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FX Derivatives Trader School

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Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

Library of Congress Cataloging-in-Publication Data:

ISBN 9781118967454 (Paperback)
ISBN 9781119096610 (ePDF)
ISBN 9781119096474 (ePub)

Cover image: Business World © iStock.com/ktsimage; abstract background © iStock.com/PiexelEmbargo
Cover design: Wiley

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

For my wife and daughters: Laura, Rosie, and Emily.

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PREFACE

In 2004 I started on an FX derivatives trading desk as a graduate. I wrote down everything I learned: how markets worked, how FX derivatives contracts were risk-managed, how to quote prices, how Greek exposures evolve over time, how different pricing models work, and so on. This book is a summary of that knowledge, filtered through a decade of trading experience across the full range of FX derivatives products.

In 2011 I started sending out monthly "Trader School" e-mails to traders on the desk, covering a wide range of topics. The e-mails were particularly popular with new joiners and support functions because they gave an accessible view of derivatives trading that did not exist elsewhere. This book collects together and expands upon those e-mails.

Part I covers the basics of FX derivatives trading. This is material I wish I'd had access to when originally applying for jobs on derivatives trading desks. Part II investigates the volatility surface and the instruments that are used to define it. Part III covers vanilla FX derivatives trading and shows how the FX derivatives market can be analyzed. Part IV covers exotic FX derivatives trading, starting with the most basic products and slowly increasing the complexity up to advanced volatility and multi-asset products. This material will mostly be useful to junior traders or traders looking to build or refresh their knowledge in a particular area.

Fundamentally, the aim of the book is to explain derivatives trading from first principles in order to develop intuition about derivative risk rather than attempting to be state of the art. Within the text, experienced quant traders will find many statements that are not entirely true, but are true the vast majority of the time. Endlessly caveating each statement would make the text interminable.

Traders can only be successful if they have a good understanding of the framework in which they operate. Importantly though, for derivatives traders this is not the same as fully understanding derivative mathematics. Therefore the mathematics is kept to an accessible "advanced high school" level throughout. Some mathematical rigor is lost as a result of this, but for traders that is a price worth paying.

Also in the interests of clarity, some other important considerations are largely ignored within the analysis, most notably, credit risk (i.e., the risk of a counterparty defaulting on money owed) and interest rates (i.e., how interest rate markets work in practice). Derivative product analysis is the primary concern here and this is cleaner if those issues are ignored or simplified.

Regulations and technology are causing significant changes within the FX derivatives market structure. The most important changes are increasing electronic execution, increasing electronic market data, more visibility on transactions occurring in the market, and less clear distinctions between banks and their clients. These changes will have profound and lasting effects on the market. However, the ideas and techniques explored within the book hold true no matter how the market structure changes.

Finally, and most importantly, if you are a student or new joiner on a derivatives trading desk: *Do the practicals*. I can guarantee that if you complete the practicals, you will hit the ground running when you join a derivatives trading desk. *Do them*. Do them *all*. Do them all *in order*. Do not download the spreadsheets from the companion website unless you are completely stuck. When you're trying to learn something, taking the easy option is never the right thing to do. The practicals require the ability to set up Excel VBA (Visual Basic for Applications) functions and subroutines. If you aren't familiar with this, there is plenty of material online that covers this in detail.

The very best of luck with your studies and careers,

Giles Jewitt, London, 2015.

ACKNOWLEDGMENTS

Thanks are due to
… those who taught me:

Fred Boillereau
Jeff Wang
Mike Killen
Rob Ross
Hossein Zaimi

… those who supported me in writing the book and helped make it happen:

Howard Savery
Caroline Prior
Vincent Craignou
Selene Chong

… all colleagues who helped me with content, especially:

Chris Potter
Charlie Chamberlain
Daniela Asikian
Allen Li

… Marouane Benchekroun and his Quants for the tools I used to produce most of the charts in the book.

… those who looked after my girls and I while the book was completed:

Frances, Tony, Phil, Gerry, Tim, Jod and Mark.

… my family for their support, encouragement and assistance: Mum, Dad, and Anna.

