T}} \quad (4.14)$$

[23] Basis points (BPS) are used to denote the percentage change in a financial instrument. One basis point is equal to 0.01%, or 0.0001.

where d_1 and $N(x)$ are defined in equation (4.4).

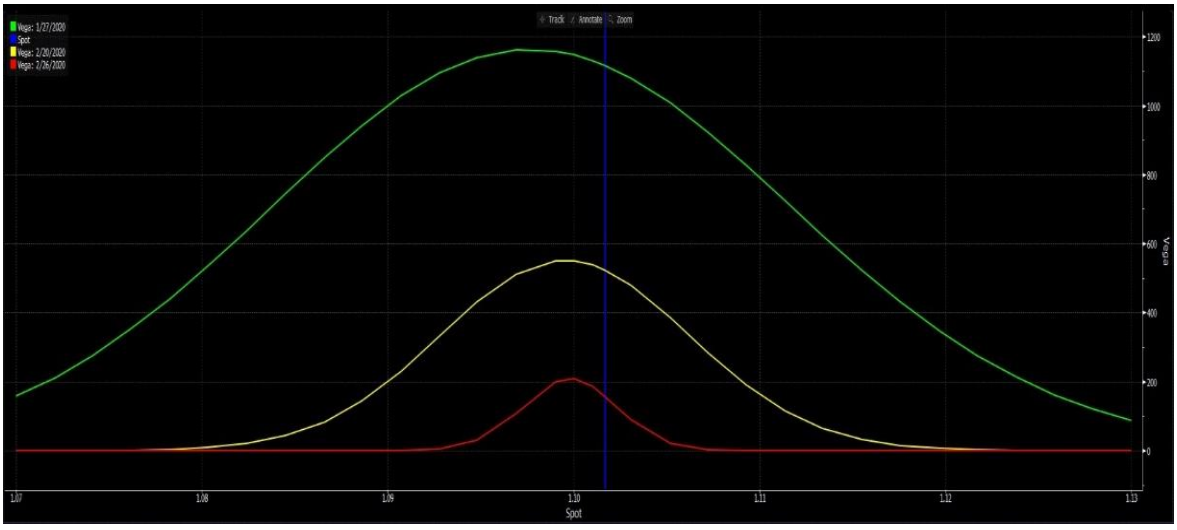
4.3.3 Vega

Up to now we have assumed that the volatility of the asset underlying a derivative is constant and then, that volatility change over time. This means that the value of a derivative is liable to change because of movements in volatility as well as because of changes in the asset price and the passage of time. Taking the first derivative of option value with respect to implied volatility gives a third important Greek: Vega. In symbols:

$$Vega(v) = \frac{\partial P}{\partial \sigma} \tag{4.15}$$

Vega measure the change in options premiums when volatility changes. Again, call and put options with the same strike and maturity have the same vega profile. If vega is highly positive or highly negative, the portfolio's value is very sensitive to small changes in volatility. If it is close to zero, volatility changes have relatively little impact on the value of the portfolio. Long option positions will be long vega and increase in value as demand increases. Short options positions will have a negative vega exposure and will profit from a decline in volatility.

Figure 4. 9: Vega Exposure in a long call EUR/USD



Source: Bloomberg

The result from the graph is that vega increases at longer maturities because there is more time for a change in implied volatility to impact the payoff.

For a European call or put option, vega given by the BS model is:

$$\upsilon = S\sqrt{T}N'(d_1) \tag{4.16}$$

where d_1 and N(x) are defined in equation (4.4).

Two other measures of the risk of an option position are theta and rho. Theta measures the rate of change of the value of the position with respect to the passage of time, with all else remaining constant. Rho measures the rate of change of the value of the position with respect to the interest rate, with all else remaining constant.

When managing a large portfolio dependent on a single pair, traders usually make delta zero, or close to zero, at least once a day by trading the underlying asset. It is usually not feasible to maintain gamma and vega neutrality on a regular basis. If it is required, at least two traded options depended on the currency pair must be used.

When trading vanilla options with strikes away from the ATM, the market convention is to always trade the OTM side (i.e., trade the call or put, whichever has the lower absolute delta). Therefore, if a vanilla option has a strike above the ATM, it will be traded as a CCY1 call/CCY2 put. If the strike is below the ATM, it will be traded as a CCY1 put/CCY2 call. This is important because, although the Greeks on a delta hedged call and a delta hedged put are the same, the OTM direction has a smaller premium and a smaller expected payoff at maturity and hence has less credit risk than the ITM direction.

4.4 Vanna-Volga Pricing

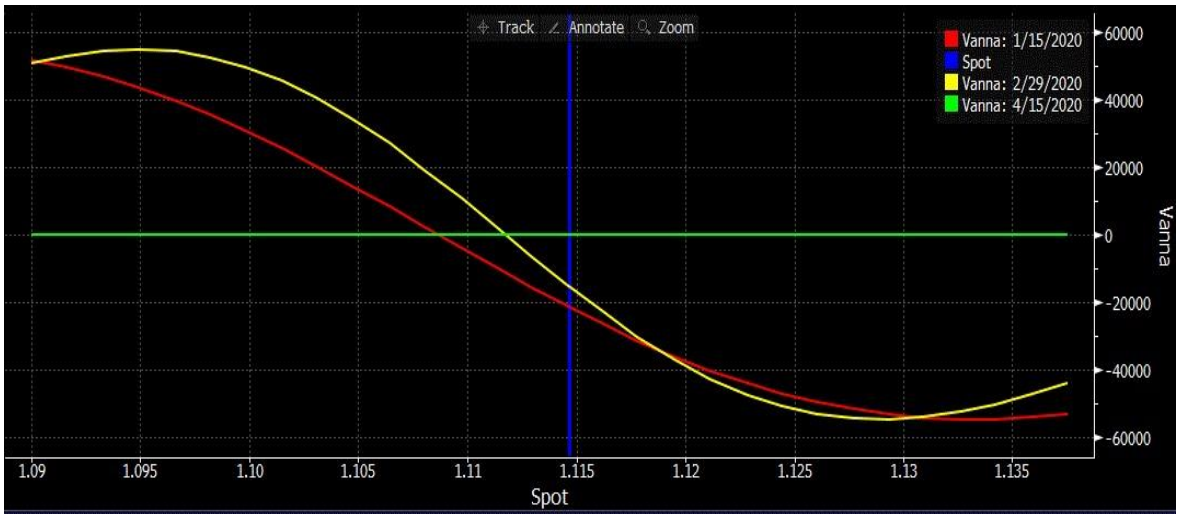
For FX options, delta and vega are the most relevant sensitivity parameters maturing within one year. However, a delta-neutral position can be achieved by trading the spot. Changes in the spot are obviously allowed in the BS model. As it already mentioned, the more sensitive part is the vega position. This is not taken care of in the BS model. A vega-neutral position is subject to changes of spot and volatility. For this reason, two more parameters, Vanna and Volga, are of special interest.

Vanna is the change of vega due to change of spot and mathematically:

$$B_{\sigma S} = \frac{\partial \upsilon}{\partial S} \tag{4.17}$$

Vanna can also be thought of as the sensitivity of delta to changes in implied volatility.

Figure 4. 10: Vanna exposure of 3 month ATM long call 1M EUR/USD



Source: Bloomberg

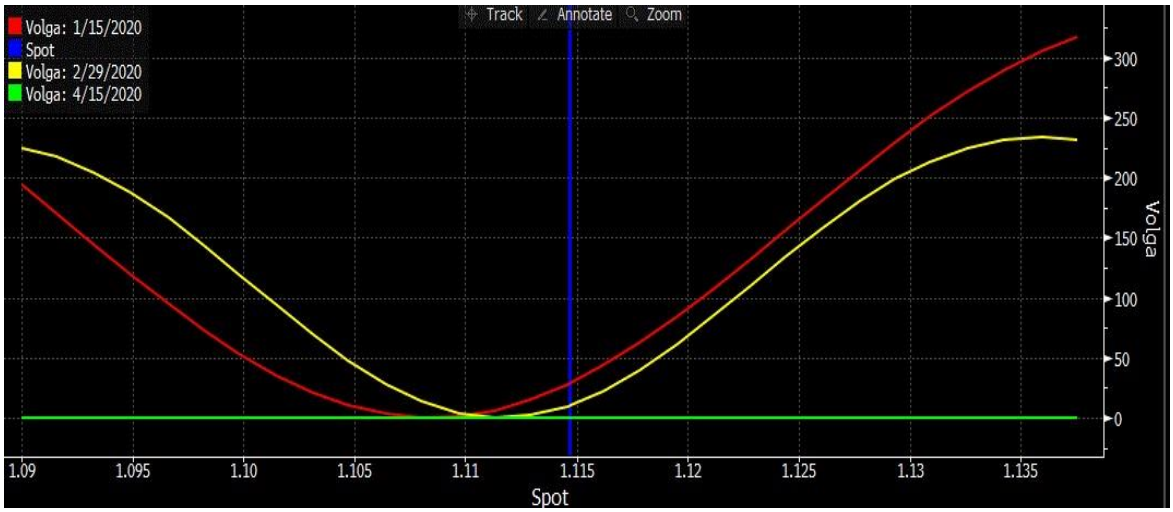
Vanna with spot above the strike is negative since vega rises into the downside peak. Vanna with spot below the strike is positive since vega rises into the topside peak. Consider an OTM call option with strike above spot. At current implied volatility the strike has 25% delta. If implied volatility rises, the chance of the strike ending ITM at maturity increases as the distribution widens and hence delta rises. Therefore, this option has a long vanna exposure. Likewise, consider an ITM call with strike below spot. At current implied volatility the strike has 75% delta. If implied volatility rises, the chance of the strike ending ITM at maturity decreases as the distribution widens and hence delta falls. Therefore, this option has a short vanna exposure.

Volga is the change of vega due to change of volatility and mathematically:

$$B_{\sigma\sigma} = \frac{\partial v}{\partial \sigma} \tag{4.18}$$

Volga is the second derivative of price with respect to changes in implied volatility.

Figure 4. 11: Volga exposure of 3 month ATM long call 1M EUR/USD



Source: Bloomberg

Volga with spot above or below the ATM strike is positive since long wing vanilla options generate positive Volga. The cost of such a vanna and volga exposure can be used to obtain prices for options that are closer to the market than their theoretical Black-Scholes value as:

$$B(\sigma_0) + p \times [cost\ of\ vanna + cost\ of\ volga] \tag{4.19}$$

where B denotes the value of a given option using the BS model, σ_0 denotes the ATM volatility, $p \in [0,1]$ is a number which is often taken to be the risk-neutral probability. When it comes to vanilla option, p=1.

Cost of Vanna and cost of Volga are:

$$cost\ of\ Vanna = \frac{B_{\sigma S}}{c_{\sigma S}(\sigma_{\Delta}^{+}) - p_{\sigma S}(\sigma_{\Delta}^{-})}[c(\sigma_{\Delta}^{+}) - c(\sigma_0) - p(\sigma_{\Delta}^{-}) + p(\sigma_0)] \tag{4.20}$$

$$cost\ of\ Volga = \frac{2B_{\sigma\sigma}}{c_{\sigma\sigma}(\sigma_{\Delta}^{+}) + p_{\sigma\sigma}(\sigma_{\Delta}^{-})}\left[\frac{c(\sigma_{\Delta}^{+}) - c(\sigma_0) + p(\sigma_{\Delta}^{-}) - p(\sigma_0)}{2}\right] \tag{4.21}$$

where $c(\sigma_0), p(\sigma_0)$ are vanilla (S, Δ, σ_0, r_d, r_f, T) that means vanilla(S, K, σ, r_d, r_f, T) for a strike K chosen to imply:

$$\Delta = |\ vanilla_S(S, K, \sigma, r_d, r_f, T)\ | \tag{4.22}$$

$$c(\sigma_{\Delta}^{+}) \triangleq call\left(S, \Delta^{+}, \sigma_{\Delta}^{+}, r_d, r_f, T\right) \tag{4.23}$$

$$p(\sigma_{\Delta}^{-}) \triangleq put\left(S, \Delta^{-}, \sigma_{\Delta}^{-}, r_d, r_f, T\right) \tag{4.24}$$

Vanna-Volga adjustment is commonly used in FX options where three main volatility quotes are typically available for a given market maturity:

I. Delta-neutral straddle referred to as ATM.
II. Risk reversal for 25 delta call and put.
III. Butterfly with 25 delta wings.

The values of risk reversals and butterflies are defined by:

$$RR(\sigma) \triangleq call\left(S, \Delta, \sigma, r_d, r_f, T\right) - put\left(S, \Delta, \sigma, r_d, r_f, T\right) \tag{4.25}$$

$$BF(\sigma) \triangleq \frac{call\left(S, \Delta, \sigma, r_d, r_f, T\right) + put(S, \Delta, \sigma, r_d, r_f, T)}{2} - \frac{call\left(S, \Delta_0, \sigma_0, r_d, r_f, T\right) + put\left(S, \Delta_0, \sigma_0, r_d, r_f, T\right)}{2} \tag{4.26}$$

$$\Delta_0 : delta\ that\ produces\ the\ ATM\ strike$$

With these approximations we obtain the formula:

$$cost\ of\ Vanna \approx \frac{B_{\sigma S}}{c_{\sigma S}(\sigma_\Delta^+) - p_{\sigma S}(\sigma_\Delta^-)} c_\sigma(\sigma_0) RR \tag{4.27}$$

$$cost\ of\ Volga = \frac{2B_{\sigma\sigma}}{c_{\sigma\sigma}(\sigma_\Delta^+) + p_{\sigma\sigma}(\sigma_\Delta^-)} c_\sigma(\sigma_0) BF \tag{4.28}$$

Chapter E: Hedging Indications for Corporate Clients

For companies exposed to fluctuating foreign currencies, such as those with a particularly heavy reliance on imports or exports, keeping abreast of the likely market trends is essential. Any company with a core business activity that relies on currency conversion, in the form of payments to foreign suppliers or repatriating international revenue, should be concerned about FX volatility. As it already mentioned, it is the era of low volatility which means cheap hedging. In this chapter, a variety of FX derivatives are priced for corporate clients who take either long or short position in EUR. Different maturities, different notionals and, most importantly, different strategies are going to be presented. The products are separated depending on the risk the investor is willing to take, or the premium is willing to pay. Except plain vanilla products, one of the exciting aspects of the OTC derivatives market is the number of nonstandard products that have been created by financial engineers. These products are termed exotic options, or simply exotics. They are important to a derivatives dealer because they are generally much more profitable than plain vanilla products and they meet a genuine hedging need in the market. Sometimes the products are designed to reflect a view on potential future movements in particular market variables.

