

# Financial Engineering: Home Assignment

2021-2022

## Design and Hedging of a Structured Product

The assignment is about the construction of a Twin-Win Certificate linked to a particular stock. Each student is assigned one stock (see last pages), for which he or she should design and investigate the product. Students should look themselves for relevant market data. **Consider USD as the currency and elaborate on an appropriate choice for the dividend yield and the interest rate.**

Each student can choose the starting date ( $t = 0$ ) of the product. This can be any date from now until the deadline (**19 May 2022**).

### Twin-Win Certificate

**Twin-win certificates** are structured products that offer the investor positive participation in both the upside and downside of the underlying asset, as long as the asset price has never hit a lower barrier level during the certificate's lifetime. Twin-win certificates have only one payment day and no early redemption is allowed.

In particular, there are three possible payoff scenarios at maturity.

**Scenario 1:** The stock price crossed the lower barrier  $H$  at least once during the lifetime of the certificate. In this case, the product pays out the value of the underlying asset at maturity,  $S_T$ . There is no principal protection, an investor can lose the full investment.

**Scenario 2:** The stock price did not hit the lower barrier  $H$  and ends up below a strike level  $K$ . In this case, the certificate pays out the strike level  $K$  plus a bonus equal to the absolute difference between the stock price and the strike level, i.e., it pays out  $K + |S_T - K|$ .

**Scenario 3:** The stock price did not hit the lower barrier and ends up above the strike level  $K$ . The payoff of the certificate is equal to the value of the underlying asset at maturity,  $S_T$ . Twin-win certificates therefore have an unlimited upside potential.

The goal of the assignment is twofold, consisting of a valuation part and a hedging part.

### Valuation

Elaborate on how you can break the certificate into different building blocks, e.g. **risk-free bank account**, **vanilla options**, **exotic options**, **stock positions**, ... Determine

ine the maturity  $T$ , strike level  $K$  and the lower barrier  $H$ , such that the product is attractive for investors and you (as a bank) have a certain margin.

Compute the price of the certificate (with specified maturity, strike level and barrier level) according to the **Heston model**. In order to price this product:

- Write an algorithm to price vanilla calls and puts under the Heston model, using **FFT** and the **Carr-Madan formula**.
- Write an algorithm that, using the above pricers, calibrates the Heston model on vanilla option prices available in the market.
- Write a Monte Carlo pricer for the exotic structure in the certificate.

Attach all programs (Matlab, Python, Excel, ...) that perform these calculations to your report.

## Hedging

Assume that you (as a bank) have a notional  $N = 1\,000\,000$  USD of investor's capital in this certificate, i.e. you are short the certificate. This means that, at maturity, the bank owes the investors the payoff promised by the product. The bank wants to hedge this short position by setting up a **Delta-hedge**.

Determine the Delta-hedging strategy under the **Heston model** that could be initiated on the starting day ( $t = 0$ ). To do this, calculate the  $\Delta$  of the twin-win certificate according to the Heston model. Describe exactly how the hedging strategy should be executed (e.g. buy 1 357 stocks).

## Instructions

Write a report of maximum 10 pages (excluding screenshots) in which you describe in detail your final product. **Elaborate on why** you believe the product is **attractive**. Clearly state the **source of the market data** on the pricing date (you can choose any date from now until the deadline) and specify the **used market assumptions**, e.g. using screenshots with market prices.

Write the report in such a way that (1) the descriptive part on the product is convincing investors and (2) the more technical part is informing your boss and risk manager about the technicalities and the profitability of selling the structured product from the bank's perspective.

## Submission

The assignment needs to be submitted before **Thursday May 19, 2022 at 3PM**. Each student should upload the assignment on Toledo, via Financial Engineering → Assignments. The home assignment consists of a report of maximum 10 pages (a pdf document named: **"YourSurname\_FEHA2022.pdf"**) and Matlab, Python

or Excel programs. The programs have to be submitted separately to the report as one attachment (e.g. as a zip file). If there are any problems submitting the assignment via Toledo, contact Eva Verschueren ([eva.verschueren@kuleuven.be](mailto:eva.verschueren@kuleuven.be)). Students should include Prof. W. Schoutens ([wim.schoutens@kuleuven.be](mailto:wim.schoutens@kuleuven.be)) in CC in all e-mail correspondence.

## Evaluation

In the evaluation, we will take into account: correctness of answers, elaboration on choices and assumptions, style and details in the report. The home assignment counts for 50% of the total mark.

## Stocks

Each student is assigned one stock as described in the table on the next pages. If your name is missing, please inform us immediately.