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All rates and figures used are for illustrative purposes only and do not reflect current market rates.

FX Derivatives Trader School

PART I

The Basics

Part I lays the foundations for understanding FX derivatives trading. Trading within a financial market, market structure, and the Black-Scholes framework are all covered from first principles. FX derivatives trading risk is then introduced with an initial focus on vanilla options since they are by far the most commonly traded contract.

Introduction to Foreign Exchange

The *foreign exchange (FX) market* is an international marketplace for trading **currencies**. In FX transactions, one currency (sometimes shortened to CCY) is *exchanged* for another. Currencies are denoted with a three-letter code and **currency pairs** are written CCY1/CCY2 where the **exchange rate** for the currency pair is the number of CCY2 it costs to buy one CCY1. Therefore, trading EUR/USD FX involves exchanging amounts of EUR and USD. If the FX rate goes higher, CCY1 is getting relatively stronger against CCY2 since it will cost more CCY2 to buy one CCY1. If the FX rate goes lower, CCY1 is getting relatively weaker against CCY2 because one CCY1 will buy fewer CCY2.

If a currency pair has both elements from the list in Exhibit 1.1, it is described as a *G10 currency pair*.

The most commonly quoted FX rate is the **spot rate**, often just called **spot**. For example, if the EUR/USD spot rate is 1.3105, EUR 1,000,000 would be exchanged for USD 1,310,500. Within a spot transaction the two cash flows actually hit the bank account (*settle*) on the **spot date**, which is usually two business days after the transaction is agreed (called T+2 settlement). However, in some currency pairs, for example, USD/CAD and USD/TRY (Turkish lira), the spot date is only one day after the transaction date (called T+1 settlement).

Another set of commonly traded FX contracts are **forwards**, sometimes called **forward outrights**. Within a forward transaction the cash flows settle on some future date other than the spot date. When rates are quoted on forwards, the **tenor** or **maturity** of the contract must also be specified. For example, if the EUR/USD 1yr (one-year) forward FX rate is 1.3245, by transacting this contract in EUR10m

EXHIBIT 1.1	G10 Currencies		
CCY Code	**Full Name**	**CCY Code**	**Full Name**
AUD	Australian dollar	JPY	Japanese yen
CAD	Canadian dollar	NOK	Norwegian krone
CHF	Swiss franc	NZD	New Zealand dollar
EUR	Euro	SEK	Swedish krona
GBP	Great British pound	USD	United States dollar

(ten million euros) **notional**, each EUR will be exchanged for 1.3245 USD (i.e., EUR10m will be exchanged for USD13.245m in one year's time). In a given currency pair, the spot rate and forward rates are linked by the respective **interest rates** in each currency. By a no-arbitrage argument, delivery to the forward maturity must be equivalent to trading spot and putting the cash balances in each currency into "risk-free" investments until the maturity of the forward. This is explained in more detail in Chapter 5.

Differences between the spot rate and a forward rate are called **swap points** or **forward points**. For example, if EUR/USD spot is 1.3105 and the EUR/USD 1yr forward is 1.3245, the EUR/USD 1yr swap points are 0.0140. 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 USD/JPY, where FX rates are usually only quoted to two decimal places, a pip is 0.01. In the above example, an FX swaps trader would say that EUR/USD 1yr swap points are at 140 ("one-forty").

Pips (sometimes called "points") are also used to describe the magnitude of FX moves (e.g., "EUR/USD has jumped forty pips higher" if the EUR/USD spot rate moves from 1.3105 to 1.3145). Another term used to describe spot moves is **figure**, meaning one hundred pips (e.g., "USD/JPY has dropped a figure" if the USD/JPY spot rate moves from 101.20 to 100.20).

FX swap contracts contain two FX deals in opposite directions (one a buy, the other a sell). 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 on the two legs of the FX swap are often equal in CCY1 terms (e.g., buy *EUR10m* EUR/USD spot against sell *EUR10m* EUR/USD 1yr forward). FX swaps are quoted in swap point terms (the difference in FX rate) between the two legs. In general, swap points change far less frequency than spot rates in a given currency pair.