5.1 EUR short – USD long

Consider an investor or a company who pays imports in USD. Company's domestic currency is EUR, henceforth, the best scenario in this occasion is to pay as less EUR is possible and buy as many USD is conceivable. That means a high EUR/USD strike. Therefore, in this sector EURUSD downside hedge is going to be presented. The contracts are divided in the following categories:

Figure 5. 1: EUR short Hedging Strategies

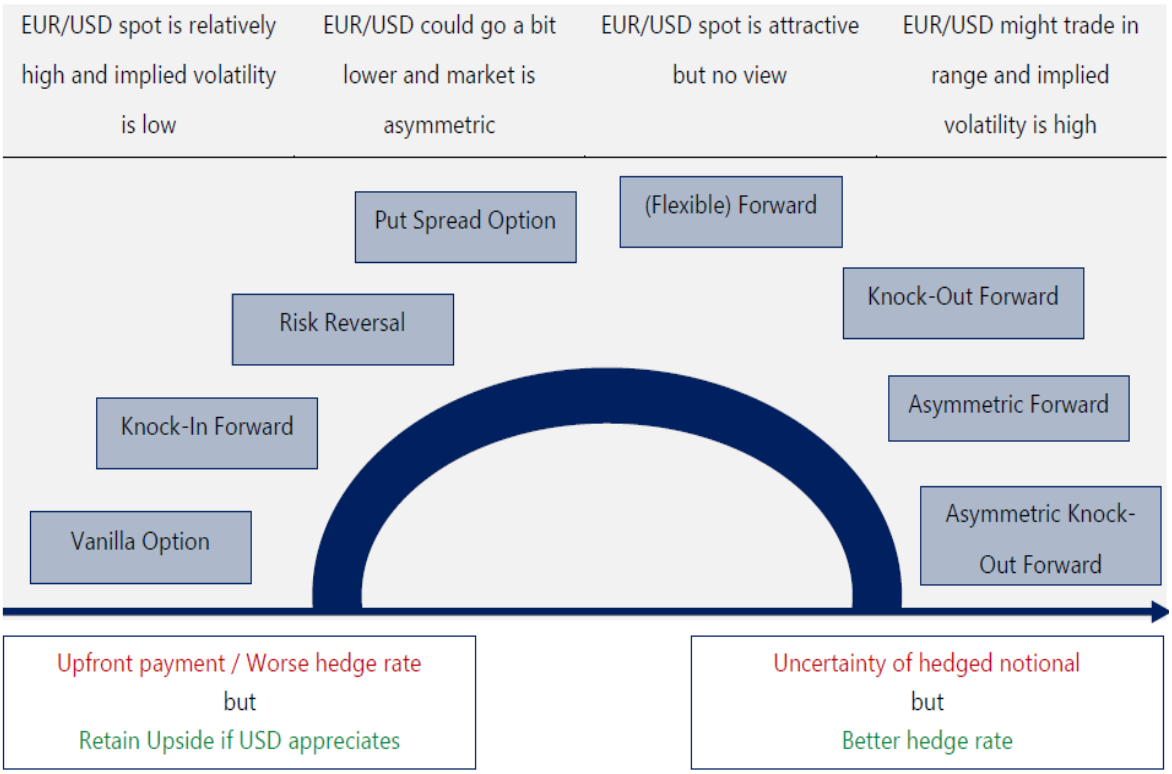
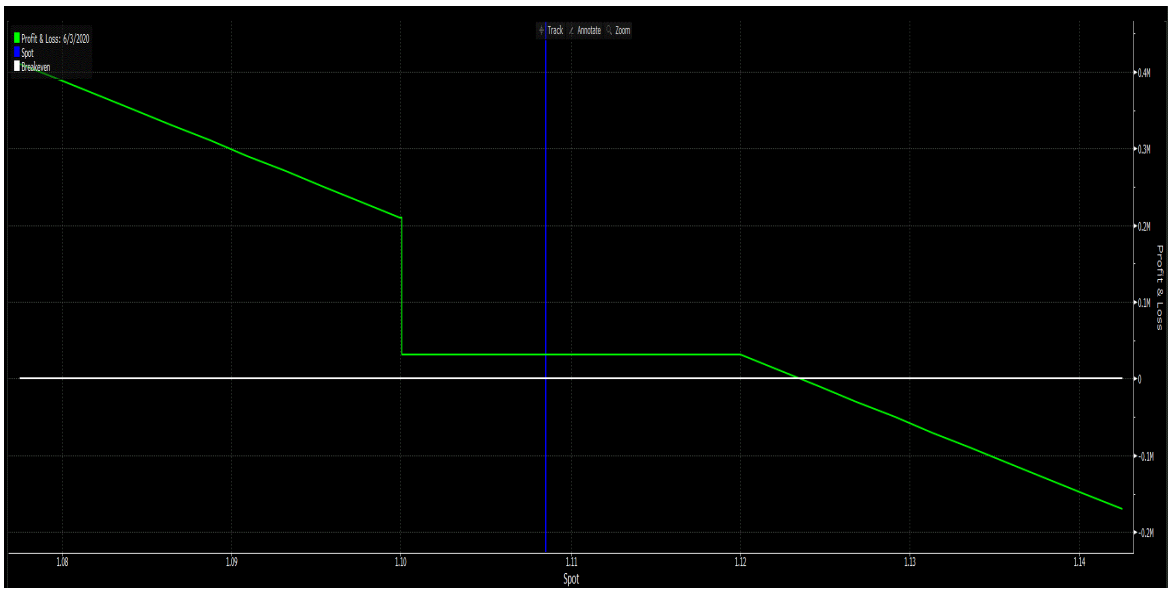


Table 5. 1: EUR short Knock-In Forward

Client :	Sells EUR / Buys USD
Notional :	USD 10,000,000
Deal Date :	03/12/19
Expiry Date :	03/06/20
Strike :	1.1200
Barrier :	1.1000
Barrier Style :	European Down & In
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6

Figure 5. 2: EUR short Knock-in Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. below the Barrier price, the client sells EUR against the preagreed Notional amount of USD at the Strike price,
II. between the Strike and the Barrier price, there is no obligation between the counterparties,
III. above the Strike price, the client sells EUR against the pre-agreed Notional amount of USD at the Strike price.

Knock-in Breaking Down

Barrier (B) options are options where the payoff depends on whether the underlying asset's price reaches a certain level during a certain period. A number of different types of barrier options regularly trade in the OTC market. They are attractive to some market participants because they are less expensive than the corresponding regular options. These barrier options can be classified as either knock-out options or knock-in options. A knock-in option comes into existence only when the underlying asset price reaches a barrier. The corresponding knock-in option is a down-and-in call. This is a regular call that comes into existence only if the asset price reaches the barrier level. If B is less than or equal to the strike price, K, the value of a down-and-in call at time zero is:

$$c_{DI} = S_0 e^{-r_f T} \left(\frac{B}{S_0}\right)^{2\lambda} N(\alpha) - K e^{-r_d T} \left(\frac{B}{S_0}\right)^{2\lambda-2} N\left(\alpha - \sigma\sqrt{T}\right) \quad (5.1)$$

where

$$\lambda = \frac{r_d - r_f + \frac{\sigma^2}{2}}{\sigma^2} \quad (5.2)$$

$$\alpha = \frac{\ln(\frac{B^2}{S_0 K})}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T} \quad (5.3)$$

A down-and-in put is a put option that comes into existence only when the barrier is reached. When the barrier is greater than the strike price, $p_{DI} = p$. When the barrier is less than the strike price:

$$p_{DI} = -S_0 e^{-r_f T} N(\beta) + K e^{-r_d T} N\left(-\beta + \sigma\sqrt{T}\right) + S_0 e^{-r_f T} \left(\frac{B}{S_0}\right)^{2\lambda} [N(\alpha) - N(\gamma)]$$
$$- K e^{-r_d T} \left(\frac{B}{S_0}\right)^{2\lambda-2} \left[N\left(\gamma - \sigma\sqrt{T}\right) - N\left(\beta - \sigma\sqrt{T}\right)\right] \quad (5.4)$$

where

$$\beta = \frac{\ln\left(\frac{S_0}{B}\right)}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T} \quad (5.5)$$

$$\gamma = \frac{\ln(\frac{B}{S_0})}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T} \quad (5.6)$$

The term Forward in the name of the product is because the product is a combination of two legs:

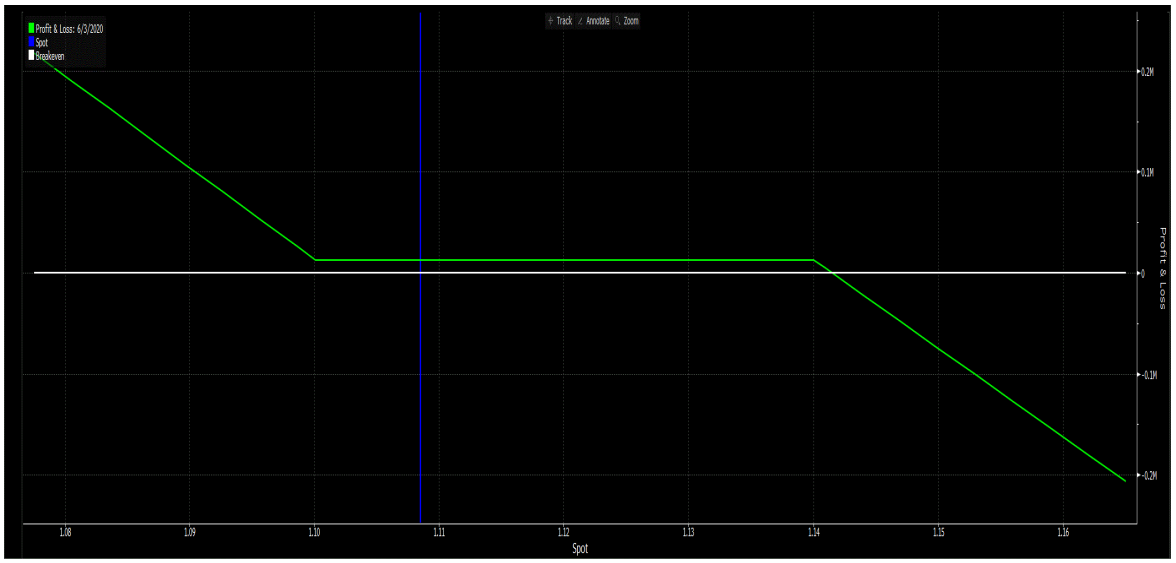
I. short EUR call.
II. long EUR put.

It's the same position as a short EUR forward. The barrier is in leg II. An important issue for barrier options is the frequency with which the FX rate, is observed for purposes of determining whether the barrier has been reached, known as Cut. To conclude, this product contains a premium receive instead of pay. In this case, the financial institution may sell this product as zero-cost premium and keep the amount as margin.

Table 5. 2: EUR short Risk Reversal

Client :	Sells EUR / Buys USD
Notional :	USD 10,000,000
Expiry Date :	03/06/20
Upper Strike :	1.1400
Lower Strike :	1.1000
Option Style :	European
Premium :	Zero – Cost
Cut:	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6
6m ATM vol (mid) :	5.079%

Figure 5. 3: EUR short Risk Reversal P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the Upper Strike price, the client sells EUR against the pre-agreed Notional amount of USD at the Upper Strike price,

II. between the Upper Strike and Lower Strike price, there is no obligation between the counterparties,

III. below the Lower Strike price, the client sells EUR against the pre-agreed Notional amount of USD at the Lower Strike price.

Risk Reversal Breaking Down

A risk reversal contains two vanilla options with the same currency pair, notional and expiry. However, the two legs have different strikes, one is a call and the other is a put, plus one is bought while the other is sold. Figure shows the value at maturity of a EUR/USD 1.1000/1.1400 risk reversal per leg:

I. Buy EUR put/USD call with strike 1.1000.
II. Sell EUR call/USD put with strike 1.1400.

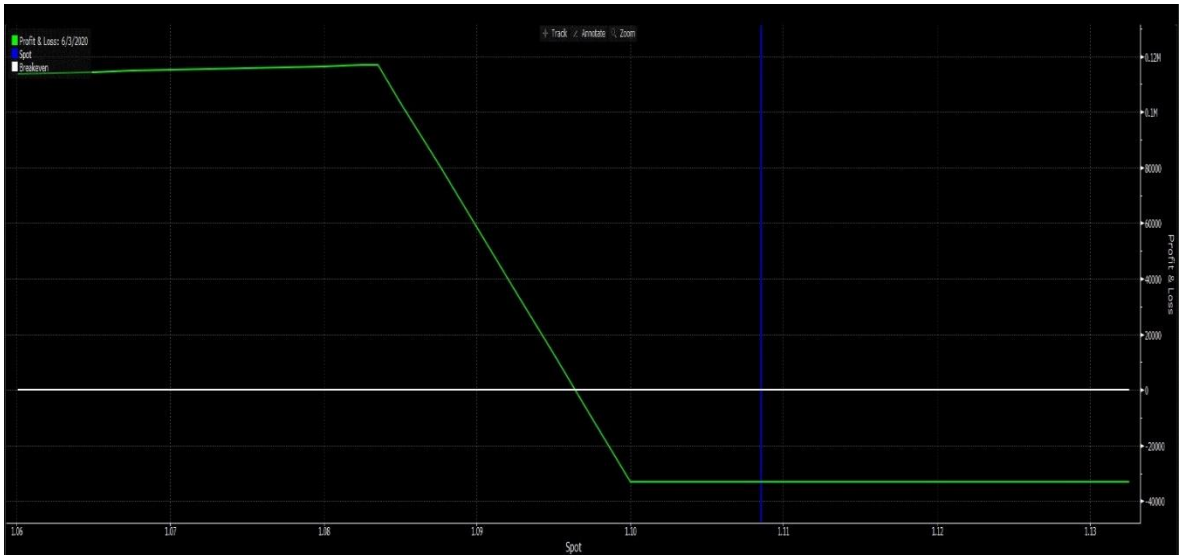
Risk reversals for a given delta are often quoted as an implied volatility differential between the two strikes. As it already mentioned, FX derivatives market expresses the amount of skew in the volatility smile via the risk reversal contract. Specifically, the risk reversal gives the differential between the OTM call strike implied volatility and the OTM put strike implied volatility for the same tenor and delta. The greater the demand for an option contract, the greater its volatility and its price. A positive risk reversal means the volatility of calls is greater than the volatility of similar puts, which implies more market participants are betting on a rise in the currency than on a drop, and vice versa if the risk reversal is negative. Thus, risk reversals can be used to gauge positions in the FX market and convey information to make trading decisions.