Company	Ticker	First name	Last name
Zoom Video Communications	ZM	Timo	Anteunis
Zebra Technologies Corporation	ZBRA	Ingilab Elçin Oglu	Babayev
Exxon Mobil Corporation	XOM	Rebecca	Baijer
WalMart	WMT	Robin	Bruneel
Whirlpool Corporation	WHR	Eliot	Bruyndonckx
Workday, Inc.	WDAY	Ouahoukpan François	Camara
Verizon Communications Inc	VZ	Bert	Ceyssens
Visa Inc.	V	Jiaying	Chen
Urban Outfitters, Inc.	URBN	Ludovic	Cornet
UnitedHealth Group Inc.	UNH	Gilles	Corswarem
Texas Instruments	TXN	Martijn	Debeuf
Twitter Inc.	TWTR	Jasper	Debrabant
The Trade Desk Inc.	TTD	Diet	Dejaegher
Tesla Inc.	TSLA	Jules	Dierckx
The Travelers Companies Inc.	TRV	Vaishnav	Dilip
TripAdvisor, Inc.	TRIP	Milan	Donvil
T-Mobile US, Inc.	TMUS	Qihao	Duan
Thermo Fisher Scientific Inc.	TMO	Liesbeth	Eeckhaudt
Tilray Inc.	TLRY	Jonathan	Elaut
Thor Industries, Inc.	THO	Arthur	Gallo
Molson Coors Brewing Company	TAP	Emmanouil	Gkigkilinis
AT&T Inc	T	Burak	Guzel
Skyworks Solutions Inc.	SWKS	Ibrahim	Haidar
Spotify Technology S.A.	SPOT	Ayrton	Hamers
Snap Inc.	SNAP	Steff	Helsen
SolarEdge Technologies Inc.	SEDG	Pieter Jan	Houben
Starbucks Corporation	SBUX	Tao	Huang
Roku Inc.	ROKU	Yelle	Hunninck

<b>Company</b>	<b>Ticker</b>	<b>First name</b>	<b>Last name</b>
Ralph Lauren Corporation	RL	Samyak	Jain
Regeneron Pharmaceuticals Inc.	REGN	Junshu	Jiang
Paypal Holdings Inc.	PYPL	Muhammed	Kaçar
Planet Fitness Inc.	PLNT	Daniel	Keil
Procter & Gamble Co	PG	Dai Duong	Le
Pfizer Inc.	PFE	Urban	Lemmens
Pepsico Inc.	PEP	Driek	Lemmens
Penn National Gaming Inc.	PENN	Tianyu	Li
Oracle Corporation	ORCL	Sisheng	Liu
NVIDIA Corporation	NVDA	Ziling	Ma
Nike	NKE	Dieter	Maes
Netflix Inc.	NFLX	Nicolas	Meysmans
Micron Technology Inc.	MU	Jeroen	Nelis
Match Group Inc.	MTCH	Jakob	Neven
Microsoft	MSFT	Christophe	Nozaradan
Moderna Inc.	MRNA	Leni	Peeters
Merck & Co. Inc.	MRK	Laurens-Jan	Peters
3M Company	MMM	Rodrigo	Pinheiro Moreira da Cruz
MGM Resorts International	MGM	Emiel	Raveschot
Medtronic plc	MDT	Diana Alejandra	Rosales Meseguer
McDonald's Corp	MCD	Yassin	Sahraoui
Mastercard Inc	MA	Sander	Schoepen
Live Nation Entertainment Inc.	LYV	Chloë	Schouppe
Eli Lilly and Company	LLY	Arbaz	Shaikh
The Coca-Cola Company	KO	Ludovic	Specen-Berry
JP Morgan Chase & Co	JPM	Selin	Sultansuyu
Johnson & Johnson Inc	JNJ	Ethan	Tombroff
Intuit Inc.	INTU	Kaushalya Priyanka	Totakura
Intel Corporation	INTC	Arne	Vaes
International Business Machines	IBM	Koen	Van Bergen
Harley-Davidson, Inc.	HOG	Sam	Van Campenhout
Home Depot	HD	Jean-Ferdinand	Van Cauwenbergh
Hasbro, Inc.	HAS	Tijmen	van der Maas
Alphabet Inc.	GOOG	Bob	Van Leemputte
General Motors	GM	Stijn	Van Loock
General Mills, Inc.	GIS	Sam	Vancraeynest
Gilead Sciences Inc	GILD	Edward	Vandercruysse
Fastly Inc.	FSLY	Sam	Vansnick
First Solar Inc.	FSLR	Harrison	Verelst
Twenty-First Century Fox, Inc	FOXA	Maarten	Vervoort
Foot Locker, Inc.	FL	Mirte	Wallenus
Five Below Inc.	FIVE	Ting	Wan
FedEx Corporation	FDX	Zhonghao	Wang
Facebook	FB	Tianqi	Xia
Expedia Group, Inc.	EXPE	Prerna	XXX
The Estee Lauder Companies Inc.	EL	Ningyu	Yang
Ecolab Inc.	ECL	Yongbo	Yu