A trader takes up a new FX position by buying USD10m USD/CAD spot at a rate of 0.9780. This means buying USD10m and simultaneously selling CAD9.78m. This position is described as "long ten dollar-cad," meaning USD10m has been bought and an equivalent amount of CAD has been sold. If USD10m USD/CAD had been sold at 0.9780 instead, the position is described as "short ten dollar-cad." Note that the long/short refers to the *CCY1* position. 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 can flip often between long (a net bought position) and short (a net sold position).

USD/CAD spot jumps up to 0.9900 after it was bought at 0.9780: The trader is a hero! Time to sell USD/CAD spot and lock in the profit. Selling USD10m USD/CAD spot at 0.9900 results in selling USD10m against buying CAD9.9m. The initial bought USD10m and new sold USD10m cancel out, leaving no net USD position, but the initial sold CAD9.78m and new bought CAD9.9m leave CAD120k profit. This is important: FX transactions and positions are usually quoted in CCY1 terms (e.g., *USD*10m USD/CAD) while the profit and loss (P&L) from the trade is naturally generated in CCY2 terms (e.g., *CAD*120k).

A **long** position in a financial instrument *makes money* if the price of the instrument *rises* and *loses money* if the price of the instrument *falls*. Mathematically, the intraday P&L from a long spot position is:

$$P\&L_{CCY2} = Notional_{CCY1}.(S_T - S_0)$$

where S_0 is the initial spot rate and S_T is the new spot rate.

Exhibit 1.2 shows the P&L from a long spot position. As expected, P&L expressed in CCY2 terms is linear in spot.

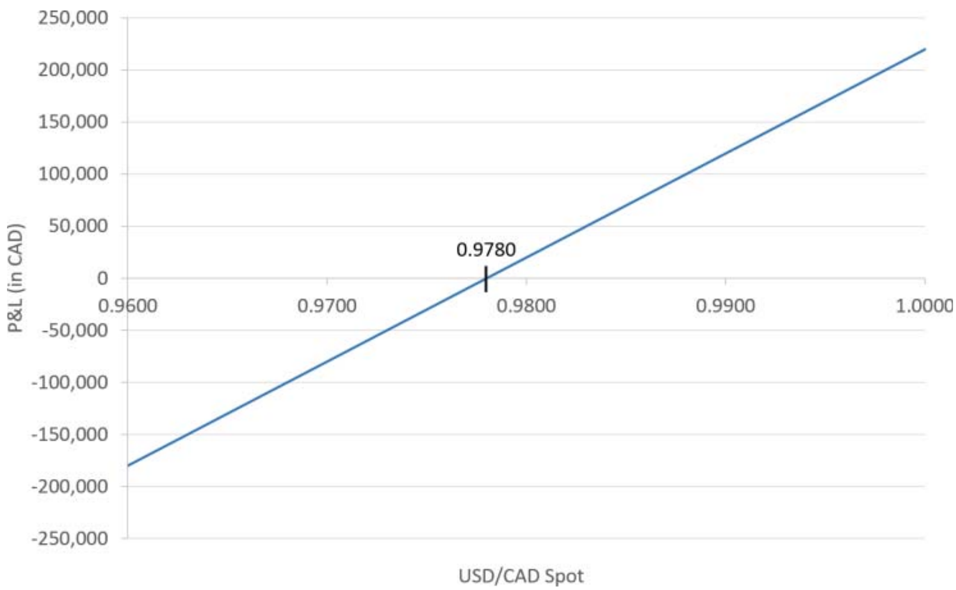

EXHIBIT 1.2 P&L from long USD10m USD/CAD spot at 0.9780

A **short** position in a financial instrument *makes money* if the price of the instrument *falls* and *loses money* if the price of the instrument *rises*. The intraday P&L from a short spot position is also:

$$P\&L_{CCY2} = Notional_{CCY1}.(S_T - S_0)$$

However, the notional will be negative to denote a short position.

Exhibit 1.3 shows the P&L from a short spot position. Again, P&L expressed in CCY2 terms is linear in spot.