When trading a risk reversal, particularly if it is long-dated, it is important to pay attention to exactly which strikes are being transacted. Strikes traded within a risk reversal are the outright strikes—the same strikes as if same-tenor and same-delta call or put vanillas are traded in isolation. If a currency pair had a completely flat volatility smile, the risk reversal strikes would be positioned approximately symmetrically around the ATM strike. Therefore, the topside strike will be further away from the ATM than the downside strike in regular spot space (as in the indication). At short maturities this effect is small but at longer maturities the impact can be significant.

Table 5. 3: EUR short Put Spread

Client :	Sells EUR / Buys USD
Notional :	USD 10,000,000
Expiry Date :	03/06/20
1st Strike :	1.1000
2nd Strike :	1.0835
Option Style :	European
Premium :	USD 36,000
Cut:	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6
6m ATM vol (mid) :	5.079%

Figure 5. 4 EUR short Put Spread P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the 1st Strike price, there is no obligation between the counterparties,

II. between the 1st and the 2nd Strike price, the client sells EUR against the pre-agreed Notional amount of USD at the 1st Strike price,

III. below the 2nd Strike price, the client sells EUR against the pre-agreed Notional amount of USD at the 1st Strike price and buys EUR against the same amount of USD at the 2nd Strike price.

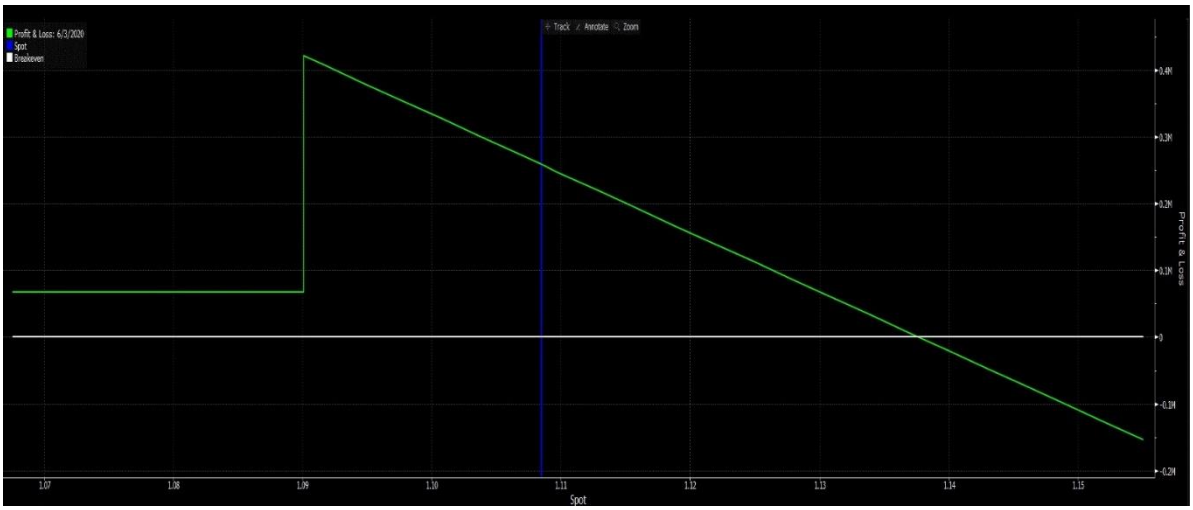
Vanilla Spreads Breaking Down

Vanilla spreads have two legs in the same notional and to the same maturity, either both calls or both puts. One leg is a buy and the other is a sell. When buying the put spread, the bought leg is always more expensive, and hence further ITM than the sold leg. In essence, the investor who buy a put with a certain strike price, choose to give up some of the profit potential by selling a put with a lower strike price. In return for the profit given up, the investor gets the price of the option sold.

Table 5. 4: EUR short Knock-Out Forward

Client :	Sells EUR / Buys USD
Notional :	USD 10,000,000
Expiry Date :	03/06/20
Strike :	1.1300
Barrier :	1.0900
Option Style :	European Down & Out
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6

Figure 5. 5: EUR short Knock-Out Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. below the Barrier price, there is no obligation between the counterparties,
II. above the Barrier price, the client sells EUR against the pre-agreed Notional amount of USD at the Strike price.

Knock-out Breaking Down

A down-and-out call is one type of knock-out option. It is a regular call option that ceases to exist if the asset price reaches a certain barrier level B. The barrier level is below the initial asset price.

If B is greater than the K, then

$$c_{DO} = S_0 e^{-r_f T} N(\beta) - Ke^{-r_d T} N\left(\beta - \sigma\sqrt{T}\right) - S_0 e^{-r_f T} \left(\frac{B}{S_0}\right)^{2\lambda} N(\gamma)$$
$$+ Ke^{-r_d T} \left(\frac{B}{S_0}\right)^{2\lambda-2} N(\gamma - \sigma\sqrt{T}) \quad (5.7)$$

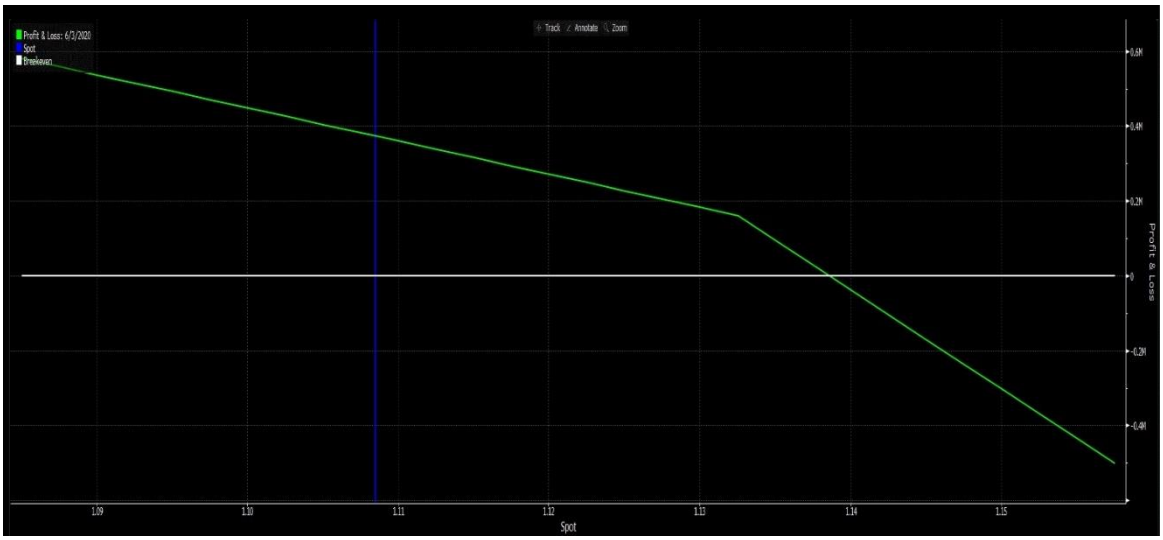
When the barrier is less than the strike price:

$$p_{DO} = P_{put} - p_{DI} \quad (5.8)$$

Table 5. 5: EUR short Asymmetric Forward

Client :	Sells EUR / Buys USD
Up Notional :	USD 20,000,000
Down Notional :	USD 10,000,000
Expiry Date :	03/06/20
Strike :	1.1325
Option Style :	European
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6
6m ATM vol (mid) :	5.079%

Figure 5. 6: EUR short Asymmetric Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the Strike price, the client sells EUR against the pre-agreed Up Notional amount of USD at the Strike price,

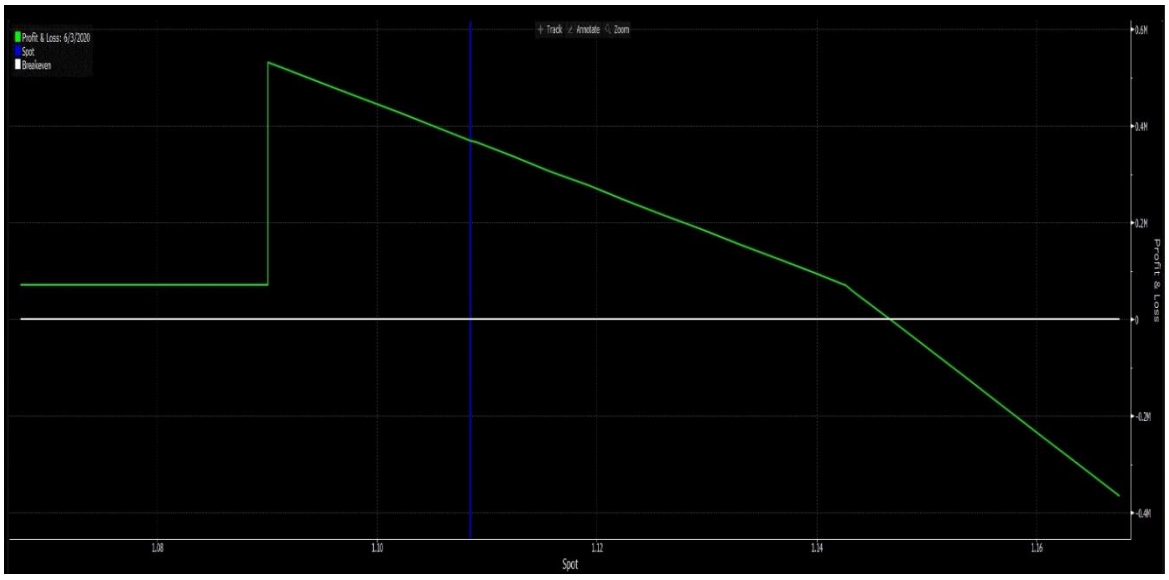
II. below the Strike price, the client sells EUR against the pre-agreed Down Notional amount of USD at the Strike price.

This product is called asymmetric due to the difference in notional. As the strike is higher than the forward rate, to rebalance the position, a higher notional is required instead of i.e. using a barrier.

Table 5. 6: EUR short Asymmetric Knock-Out Forward

Client :	Sells EUR / Buys USD
Up Notional :	USD 20,000,000
Down Notional :	USD 10,000,000
Expiry Date :	03/06/20
Strike :	1.1425
Barrier :	1.0900
Option Style :	European Down & Out
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1085
6m fwd points (mid) :	132.6
6m ATM vol (mid) :	5.079%

Figure 5. 7: EUR short Asymmetric Knock-Out Forward



Source: Bloomberg

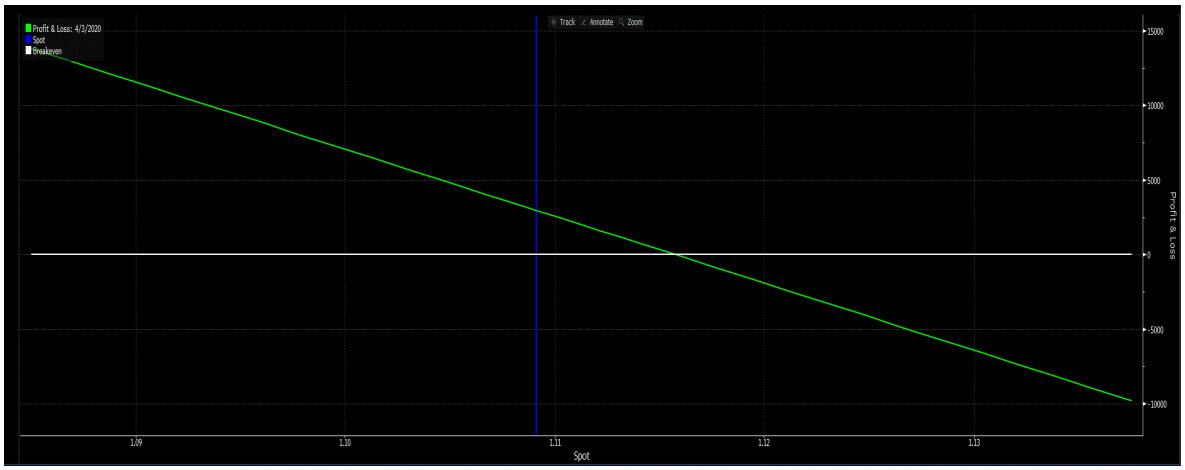
At expiry date, if spot is trading:

I. below the Barrier price, there is no obligation between the counterparties,
II. between the Barrier and the Strike price, the client sells EUR against the pre-agreed Down Notional amount of USD at the Strike price,
III. above the Strike price, the client sells EUR against the pre-agreed Up Notional amount of USD at the Strike price.

Table 5. 7: EUR short Flexible Forward

Client :	Sells EUR / Buys USD
Notional :	USD 500,000
Deal Date :	04/12/19
Fwd Starting Date :	02/03/20
Expiry Date :	03/12/20
Strike :	1.1130
Premium :	Zero - Cost
Spot Reference :	1.1091

Figure 5. 8: EUR short Flexible Forward P&L



Source: Bloomberg

The client has the right to sell EUR/ buys USD against an amount of Notional (but it cannot be exceeded) at the Strike price whenever between the Fwd Starting Date and the Expiry Date. If at the Expiry Date there is still residual of the Notional (i.e. USD 45,000), the client is obliged to sell EUR/ buys USD against the rest of the Notional at the Strike price.

Flexible Forward Breaking Down

Generally, the strike in the Flexible Forward is less than the forward price due to the flexibility that client earns. But in this indication, there is a Fwd Starting Date. That means from 04/12/19 until 02/03/19 the client cannot make any transaction.

Forward start options are options that will start at some time in the future. Consider a forward start ATM European call option that will start at time T_1 and mature at time T_2. Suppose that

the spot rate is S_0 at time zero and S_1 at time T_1. The value of the forward start option at time is T_1 therefore:

$$v = c\frac{S_1}{S_0} \tag{5.9}$$

where c is the value at time zero of an ATM option that lasts for $T_2 - T_1$. The value of the forward start option at time zero is:

$$v = e^{(r_f - r)T_1} E\left[c\frac{S_1}{S_0}\right] \tag{5.10}$$

where E denotes the expected value in a risk-neutral world and

$$E[S_1] = S_0 e^{(r - r_f)T_1} \tag{5.11}$$

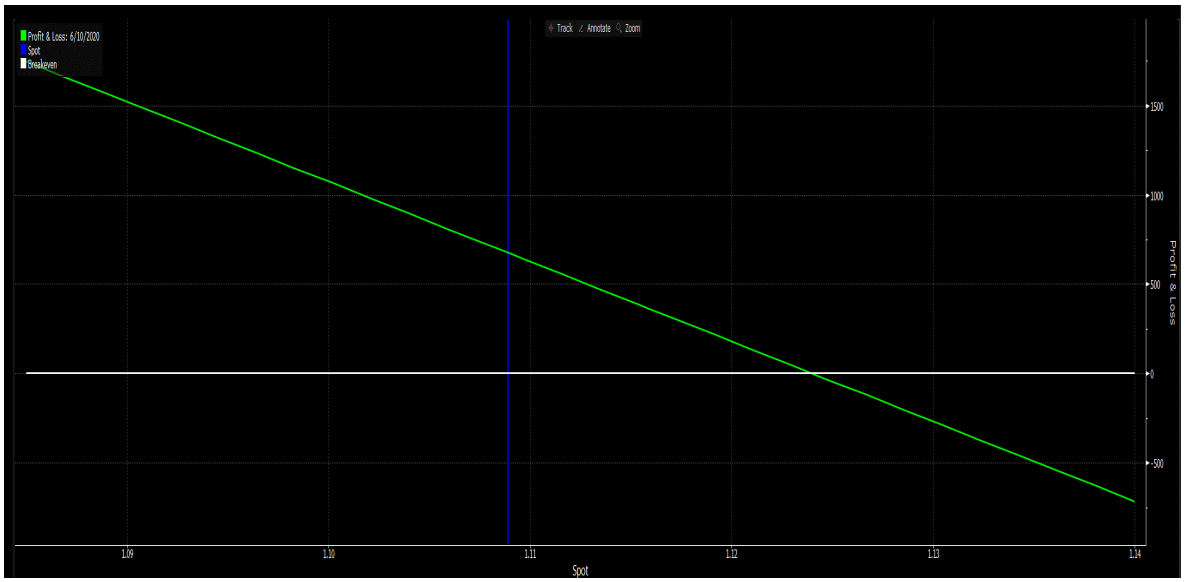
That gives him a better rate because at long dates and in short EUR positions, the financial institutions make profit from the carry trade. To explain, when a financial institution sells a Flexible Forward, to hedge its position, it takes the same as the client. So, it sells EUR/ buys USD. To sell EUR it has to borrow and it is known that the rates of EUR are negative. Therefore, as later is the Fwd Starting Date, the more benefited the institution is from the carry trade (It borrows and earn money). It has to be mentioned that hedging is almost always occurred in the spot rate, because if it was occurred in the fwd rate, this would shift all the market up.

Like Flexible Forward, if the investor needs a lot of deliveries (i.e. does imports at the end of each month), there are another downside hedging strategies.

Table 5. 8: EUR short Par Forward

Client :	Sells EUR / Buys USD
Notional per Delivery :	USD 50,000
No of Deliveries (bi-weekly) :	14
Deal Date :	11/12/19
Expiry Date :	10/06/20
Strike :	1.1159
Premium :	Zero - Cost
Spot Reference :	1.1089

Figure 5. 9: EUR short Par Forward P&L



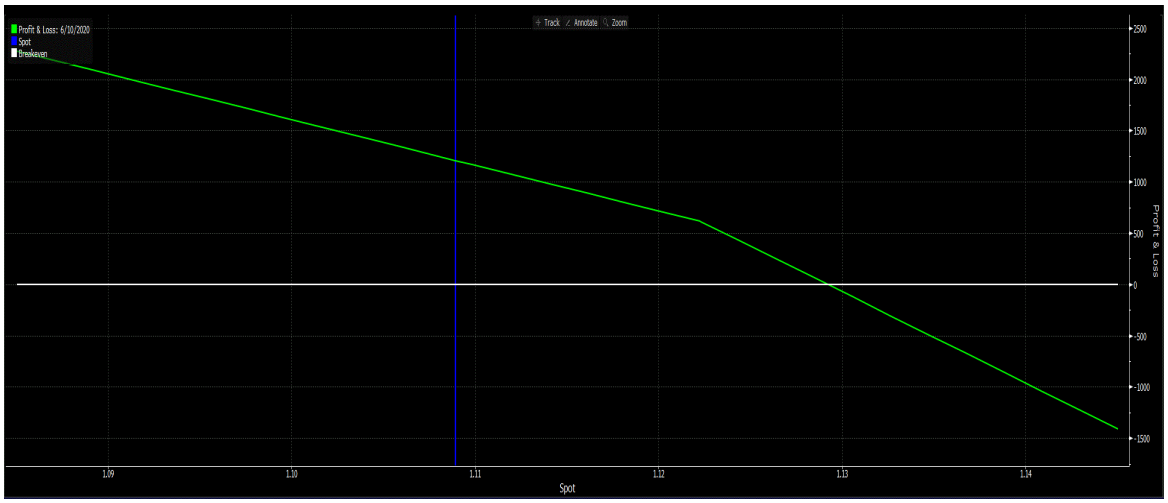
Source: Bloomberg

Par Forward is a product that allows the client to hedge FX risk through the classic Forward that offers an attractive pricing at zero initial cost. At each Expiry Date, client buys the Notional amount at Strike. As each expiry is a single forward contract with different maturities, the Strike is approximately the average of each forward FX rate.

Table 5. 9: EUR short Asymmetric Par Forward

Client :	Sells EUR / Buys USD
Notional 1 per Delivery :	USD 50,000
Notional 2 per Delivery :	USD 100,000
No of Deliveries (bi-weekly) :	14
Deal Date :	23/12/19
Expiry Date :	10/06/20
Strike :	1.1223
Premium :	Zero - Cost
Spot Reference :	1.1089

Figure 5. 10: EUR short Asymmetric Par Forward P&L



Source: Bloomberg

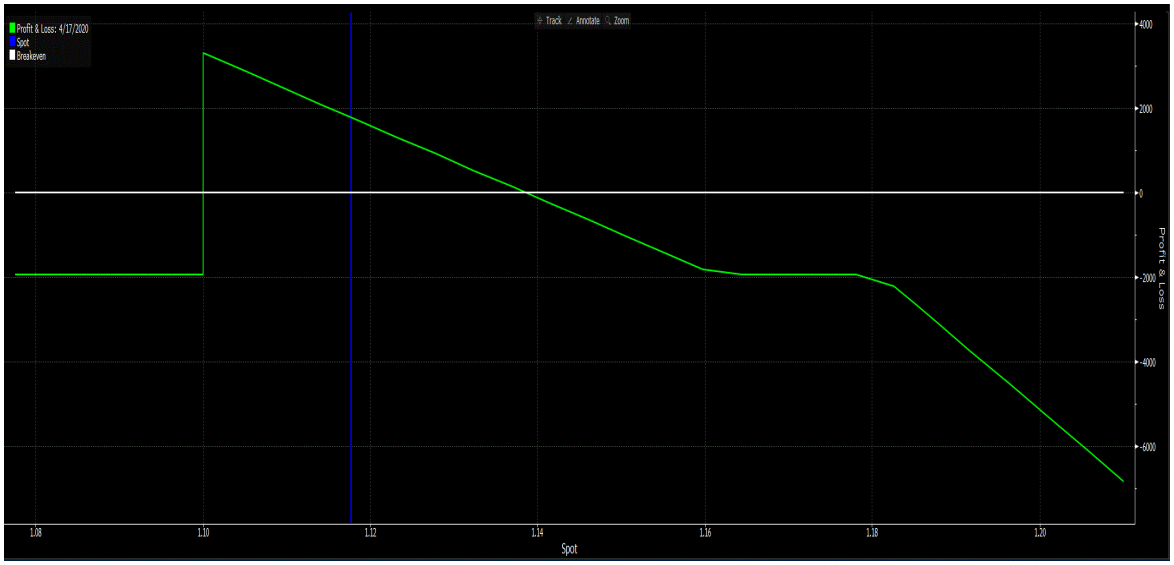
An Asymmetric Par Forward is a structured forward that allows client to trade at a better rate than a Par Forward transaction by integrating leverage. At each Expiry Date, if spot is trading:

I. at or below the Strike rate, client buys the Notional 1 amount at the Strike rate.
II. above the Strike rate, client buys the Notional 2 amount at the Strike rate.

Table 5. 10: EUR short Asymmetric Knock-Out Par Forward

Client :	Sells EUR / Buys USD
Notional 1 per Delivery :	USD 100,000
Notional 2 per Delivery :	USD 200,000
No of Deliveries (monthly) :	6
Deal Date :	27/12/19
Expiry Date :	15/06/20
Strike :	1.1650 / 1.1850
Barrier :	1.1000
Option Style :	European Down & Out
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1177
Par Forward :	1.1500
1year 25D RR :	0.10

Figure 5. 11: EUR short Asymmetric Knock-Out Par Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. between the Lower Strike rate and the Barrier level, the client buys the Lower Notional amount at the Lower Strike rate.
II. between the Lower and the Upper Strike rates, there is no obligations between the counterparties.
III. above the Upper Strike rate, the client buys the Upper Notional amount at the Upper Strike rate.
IV. below the Barrier level rate, there is no obligations between the counterparties.

An Asymmetric European Knock-Out(EKO) Forward is a structured forward that allows client to trade at a better rate than an EKO Forward transaction by integrating leverage and a knock-out feature. The holder of an Asymmetric EKO Forward therefore could buy (or sell) a currency against another at a lower (or higher) level than the respective EKO Forward rate at the expiry date as long as the knock-out barrier is not reached or breached. Once this happens, no transaction will occur.

5.2 EUR long – USD short

Consider a Greek company who earns USD from exports. When it comes to sell those USD and buy the local currency EUR, the company searches for the cheaper price to buy. That

means a low EUR/USD strike. Therefore, in this sector EURUSD upside hedge is going to be presented. The contracts are separated in the following categories:

Figure 5. 12: EUR Long Hedging Strategies

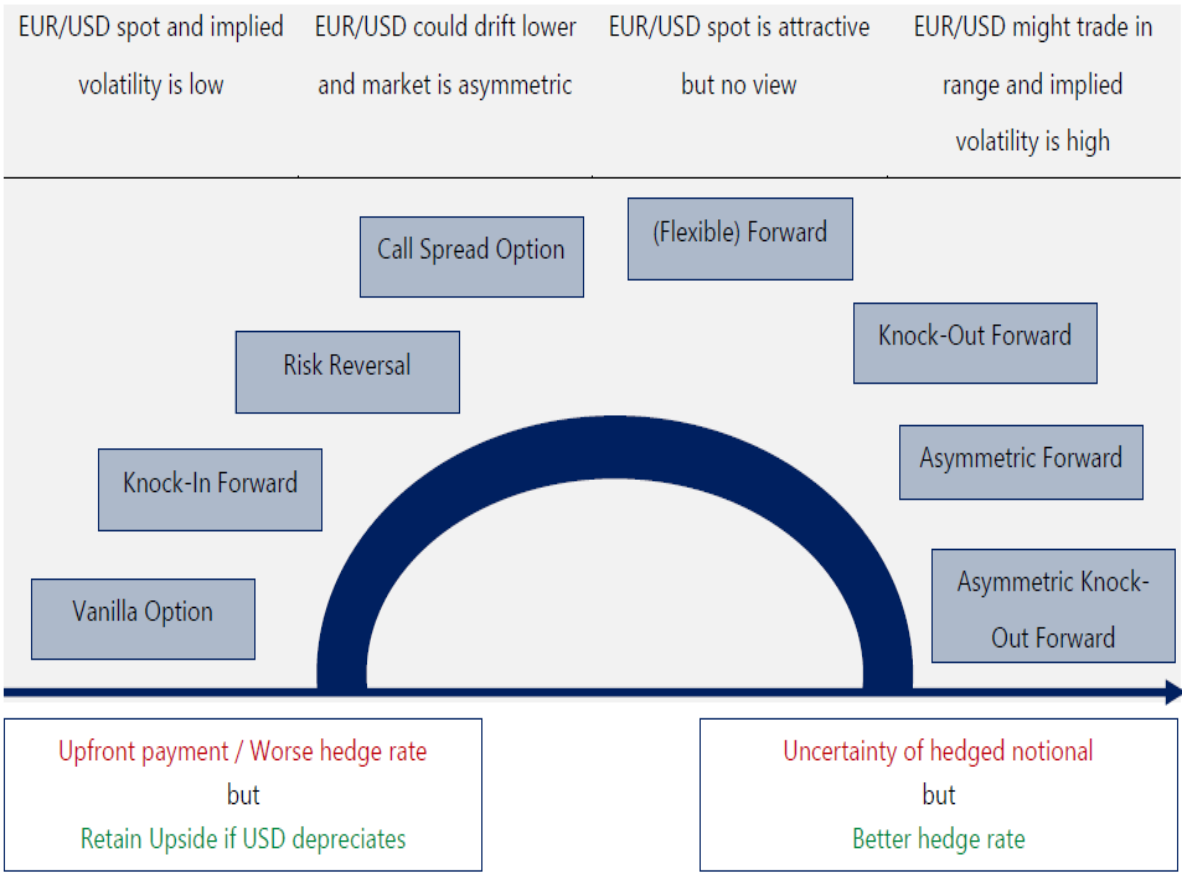
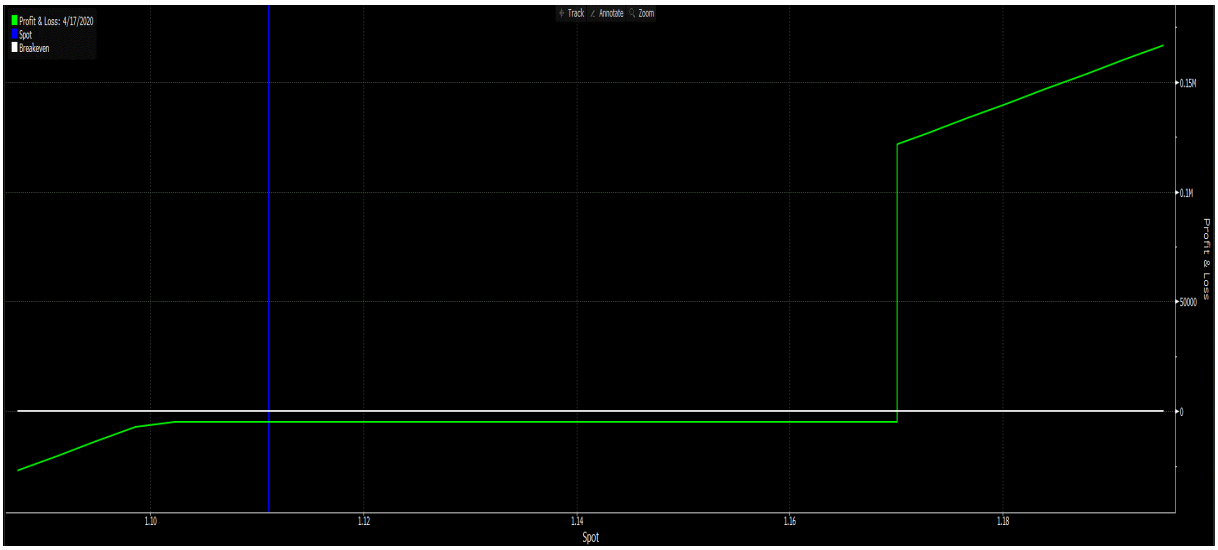