If the P&L from these spot deals is brought back into CCY1 terms, the conversion between CCY2 and CCY1 takes place at the prevailing spot rate. Therefore, the CCY1 P&L from a spot position is:

$$P\&L_{CCY1} = Notional_{CCY1}.\frac{(S_T - S_0)}{S_T}$$

At lower spot levels, an amount of CCY2 will be worth relatively more CCY1 (spot lower means CCY2 stronger and CCY1 weaker). At higher spot levels, an amount of CCY2 will be worth relatively fewer CCY1 (spot higher means CCY1 stronger and CCY2 weaker). This effect introduces curvature into the P&L profile as shown in Exhibit 1.4.

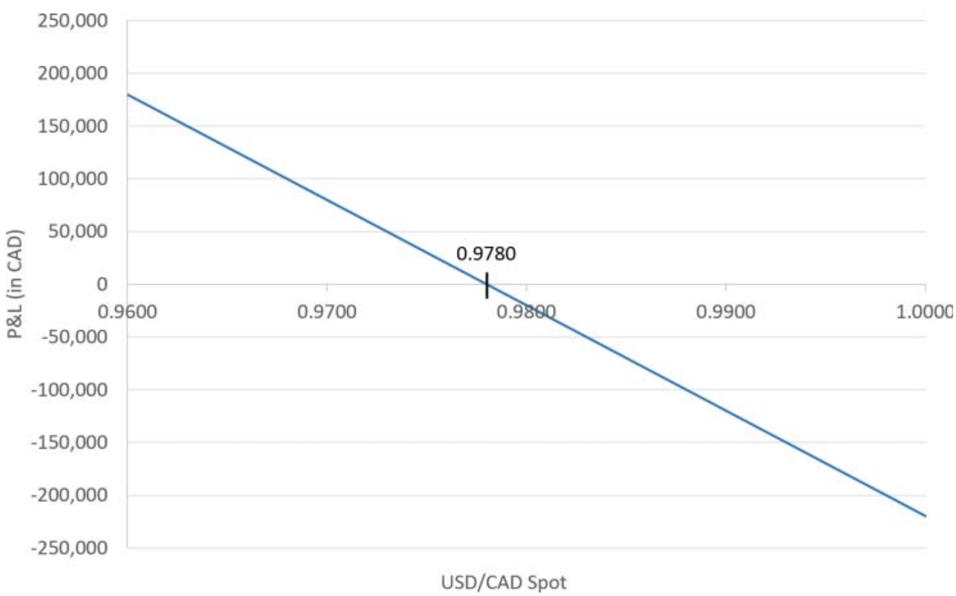

EXHIBIT 1.3 P&L from short USD10m USD/CAD spot at 0.9780

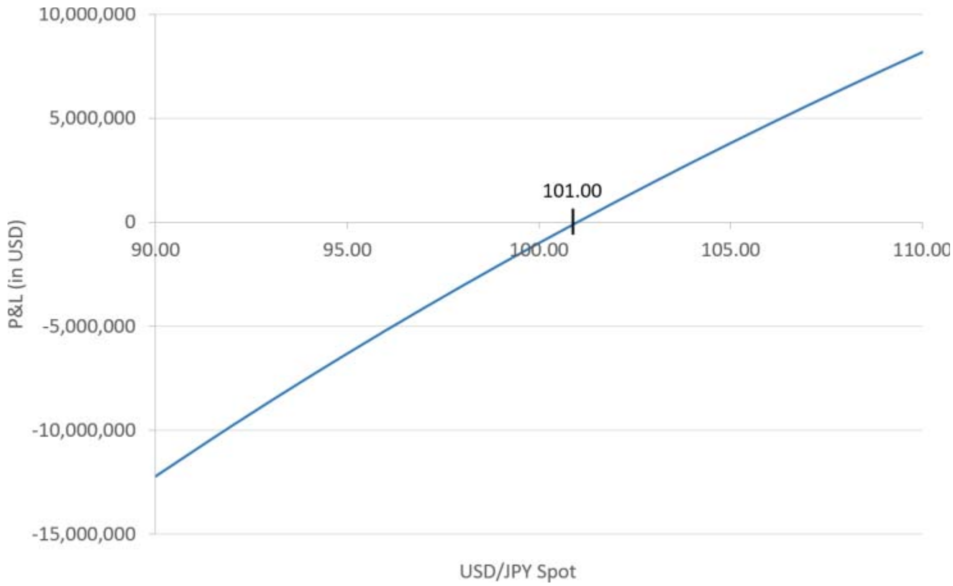

EXHIBIT 1.4 P&L from long USD100m USD/JPY spot at 101.00

Practical Aspects of the FX Market

The international foreign exchange market is enormous, with trillions of dollars' worth of deals transacted each day. The most important international center for FX is London, followed by New York. In Asia, Tokyo, Hong Kong, and Singapore are roughly equally important.

The USD is by far the most frequently traded currency with the majority of FX trades featuring USD as either CCY1 or CCY2. 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**: the most commonly traded currency pairs, usually against the USD, and **cross currency pairs**. For example, EUR/USD and AUD/USD are majors while EUR/AUD is a cross. FX rates in cross pairs are primarily determined by the trading activity in the majors. The FX market is highly efficient so if EUR/USD spot is trading at 1.2000 and AUD/USD spot is trading at 0.8000, EUR/AUD spot will certainly be trading at 1.5000 (1.2/0.8).

Exhibit 1.5 is a mocked-up screen-grab of a market-data tool showing live spot rates in major G10 currency pairs. In practice these rates change (*tick*) many times a second.

Pair	Bid	Offer	Day Low	Day High
EUR/USD	1.3651	1.3652	1.3647	1.3688
GBP/USD	1.6898	1.6899	1.6856	1.6913
USD/CHF	0.8933	0.8934	0.8923	0.8950
AUD/USD	0.9237	0.9238	0.9221	0.9274
NZD/USD	0.8567	0.8568	0.8556	0.8587

EXHIBIT 1.5 Sample G10 spot rates

G10 currency pairs are (mostly) freely floating with no restrictions on their trading. The G10 FX markets are tradable 24 hours a day between Wellington Open (9 A.M. Wellington, New Zealand time) on Monday through to New York Close (5 P.M. New York time) on Friday.