Table 5. 11: EUR long Knock-In Forward

Client :	Buys EUR / Sells USD
Notional :	USD 2,000,000
Deal Date:	17/01/20
Expiry Date :	04/12/20
Strike :	1.1150
Barrier :	1.1700
Barrier Style :	European Up & In
Premium :	USD 6,000
Cut :	NY 10:00
Spot Reference :	1.1111

Figure 5. 13: EUR long Knock-In Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the Barrier price, the client buys EUR against the pre-agreed Notional amount of USD at the Strike price,
II. between the Strike and the Barrier price, there is no obligation between the counterparties,
III. below the Strike price, the client buys EUR against the pre-agreed Notional amount of USD at the Strike price.

An up-and-in call is a regular call option that comes into existence only if the barrier is reached. When B is less than or equal to K, the value of the up-and in call, c_{UI}, is c. When B is greater than K,

$$c_{UI} = S_0 e^{-r_f T} N(\beta) - K e^{-r_d T} N\left(\beta - \sigma\sqrt{T}\right) - S_0 e^{-r_f T} \left(\frac{B}{S_0}\right)^{2\lambda} [N(-\alpha) - N(-\gamma)]$$
$$+ K e^{-r_d T} \left(\frac{B}{S_0}\right)^{2\lambda-2} \left[N\left(-\beta + \sigma\sqrt{T}\right)\right.$$
$$\left. - N\left(-\gamma + \sigma\sqrt{T}\right)\right] \quad (5.12)$$

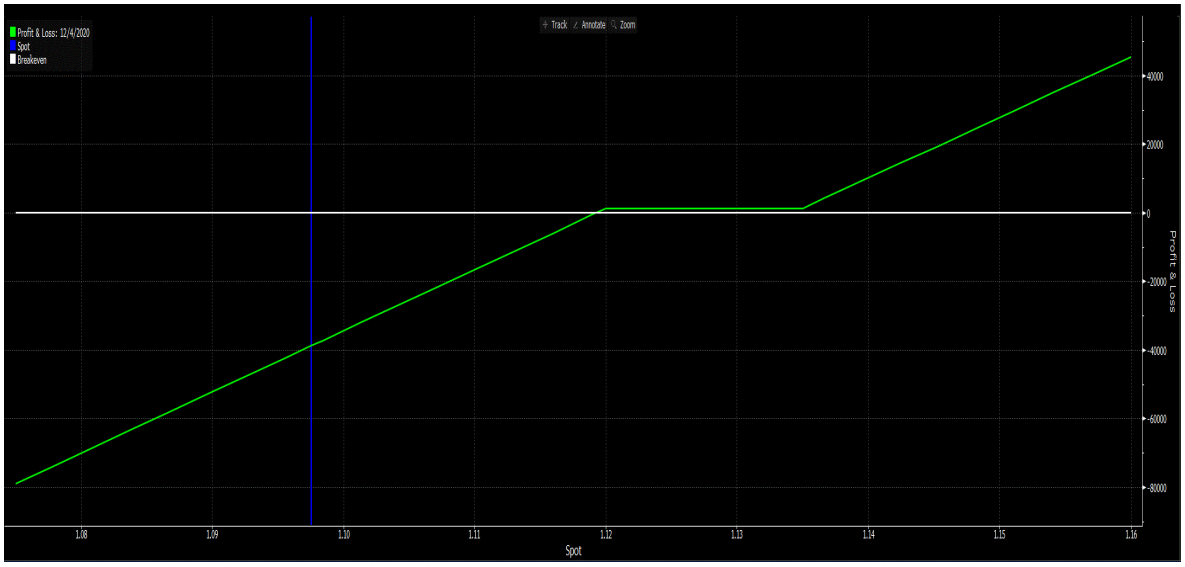
Put barrier options are defined similarly to call barrier options. An up-and-out put is a put option that ceases to exist when a barrier, B, that is greater than the current asset price is reached. An up-and-in put is a put that comes into existence only if the barrier is reached. When the barrier, B, is greater than or equal to the strike price, K, their prices are:

$$p_{UI} = -S_0 e^{-r_f T}\left(\frac{B}{S_0}\right)^{2\lambda} N(-\alpha) \; - \; K e^{-r_d T}\left(\frac{B}{S_0}\right)^{2\lambda-2} N\left(-\alpha + \sigma\sqrt{T}\right) \qquad (5.13)$$

Table 5. 12: EUR long Risk Reversal

Client :	Buys EUR / Sells USD
Notional :	USD 2,000,000
Deal Date :	20/11/19
Expiry Date :	04/12/20
Upper Strike :	1.1350
Lower Strike :	1.1200
Option Style :	European
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.0975

Figure 5. 14: EUR long Risk Reversal P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the Upper Strike price, the client buys EUR against the pre-agreed Notional amount of USD at the Upper Strike price,

II. between the Upper Strike and Lower Strike price, there is no obligation between the counterparties,

III. below the Lower Strike price, the client buys EUR against the pre-agreed Notional amount of USD at the Lower Strike price.

The two legs have different strikes, one is a call and the other is a put, plus one is bought while the other is sold. Figure shows the value at maturity of a EUR/USD 1.1200/1.1400 risk reversal per leg:

I. Sell EUR put/USD call with strike 1.1200.

II. Buy EUR call/USD put with strike 1.1350.

Table 5. 13: EUR long Call Spread Option

Client :	Buys EUR / Sells USD
Notional :	USD 2,000,000
Deal Date :	20/11/19
Expiry Date :	04/12/20
1st Strike :	1.1100
2nd Strike :	1.1500
Option Style :	European
Premium :	USD 18,000
Cut :	NY 10:00
Spot Reference :	1.0975

Figure 5. 15: EUR long Call Spread Option P&L

Source: Bloomberg

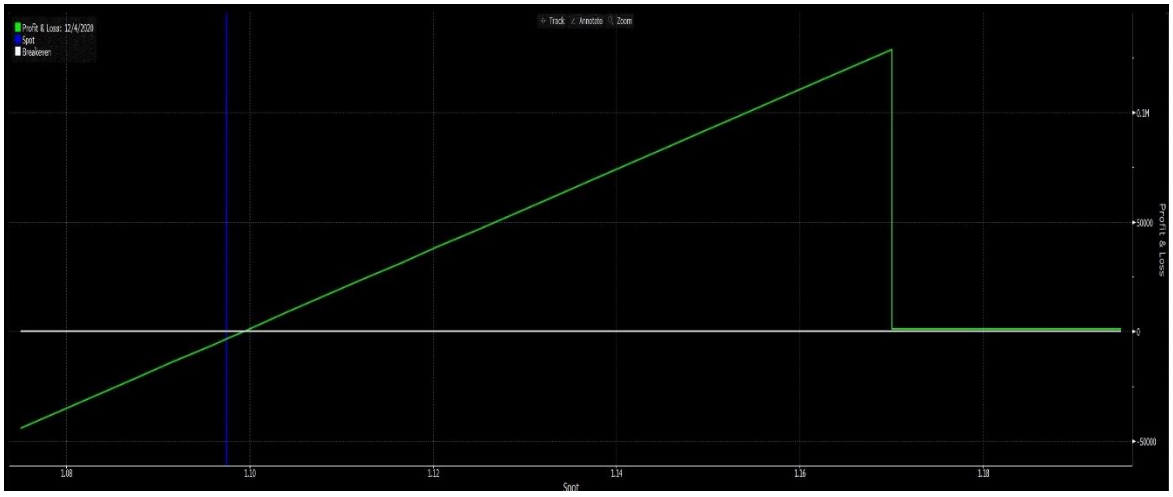
At expiry date, if spot is trading:

I. below the 1st Strike price, there is no obligation between the counterparties,
II. above the 1st Strike price, the client buys EUR against the pre-agreed Notional amount of USD at the 1st Strike price,
III. above the 2nd Strike price, the client buys EUR against the pre-agreed Notional amount of USD at the 1st Strike and sells EUR against the same amount of USD at the 2nd Strike price

Table 5. 14: EUR long Knock-Out Forward

Client :	Buys EUR / Sells USD
Notional :	USD 2,000,000
Expiry Date :	04/12/20
Strike :	1.1000
Barrier :	1.1700
Option Style :	European Up & Out
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.0975
6m fwd points (mid) :	259.43

Figure 5. 16: EUR long Knock-Out Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

I. above the Barrier price, there is no obligation between the counterparties,

II. below the Barrier price, the client buys EUR against the pre-agreed Notional amount of USD at the Strike price.

An up-and-out call is a regular call option that ceases to exist if the asset price reaches a barrier level, B, that is higher than the current asset price. When B is less than or equal to K, the value of the up-and-out call, c_{UO}, is zero. When B is greater than K:

$$c_{UO} = c - c_{UI} \tag{5.14}$$

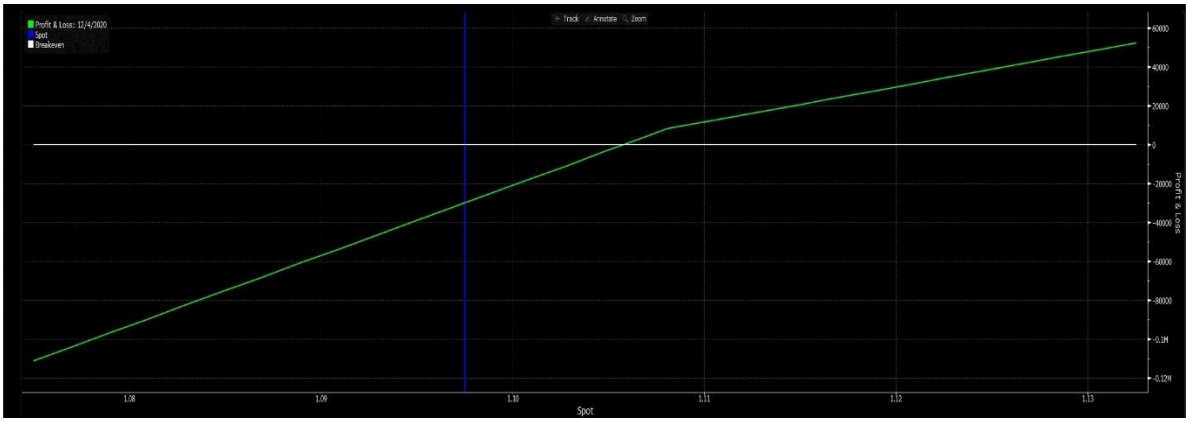
When B is less than or equal to K:

$$p_{UO} = -S_0 N(\beta) + KN\left(-\beta + \sigma\sqrt{T}\right) + S_0 \left(\frac{B}{S_0}\right)^{2\lambda} N(-\gamma) - K\left(\frac{B}{S_0}\right)^{2\lambda-2} N(-\gamma + \sigma\sqrt{T}) \tag{5.15}$$

Table 5. 15: EUR long Asymmetric Forward

Client :	Buys EUR / Sells USD
Up Notional :	USD 2,000,000
Down Notional :	USD 4,000,000
Expiry Date :	04/12/20
Strike :	1.1080
Option Style :	European
Premium :	Zero - Cost
Spot Reference :	1.0975

Figure 5. 17: EUR long Asymmetric Forward P&L



Source: Bloomberg

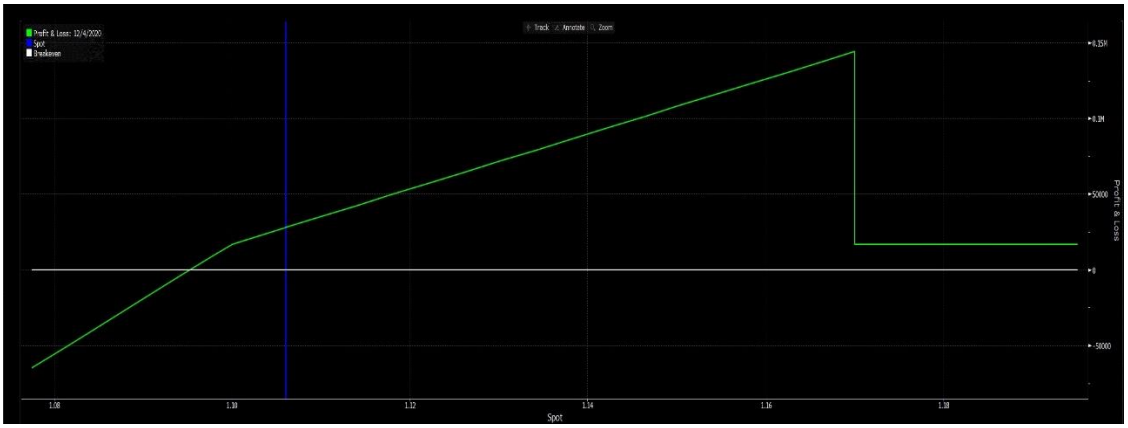
At expiry date, if spot is trading:

I. above the Strike price, the client buys EUR against the pre-agreed Up Notional amount of USD at the Strike price,
II. below the Strike price, the client buys EUR against the pre-agreed Down Notional amount of USD at the Strike price.

Table 5. 16: EUR long Asymmetric Knock-Out Forward

Client :	Buys EUR / Sells USD
Up Notional :	USD 2,000,000
Down Notional :	USD 4,000,000
Expiry Date :	04/12/20
Strike :	1.0850
Barrier :	1.1700
Option Style :	European Up & Out
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.0975
6m fwd points (mid) :	295.6

Figure 5. 18: EUR long Asymmetric Knock-Out Forward P&L



Source: Bloomberg

At expiry date, if spot is trading:

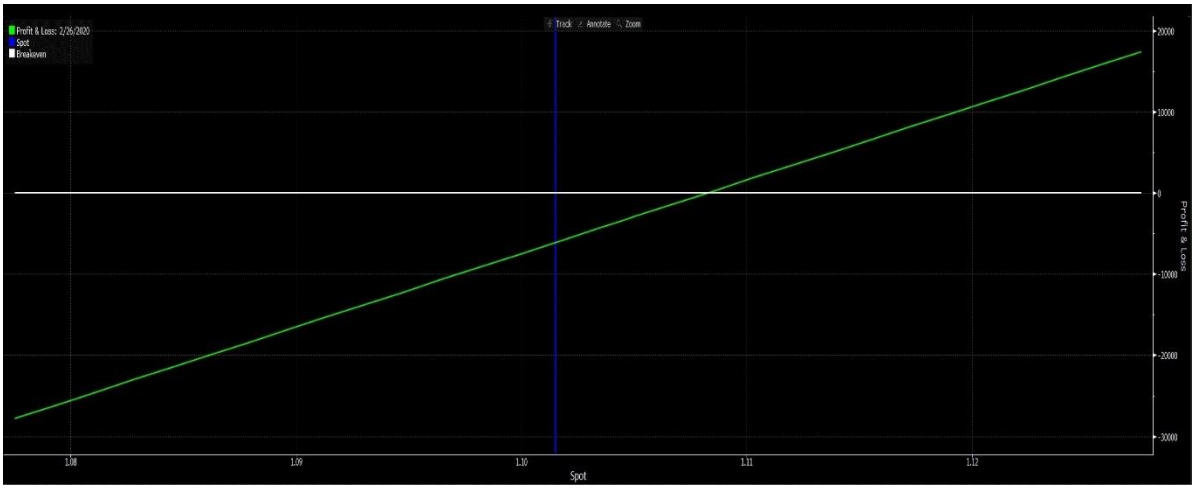
I. above the Barrier price, there is no obligation between the counterparties,
II. between the Barrier and the Strike price, the client buys EUR against the pre-agreed Up Notional amount of USD at the Strike price,

III. above the Strike price, the client buys EUR against the pre-agreed Down Notional amount of USD at the Strike price.

Table 5. 17: EUR long Flexible Forward

Client :	Buys EUR / Sells USD
Notional :	USD 1,000,000
Deal Date :	26/11/19
Expiry Date :	16/12/19
Strike :	1.1045
Premium :	Zero - Cost
Spot Reference :	1.1015

Figure 5. 19: EUR long Flexible Forward P&L



Source: Bloomberg

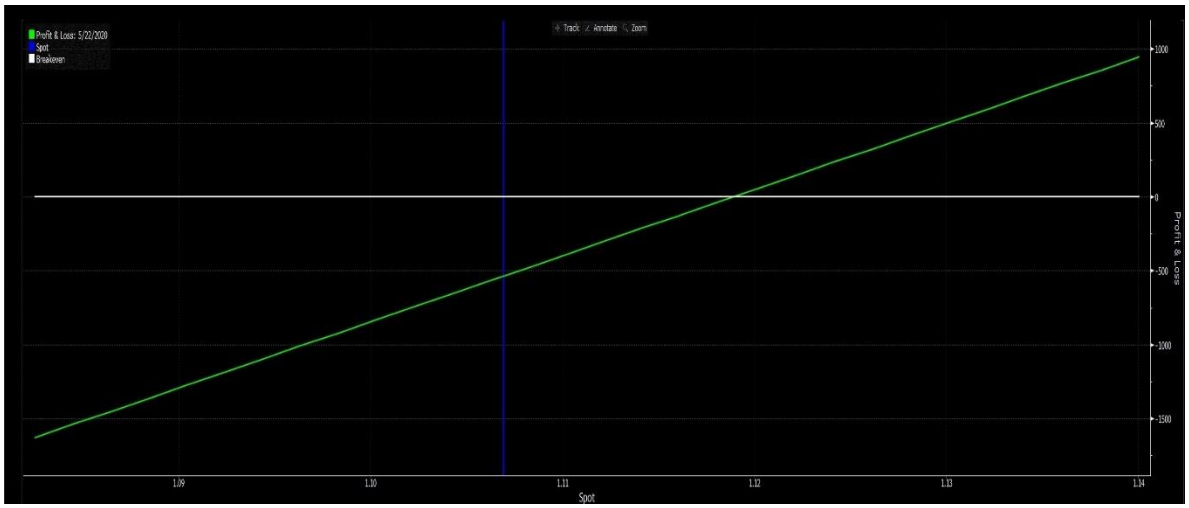
The client has the right to buy EUR/ sell USD against an amount of Notional (but it cannot be exceeded) at the Strike price whenever he wants until the Expiry Date. If at the Expiry Date there is still residual of the Notional (i.e. USD 45,000), the client is obliged to sell EUR/ buys USD against the rest of the Notional at the Strike price. In this indication, there is no Forward Starting Date because there is no profit for EUR long positions. To explain, when a financial institution sells a Flexible Forward, to hedge its position, it buys EUR/ sells USD (the same position). To buy EUR it has to lend and it is known that the rates of EUR are negative (pay more money than it lends). Therefore, as later is the Fwd Starting Date, the more disadvantaged the institution is from the carry trade.

Like Flexible Forward, if the investor needs a lot of deliveries (i.e. does imports at the end of each month), there are another downside hedging strategies.

Table 5. 18: EUR long Par Forward

Client :	Buys EUR / Sells USD
Notional per Delivery :	USD 50,000
No of Deliveries :	13
Deal Date :	05/12/19
Expiry Date :	22/05/20
Strike :	1.1160
Premium :	Zero - Cost
Spot Reference :	1.1069

Figure 5. 20: EUR long Par Forward P&L

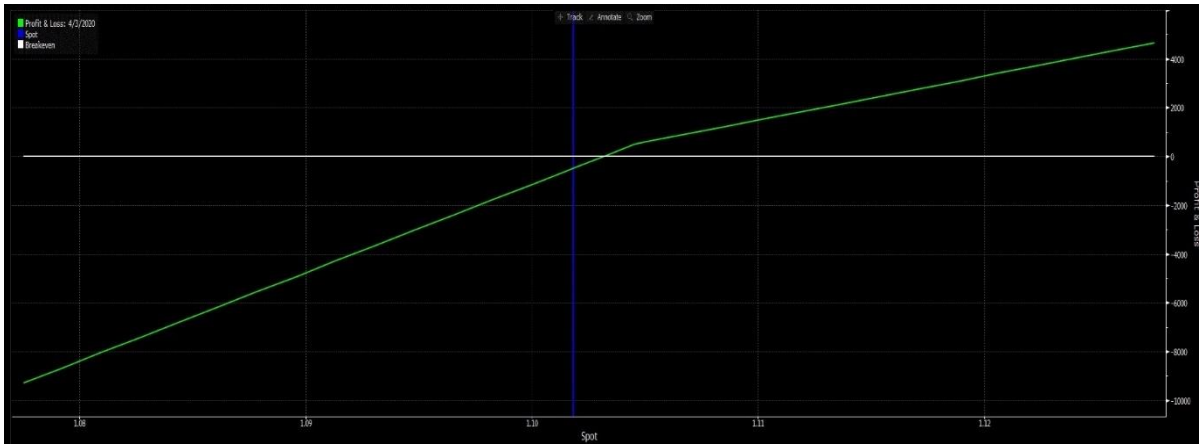


Source: Bloomberg

Table 5. 19: EUR long Asymmetric Par Forward

Client :	Long EUR / Short USD
Notional per Delivery :	
above strike	USD 200,000
below strike	USD 400,000
No of Deliveries :	6
Deal Date :	13/11/19
Expiry Date :	10/06/20
Strike :	1.1045
Cut	BFIX 15:00
Premium :	Zero - Cost
Spot Reference :	1.1018

Figure 5. 21: EUR long Asymmetric Par Forward P&L



Source: Bloomberg

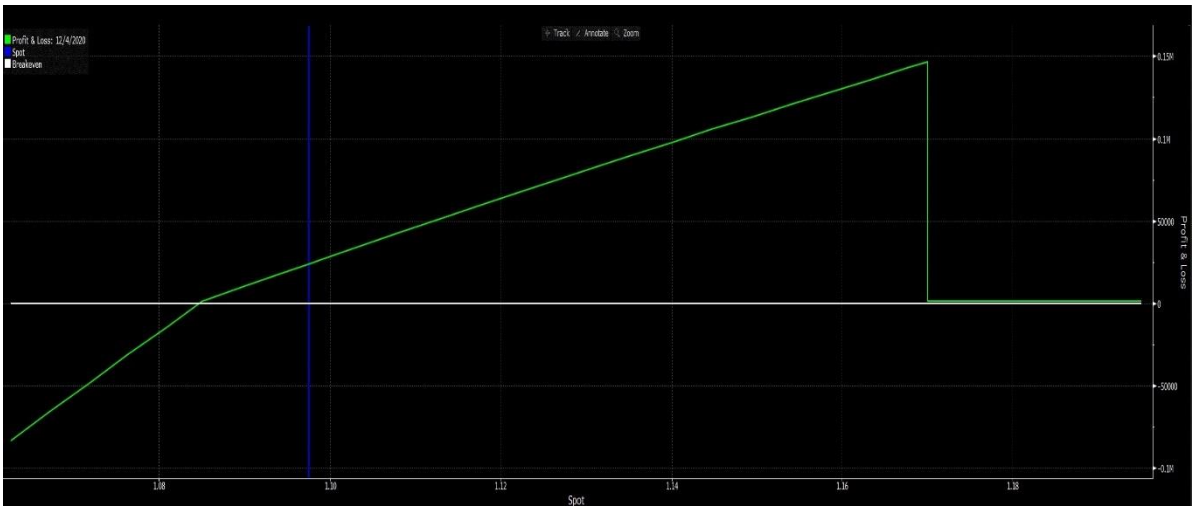
An Asymmetric Par Forward is a structured forward that allows client to trade at a better rate than a Par Forward transaction by integrating leverage. At each expiry, if the currency pair trades:

I. at or below the Strike rate, client buys the Notional 1 amount at the Strike rate.
II. above the Strike rate, client buys the Notional 2 amount at the Strike rate.

Table 5. 20: EUR long Asymmetric Knock Out Par Forward

Client :	Long EUR / Short USD
Notional 1 per Delivery :	USD 50,000
Notional 2 per Delivery :	USD 100,000
No of Deliveries (bi-weekly) :	13
Deal Date :	05/12/2019
Expiry Date :	10/06/2020
Strike :	1.1000
Barrier :	1.1300
Premium :	Zero - Cost
Cut :	NY 10:00
Spot Reference :	1.1069

Figure 5. 22: EUR long Asymmetric Knock Out Par Forward P&L



Source: Bloomberg

At each expiry:

I. if no knock-out event occurs and the currency pair trades at or below the Strike rate, client sells the Notional 2 amount at the Strike rate.

II. if no knock-out event occurs and the currency pair trades above the Strike rate, client sells the Notional 1 amount at the Strike rate.

III. if the currency pair reaches or breaches the knock-out level, the Asymmetric EKO Forward will be terminated and no transaction will occur for this period.