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 GBP FX rate is quoted in the market as GBP/CAD. Unfortunately, with market convention rules there are often exceptions. For example, the majority of the market quotes EUR against GBP as EUR/GBP but some U.K. corporates trade in GBP/EUR terms since GBP is their natural notional currency.

Emerging market (EM) countries often have mechanisms in place to control currency flows. For example, some EM currencies have limited spot open hours and some *peg* their currency at a fixed level or maintain it within a trading band by buying and selling spot or by restricting transactions. When trading in an emerging market currency it is vital to learn exactly how the FX market functions in that country. EM majors are quoted as the number of EM currency to buy one USD (i.e., USD/CCY).

In currency pairs with restrictions on spot transactions, **Non-Deliverable Forward** (**NDF**) contracts are often traded. NDFs settle into a single cash payment (usually in USD) at maturity rather than the two cash flows in a regular FX settlement. The **fix**, a reference FX rate published at a certain time every business day in the appropriate country, is used to determine the settlement payment.

Up-to-date FX rates can be found on the Internet using, for example, Yahoo finance (http://finance.yahoo.com/) or XE.com (http://www.xe.com/).

What Do FX Traders Call Different Currency Pairs?

Nobody on the trading floor calls USD/JPY "*you-ess-dee-jay-pee-why*." Major currency pairs have names that are well established and widely used. Standardized

EXHIBIT 1.6 **Selected G10 Currency Pair Names**

Currency Pair	Common Name
USD/CAD	"dollar-cad"
USD/JPY	"dollar-yen"
GBP/USD	"cable" (FX prices between London and New York used to be transmitted over a cable on the Atlantic ocean floor.)
EUR/USD	"euro-dollar"
AUD/USD	"aussi-dollar"
NZD/USD	"kiwi-dollar"
EUR/CHF	"euro-swiss" or "the cross"
EUR/NOK	"euro-nock" or "euro-nockie"
EUR/SEK	"euro-stock" or "euro-stockie"

EXHIBIT 1.7 **Selected EM Currency Pair Names**

Currency Pair	Common Name
USD/HKD	"dollar-honkie"
USD/CNY	"dollar-china"
USD/SGD	"dollar-sing"
USD/MXN	"dollar-mex"
USD/TRY	"dollar-try" or "dollar-turkey"
USD/ZAR	"dollar-rand"
USD/BRL	"dollar-brazil"

language is common in financial markets. It enables quick and accurate communication but it exposes those who are not experienced market participants. For this reason, using the correct market terms is important. See Exhibits 1.6 and 1.7 for common G10 and EM currency pair names.