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XIII. Cross Asset Research, "FX Outlook 2020", *Societe Generale,* 9 December 2019

XIV. Frontline, *The warning*, Aired: 10/20/09, https://www.pbs.org/video/frontline-the-warning/

XV. The definitions of the terms in glossary and MIFID are founded in: https://www.investopedia.com/

APPENDIX: Pricing Snapshots

Table 1: EUR short Knock-in Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.1085	1.1085		1.1085	
Style				Knockin		European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR		EUR	Put	EUR	Call
Expiry		175 days		175 days	06/03/20	175 days	06/03/20
Delivery		NY 10:00		NY 10:00	06/05/20	NY 10:00	06/05/20
Strike			Forward	1.1200	0.12% OTMF	1.1200	0.12% ITMF
Notional		USD		USD	10,000,000.00	USD	10,000,000.00
Barrier Dir.		Down & In		Down & In			
Barrier Type		European		European			
Barrier Level				1.1000	0.77% ITMS		
Model				Vanna-Volga		Black-Scholes	
ATM Vol	BGN			5.244%		5.131%/5.335%	
Results							
Price	USD pips	28.303 R		136.167 P		164.470 R	
Premium	USD	25,270.95 R		121,577.48 P		146,848.43 R	
Prem Date		12/13/19		12/13/19		12/13/19	
SLV Prem	Calculate						
T.V.		31.879 R		136.076 P		167.955 R	
Vanilla Equiv. Price							
Delta	Spot	-99.6987%		-47.4292%		-52.2695%	
Sticky Delta		-98.1381%		-47.4292%		-50.7089%	
Hedge		8,901,666.14		4,234,746.52		4,666,919.62	

Table 2:EUR short Risk Reversal

TS Description		EUR/USD RISK_REVERSAL 20200		EUR/USD RISK_REVERSAL 20200		EUR/USD RISK_REVERSAL 20200	
Price Date		12/03/19	11:48				
Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.1085	1.1085		1.1085	
Style				European	Vanilla	European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR		EUR	Put	EUR	Call
Expiry		183 days		183 days	06/03/20	183 days	06/03/20
Delivery		NY 10:00		NY 10:00	06/05/20	NY 10:00	06/05/20
Strike			Forward	1.1000	1.92% OTMF	1.1400	1.64% OTMF
Notional		USD		USD	10,000,000.00	USD	10,000,000.00
Model				Black-Scholes		Black-Scholes	
Vol	BGN			5.037%		5.088%/5.339%	
More Market Data							
Results							
Price	% USD	0.0963% R		0.6589% P		0.7552% R	
Premium	USD	9,627.39 R		65,888.10 P		75,515.49 R	
Prem Date		12/05/19		12/05/19		12/05/19	
T.V.		0.0835% R		0.6572% P		0.7407% R	
Delta	Spot	-61.3861%		-28.8085%		-33.7621%	
Sticky Delta		-55.9731%		-27.2630%		-29.7541%	
Hedge		5,580,550.43		2,618,959.03		2,961,591.40	

Table 3: EUR short Put Spread

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.1085	1.1085		1.1085	
Style				European	Vanilla	European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR	Put	EUR	Put	EUR	Put
Expiry		204 days		204 days	06/03/20	204 days	06/03/20
Delivery		NY 10:00		NY 10:00	06/05/20	NY 10:00	06/05/20
Strike			Forward	1.1000	2.06% OTMF	1.0835	3.53% OTMF
Notional		USD		USD	10,000,000.00	USD	10,000,000.00
Model				Black-Scholes		Black-Scholes	
Vol	BGN			5.394%		5.390%/5.716%	
More Market Data							
Points	BGN	Mid		146.77...		146.77...	
Forward		Mid		1.1232...		1.1232...	
EUR Depo	Implied	Mid		-0.838...%		-0.838...%	
USD Depo	USD OIS	Mid		1.488...%		1.488...%	
Results							
Price	% USD	0.3641% P		0.7782% P		0.4141% R	
Premium	USD	36,406.79 P		77,815.99 P		41,409.20 R	
Prem Date		11/14/19		11/14/19		11/14/19	
T.V.		0.3600% P		0.7645% P		0.4045% R	
Delta	Spot	-10.5689%		-29.6972%		18.8414%	
Sticky Delta		-11.0031%		-27.5755%		16.3239%	
Hedge		960,810.09		2,699,748.36		-1,738,938.27	

Table 4: EUR short Knock-Out Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot	Mid	1.1085		1.1085		1.1085	
Style				Knockout		Knockout	
Direction		Physical	Client sells	Physical	Client buys	Physical
Call/Put	EUR		EUR	Call	EUR	Put
Expiry	204 days		204 days	06/03/20	204 days	06/03/20
Delivery	NY 10:00		NY 10:00	06/05/20	NY 10:00	06/05/20
Strike		Spot	1.1300	1.94% OTMS	1.1300	1.94% ITMS
Notional	USD		USD	10,000,000.00	USD	10,000,000.00
Barrier Dir.		Down & Out		Down & Out		Down & Out
Barrier Type		European		European		European
Barrier Level			1.0900	1.67% OTMS	1.0900	1.67% ITMS
Model				Vanna-Volga		Vanna-Volga
ATM Vol BGN				5.342%		5.342%
Results						
Price % USD		0.6275% R		1.2690% R		0.6415% P
Premium USD		62,747.02 R		126,898.82 R		64,151.80 P
Prem Date		11/14/19		11/14/19		11/14/19
SLV Prem Calculate						
T.V.		0.7250% R		1.2937% R		0.5687% P
Vanilla Equiv. Price						N/A
Delta Spot		-52.9006%		-43.1924%		-9.7082%
Sticky Delta		-52.9006%		-43.1924%		-9.7082%
Hedge		4,681,468.96		3,822,339.15		859,129.81

Table 5: EUR short Asymmetric Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot	Mid	1.1085		1.1085		1.1085	
Style				FX Hedge		European	Vanilla
Direction		Physical	Client buys US	Physical	Client sells	Physical
Call/Put	EUR	Call		EUR		EUR	Call
Expiry	202 days		202 days	mm/dd/yy	204 days	06/03/20
Delivery	NY 10:00		NY 10:00	06/03/20	NY 10:00	06/05/20
Strike		Forward	1.1325	0.84% OTMF	1.1325	0.83% OTMF
Notional	USD		USD	10,000,000.00	USD	20,000,000.00
Model						Black-Scholes	
Vol BGN						5.276%/5.500%	
More Market Data							
Points BGN	Mid			145.41...		146.77...	
Forward	Mid			1.1230...		1.1232...	
EUR Depo Implied	Mid			-0.839...%		-0.838...%	
USD Depo USD OIS	Mid			1.488...%		1.488...%	
Results							
Price USD pips		173.390 R		93.809 P		133.600 R	
Premium USD		153,103.43 R		82,833.91 P		235,937.35 R	
Prem Date		11/14/19		11/14/19		11/14/19	
T.V.		177.688 R				135.749 R	
Delta Spot		-186.1969%		-100.4729%		-42.8620%	
Sticky Delta		-181.4088%		-100.4729%		-40.4679%	
Hedge		16,441,223.70		8,871,780.22		7,569,443.48	

Table 6: EUR short Asymmetric Knock-Out Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot	Mid	1.1085		1.1085		1.1085	
Style				Knockout		European	Vanilla
Direction		Physical	Client buys	Physical	Client sells	Physical
Call/Put	EUR		EUR	Put	EUR	Call
Expiry	204 days		204 days	06/03/20	204 days	06/03/20
Delivery	NY 10:00		NY 10:00	06/05/20	NY 10:00	06/05/20
Strike		Forward	1.1425	1.72% ITMF	1.1425	1.72% OTMF
Notional	USD		USD	10,000,000.00	USD	20,000,000.00
Barrier Dir.		Down & Out		Down & Out		
Barrier Type		European		European		
Barrier Level			1.0900	1.67% ITMS		
Model				Vanna-Volga		Black-Scholes	
ATM Vol BGN				5.342%		5.360%/5.598%	
Results							
Price USD pips		70.415 R		129.155 P		99.785 R	
Premium USD		61,632.77 R		113,046.20 P		174,678.97 R	
Prem Date		11/14/19		11/14/19		11/14/19	
SLV Prem Calculate							
T.V.		86.016 R		112.449 P		99.232 R	
Vanilla Equiv. Price							
Delta Spot		-82.2976%		-12.7530%		-34.7723%	
Sticky Delta		-75.3525%		-12.7530%		-31.2997%	
Hedge		7,203,291.17		1,116,240.44		6,087,050.72	

Table 7: EUR short Flexible Forward

Leg 1			
TS Description		EUR/USD Flexi Forward 20200403	
Price Date		12/04/19	17:16
Asset		EURUSD	
Spot		Mid	1.1091
Style		Flexi Forward	
Exercise start		03/02/20	
Exercise end		12/01/20	
Direction		Client buys US	Physical
Expiry		363 days	mm/dd/yy
Delivery		NY 10:00	12/03/20
Rate		1.1130	1.83% ITMF
Notional		USD	500,000.00
Model		BS - PDE	
Vol	BGN	4.770%/5.069%	
More Market Data			
Points	BGN	Mid	246.67...
Forward		Mid	1.1338...
EUR Depo	Implied	Mid	-0.758...%
USD Depo	USD OIS	Mid	1.431...%
Greeks			
Results			
Price	% USD	0.2405% R	
Premium	USD	1,202.67 R	
Prem Date		12/06/19	
Delta	Spot	-100.2282%	
Sticky Delta		-100.2195%	
Hedge		450,261.34	

Table 8: EUR short Par Forward

Asset		EURUSD	
Spot		Mid	1.1089
Style		FX Hedge	
Direction		Client buys US	Physical
Expiry		209 days	mm/dd/yy
Delivery		NY 10:00	06/10/20
Rate		1.1159	0.71% ITMF
Notional		USD	50,000.00
More Market Data			
Points	BGN	Mid	150.17...
Forward		Mid	1.1239...
EUR Depo	Implied	Mid	-0.835...%
USD Depo	USD OIS	Mid	1.487...%
Greeks			
Results			
Price	% USD	0.7123% R	
Premium	USD	356.16 R	
Prem Date		11/14/19	
Delta	Spot	-100.4869%	
Sticky Delta		-100.4869%	
Hedge		45,025.05	

Table 9: EUR short Asymmetric Par Forward

TS Description	EUR/USD PARTICIPATING_FWD 2(	EUR/USD PARTICIPATING_FWD 2(	EUR/USD PARTICIPATING_FWD 2(
Price Date	12/23/19 14:22		
Asset	EURUSD	EURUSD	EURUSD
Spot	Mid 1.1089	1.1089	1.1089
Style		European Vanilla	European Vanilla
Direction	Physical	Client sells Physical	Client buys Physical
Call/Put	EUR	EUR Call	EUR Put
Expiry	170 days	170 days 06/10/20	170 days 06/10/20
Delivery	NY 10:00	NY 10:00 06/12/20	NY 10:00 06/12/20
Strike	Forward	1.1223 0.10% OTMF	1.1223 0.10% ITMF
Notional	USD	USD 100,000.00	USD 50,000.00
Model		Black-Scholes	Black-Scholes
Vol BGN		5.066%	4.917%/5.215%
More Market Data			
Spread Data			
Results			
Price % USD	0.5515% R	1.2805% R	1.4581% P
Premium USD	551.48 R	1,280.52 R	729.04 P
Prem Date	12/27/19	12/27/19	12/27/19
T.V.	0.6115% R	1.3200% R	1.4171% P
Delta Spot	-75.0731%	-49.7547%	-50.6367%
Sticky Delta	-74.0521%	-47.7301%	-52.6440%
Hedge	66,892.15	44,332.83	22,559.33

Table 10: EUR short Asymmetric Knock Out Par Forward

TS Description	EUR/USD Multi-leg 20200417	EUR/USD Multi-leg 20200417	EUR/USD Multi-leg 20200417
Price Date	12/27/19 12:55		
Asset	EURUSD	EURUSD	EURUSD
Spot	Mid 1.1177	1.1177	1.1177
Style		Knockout	European Vanilla
Direction	Physical	Client buys Physical	Client sells Physical
Call/Put	EUR	EUR Put	EUR Call
Expiry	112 days	112 days 04/17/20	112 days 04/17/20
Delivery	NY 10:00	NY 10:00 06/15/20	NY 10:00 06/15/20
Strike	Forward	1.1650 3.13% ITMF	1.1850 4.90% OTMF
Notional	USD	USD 100,000.00	USD 200,000.00
Barrier Dir.	Down & Out	Down & Out	
Barrier Type	European	European	
Barrier Level		1.1000 1.58% ITMS	
Results			
Price USD pips	243.170 P	258.116 P	7.601 R
Premium USD	2,087.29 P	2,215.59 P	128.29 R
Prem Date	12/31/19	12/31/19	12/31/19
SLV Prem Calculate			
T.V.	221.493 P	232.553 P	5.625 R
Vanilla Equiv. Price			
Delta Spot	-34.5540%	-19.9276%	-7.4387%
Sticky Delta	-32.1229%	-19.9276%	-6.2024%
Hedge	29,660.06	17,105.22	12,554.85

Table 11: EUR long Knock-In Forward

Asset	EURUSD	EURUSD	EURUSD
Spot	Mid 1.1111	1.1111	1.1111
Style		Knockin	European Vanilla
Direction	Physical	Client buys Physical	Client sells Physical
Call/Put	EUR	EUR Call	EUR Put
Expiry	322 days	322 days 12/04/20	322 days 12/04/20
Delivery	NY 10:00	NY 10:00 12/08/20	NY 10:00 12/08/20
Strike	Forward	1.1150 1.60% ITMF	1.1150 1.60% OTMF
Notional	USD	USD 2,000,000.00	USD 2,000,000.00
Barrier Dir.	Up & In	Up & In	
Barrier Type	European	European	
Barrier Level		1.1700 5.30% ITMS	
Results			
Price USD pips	84.506 P	217.318 P	132.811 R
Premium USD	15,158.07 P	38,980.74 P	23,822.67 R
Prem Date	01/21/20	01/21/20	01/21/20
SLV Prem Calculate			
T.V.	81.446 P	220.212 P	138.766 R
Vanilla Equiv. Price			
Delta Spot	88.5448%	52.2282%	36.3166%
Sticky Delta	88.3128%	52.2282%	36.0846%
Hedge	-1,588,246.82	-936,828.68	-651,418.14

Table 12: EUR long Risk Reversal

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.0975	1.0975		1.0975	
Style				European	Vanilla	European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR		EUR	Call	EUR	Put
Expiry		380 days		380 days	12/04/20	380 days	12/04/20
Delivery		NY 10:00		NY 10:00	12/08/20	NY 10:00	12/08/20
Strike			Forward	1.1350	1.03% OTMF	1.1200	0.31% OTMF
Notional		USD		USD	2,000,000.00	USD	2,000,000.00
Model				Black-Scholes		Black-Scholes	
Vol	BGN			6.444%		5.679%/5.841%	
More Market Data							
Points	BGN	Mid		259.43...		259.43...	
Forward		Mid		1.1234...		1.1234...	
EUR Depo	Implied	Mid		-0.811...%		-0.811...%	
USD Depo	USD OIS	Mid		1.397...%		1.397...%	
Spread Data							
Results							
Price	% USD	0.0000%		2.1328% P		2.1328% R	
Premium	USD	0.00		42,655.36 P		42,655.36 R	
Prem Date		11/22/19		11/22/19		11/22/19	
T.V.		0.0703% R		2.1007% P		2.1709% R	
Delta	Spot	93.2914%		45.5060%		47.1539%	
Sticky Delta		90.6844%		41.9642%		48.0763%	
Hedge		-1,643,902.08		-801,867.47		-842,034.61	

Table 13: EUR long Call Spread Option

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.0975	1.0975		1.0975	
Style				European	Vanilla	European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR	Call	EUR	Call	EUR	Call
Expiry		145 days		145 days	04/12/20	145 days	04/12/20
Delivery		NY 10:00		NY 10:00	04/15/20	NY 10:00	04/15/20
Strike			Forward	1.1100	0.17% OTMF	1.1500	3.78% OTMF
Notional		USD		USD	2,000,000.00	USD	2,000,000.00
Model				Black-Scholes		Black-Scholes	
Vol	BGN			5.008%		5.454%/5.781%	
More Market Data							
Points	BGN	Mid		105.74...		105.74...	
Forward		Mid		1.1081...		1.1081...	
EUR Depo	Implied	Mid		-0.878...%		-0.878...%	
USD Depo	USD OIS	Mid		1.505...%		1.505...%	
Spread Data							
Results							
Price	% USD	0.9252% P		1.1619% P		0.2366% R	
Premium	USD	18,504.95 P		23,237.56 P		4,732.61 R	
Prem Date		11/22/19		11/22/19		11/22/19	
T.V.		0.9814% P		1.1592% P		0.1778% R	
Delta	Spot	34.0330%		48.5968%		-15.0886%	
Sticky Delta		34.4929%		46.2812%		-12.2131%	
Hedge		-613,208.10		-875,618.27		262,410.17	

Table 14: EUR long Knock-Out Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.0975	1.0975		1.0975	
Style				Knockout		Knockout	
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR		EUR	Call	EUR	Put
Expiry		380 days		380 days	12/04/20	380 days	12/04/20
Delivery		NY 10:00		NY 10:00	12/08/20	NY 10:00	12/08/20
Strike			Spot	1.1000	0.23% OTMS	1.1000	0.23% ITMS
Notional		USD		USD	2,000,000.00	USD	2,000,000.00
Barrier Dir.		Up & Out		Up & Out		Up & Out	
Barrier Type		European		European		European	
Barrier Level				1.1700	6.61% ITMS	1.1700	6.61% OTMS
Model				Vanna-Volga		Vanna-Volga	
ATM Vol	BGN			5.224%		5.774%	
More Market Data							
Points	BGN	Mid		259.43...		259.43...	
Forward		Mid		1.1234...		1.1234...	
Results							
Price	% USD	0.0000%		1.4220% P		1.4220% R	
Premium	USD	0.00		28,440.86 P		28,440.86 R	
Prem Date		11/22/19		11/22/19		11/22/19	
SLV Prem	Calculate						
T.V.		0.1606% R		1.2780% P		1.4386% R	
Vanilla Equiv. Price						N/A	
Delta	Spot	52.4039%		18.2127%		34.1912%	
Sticky Delta		52.4039%		18.2127%		34.1912%	
Hedge		-952,797.63		-331,139.83		-621,657.80	

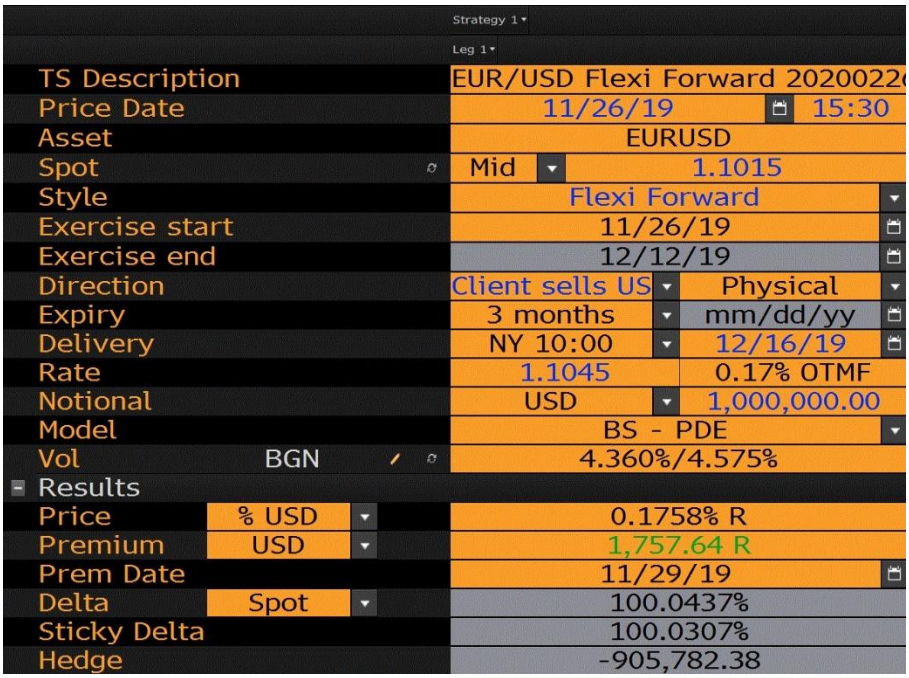
Table 15: EUR long Asymmetric Forward

Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.0975	1.0975		1.0975	
Style				European	Vanilla	European	Vanilla
Direction			Physical	Client sells	Physical	Client buys	Physical
Call/Put		EUR		EUR	Put	EUR	Call
Expiry		317 days		317 days	12/04/20	317 days	12/04/20
Delivery		NY 10:00		NY 10:00	12/08/20	NY 10:00	12/08/20
Strike			Forward	1.1080	0.99% OTMF	1.1080	0.99% ITMF
Notional		USD		USD	4,000,000.00	USD	2,000,000.00
Model				Black-Scholes		Black-Scholes	
Vol	BGN			4.958%		4.855%/5.061%	
More Market Data							
Spread Data							
Results							
Price	% USD	0.1427% R		1.3417% R		2.3980% P	
Premium	USD	5,709.98 R		53,669.76 R		47,959.78 P	
Prem Date		01/24/20		01/24/20		01/24/20	
T.V.		0.2058% R		1.3938% R		2.3762% P	
Delta	Spot	70.7458%		40.8681%		59.7554%	
Sticky Delta		71.0580%		41.5011%		59.1137%	
Hedge		-2,553,999.26		-1,475,382.64		-1,078,616.61	

Table 16: EUR long Asymmetric Knock-Out Forward

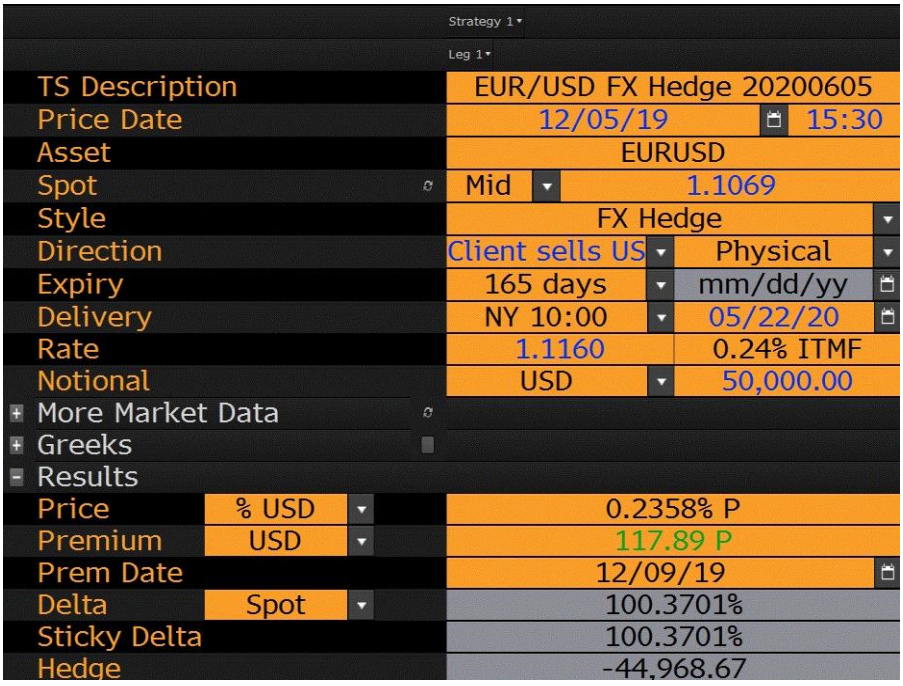
Price Date		12/06/19	13:47				
Asset		EURUSD		EURUSD		EURUSD	
Spot		Mid	1.1060	1.1060		1.1060	
Style				Knockout		European	Vanilla
Direction			Physical	Client buys	Physical	Client sells	Physical
Call/Put		EUR		EUR	Call	EUR	Put
Expiry		364 days		364 days	12/04/20	364 days	12/04/20
Delivery		NY 10:00		NY 10:00	12/08/20	NY 10:00	12/08/20
Strike			Forward	1.1000	2.74% ITMF	1.1000	2.74% OTMF
Notional		USD		USD	2,000,000.00	USD	4,000,000.00
Barrier Dir.		Up & Out		Up & Out			
Barrier Type		European		European			
Barrier Level				1.1700	5.79% ITMS		
Model				Vanna-Volga		Black-Scholes	
ATM Vol	BGN			5.630%		5.524%/5.754%	
Results							
Price	% USD	0.7086% R		1.4602% P		1.0844% R	
Premium	USD	14,172.87 R		29,203.44 P		43,376.31 R	
Prem Date		12/10/19		12/10/19		12/10/19	
SLV Prem	Calculate						
T.V.		0.9733% R		1.2702% P		1.1217% R	
Vanilla Equiv. Price							
Delta	Spot	72.8183%		12.1335%		30.3424%	
Sticky Delta		69.2473%		12.1335%		28.5569%	
Hedge		-1,323,968.36		-220,608.71		-1,103,359.65	

Table 17:EUR long Flexible Forward



Strategy 1		
Leg 1		
TS Description		EUR/USD Flexi Forward 2020022
Price Date		11/26/19 15:30
Asset		EURUSD
Spot		Mid 1.1015
Style		Flexi Forward
Exercise start		11/26/19
Exercise end		12/12/19
Direction		Client sells US Physical
Expiry		3 months mm/dd/yy
Delivery		NY 10:00 12/16/19
Rate		1.1045 0.17% OTMF
Notional		USD 1,000,000.00
Model		BS - PDE
Vol	BGN	4.360%/4.575%
Results		
Price	% USD	0.1758% R
Premium	USD	1,757.64 R
Prem Date		11/29/19
Delta	Spot	100.0437%
Sticky Delta		100.0307%
Hedge		-905,782.38

Table 18: EUR long Par Forward



Strategy 1		
Leg 1		
TS Description		EUR/USD FX Hedge 20200605
Price Date		12/05/19 15:30
Asset		EURUSD
Spot		Mid 1.1069
Style		FX Hedge
Direction		Client sells US Physical
Expiry		165 days mm/dd/yy
Delivery		NY 10:00 05/22/20
Rate		1.1160 0.24% ITMF
Notional		USD 50,000.00
More Market Data		
Greeks		
Results		
Price	% USD	0.2358% P
Premium	USD	117.89 P
Prem Date		12/09/19
Delta	Spot	100.3701%
Sticky Delta		100.3701%
Hedge		-44,968.67

Table 19: EUR long Asymmetric Par Forward

TS Description	EUR/USD PARTICIPATING_FWD 2(	EUR/USD PARTICIPATING_FWD 2(	EUR/USD PARTICIPATING_F
Price Date	11/13/19 15:26		
Asset	EURUSD	EURUSD	EURUSD
Spot	Mid 1.1018	1.1018	1.1018
Style		European Vanilla	European Vanilla
Direction	Physical	Client buys Physical	Client sells Physical
Call/Put	EUR	EUR Call	EUR Put
Expiry	142 days	142 days 04/03/20	142 days 04/03/2(
Delivery	NY 10:00	NY 10:00 04/07/20	NY 10:00 04/07/2(
Strike	Forward	1.1045 0.71% ITMF	1.1045 0.71% OT
Notional	USD	USD 200,000.00	USD 400,000.
Model		Black-Scholes	Black-Scholes
Results			
Price % USD	0.1691% R	1.6834% P	0.9263% R
Premium USD	338.24 R	3,366.82 P	3,705.07 R
Prem Date	11/15/19	11/15/19	11/15/19
T.V.	0.2455% R	1.6608% P	0.9532% R
Delta Spot	141.1061%	59.6023%	40.7519%
Sticky Delta	140.7591%	59.9320%	40.4135%
Hedge	-255,511.20	-107,926.39	-147,584.81

Table 20: EUR long Asymmetric Knock Out Par Forward

TS Description	EUR/USD Multi-leg 20200610	EUR/USD Multi-leg 20200610	EUR/USD Multi-leg 20200610
Price Date	12/05/19 13:47		
Asset	EURUSD	EURUSD	EURUSD
Spot	Mid 1.1069	1.1069	1.1069
Style		Knockout	European Vanilla
Direction	Physical	Client buys Physical	Client sells Physical
Call/Put	EUR	EUR Call	EUR Put
Expiry	188 days	188 days 06/10/20	188 days 06/10/20
Delivery	NY 10:00	NY 10:00 06/12/20	NY 10:00 06/12/20
Strike	Forward	1.1000 1.79% ITMF	1.1000 1.79% OTMF
Notional	USD	USD 50,000.00	USD 100,000.00
Barrier Dir.	Up & Out	Up & Out	
Barrier Type	European	European	
Barrier Level		1.1300 2.09% ITMS	
Results			
Price USD pips	100.872 R	52.697 P	76.784 R
Premium USD	458.51 R	239.53 P	698.04 R
Prem Date	12/09/19	12/09/19	12/09/19
SLV Prem Calculate			
T.V.	118.794 R	42.746 P	80.770 R
Vanilla Equiv. Price			
Delta Spot	62.5324%	1.4366%	30.5479%
Sticky Delta	60.0459%	1.4366%	29.3047%
Hedge	-28,423.81	-652.99	-27,770.82