Introduction to FX Derivatives

The FX market can be split into three main product areas with increasing complexity:

1. Spot: guaranteed currency exchange occurring on the spot date.
2. Swaps / Forwards: guaranteed currency exchange(s) occurring on a specified date(s) in the future.
3. **Derivatives**: contracts whose value is *derived* in some way from a reference FX rate (most often spot). This can be done in many different ways, but the most common FX derivative contracts are **vanilla call options** and **vanilla put options**, which are a *conditional* currency exchange occurring on a specified date in the future.

Vanilla Call and Put 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. The vast majority (90%+) of derivative transactions executed by an FX derivatives trading desk are vanilla contracts as opposed to **exotic contracts**. Exotic FX derivatives (covered in Part IV) have additional features (e.g., more complex payoffs, barriers, averages).

To understand how call and put options work, forget FX for the moment and think about buying and selling apples (not Apple Inc. stock, but literally the green round things you eat). Apples currently cost 10p each. I know that I will need to buy

100 apples in one month's time. If I simply wait one month and then buy the apples, perhaps the prevailing price will be 5p and hence I can buy the apples cheaper than they currently are *or* perhaps the price will be 15p and hence more expensive *or* perhaps they will cost 10p, 1p, or 999p. The point is that there is *uncertainty* about how much the apples will cost and this uncertainty makes planning for the future of my fledgling apple juice company more difficult. Call and put options allow this uncertainty to be controlled.

One possible contract that could be purchased to control the risk is a one-month (1mth) call option with a **strike** of 10p and a **notional** of 100 apples. Note the different elements within the contract: the date in the future at which I want to complete the transaction (maturity: one month), the direction (I want to buy apples; therefore, I purchase a call option), the level at which I want to transact (strike: 10p) and the amount I want to transact (notional: 100 apples). After buying this call option, one month hence, at the maturity of the contract, if the price of apples is above the strike (e.g., at 15p) I will **exercise** the call option I bought and buy 100 apples at 10p from the seller (also known as the **writer**) of the option contract. Alternatively, if the price of apples is below the strike (e.g., at 5p), I don't want or need to use my right to buy them at 10p; hence the call option contract **expires**. Instead I will buy 100 apples directly in the market at the lower rate.

Therefore, by buying the call option, the **worst-case purchasing rate** is known; under no circumstances will I need to buy 100 apples in one month at a rate higher than 10p (the strike). This reduction in uncertainty comes at a cost: the **premium** paid upfront to purchase the call option. It is not hard to imagine that the premium of the call option will depend on the details of the contract: How long it lasts, how many apples it covers, the transaction level, plus crucially the **volatility** of the price of apples will be a key factor. The more volatile the price of apples, the more the call option will cost.

Exhibit 2.1 shows the P&L profile from this call option at maturity, presented in familiar hockey-stick diagram terms but without the initial premium included.

At the option maturity, if the price of apples is below the strike (10p), the call option has no value because the underlying can be bought cheaper in the market. If the price of apples is above the strike at maturity, the call option value rises linearly with the value of the underlying.

Mathematically, the P&L at maturity from this call option is:

$$P\&L = Notional \; . \; max(S_T - K,\ 0)$$

where *Notional* is expressed in terms of number of apples, S_T is the price of apples at the option maturity, and K is the strike. Often $max(S_T - K,\ 0)$ is written $(S_T - K)^+$.

It is worth noting that the P&L at maturity from the contract depends only on the price of apples at the moment the option contract matures; the path taken to get there is irrelevant.