Financial Instruments Valuation and the Role of Quantitative Analysis in a Consulting Firm

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Praha, May 30th, 2012

Audit • Tax • Consulting • Financial Advisory
Global financial assets = 212 trillion USD
Size of derivatives market = 647 trillion USD

<table>
<thead>
<tr>
<th>Table 19: Amounts outstanding of over-the-counter (OTC) derivatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>By risk category and instrument</td>
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<tr>
<td>In billions of US dollars</td>
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<tr>
<td>Total contracts</td>
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<tr>
<td>Foreign exchange contracts</td>
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<td>Forwards and forex swaps</td>
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<td>Currency swaps</td>
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<td>Options</td>
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<td>Interest rate contracts</td>
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<td>Forward rate agreements</td>
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<td>Interest rate swaps</td>
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<td>Options</td>
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<td>Equity-linked contracts</td>
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<td>Forwards and swaps</td>
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<td>Options</td>
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<td>Commodity contracts</td>
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<td>Gold</td>
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<td>Other commodities</td>
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<td>Forwards and swaps</td>
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<td>Options</td>
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<tr>
<td>Credit default swaps</td>
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<tr>
<td>Single-name instruments</td>
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<tr>
<td>Multi-name instruments</td>
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<tr>
<td>of which index products</td>
</tr>
</tbody>
</table>

Memorandum Item: Gross Credit Exposure

BIS Quarterly Review, June 2012
Size of derivatives market

- The value of the world's financial assets—including all stock, bonds, and bank deposits—is about 212 trillion USD
- Over the counter derivatives market has an estimated size of about 647 trillion USD

How can the derivatives market be worth more than the world's total financial assets?

ANSWER: Because the same assets might be involved in several different derivatives.
Why derivatives

There is not a single investment bank which does not have a derivatives desk. Moreover, now even some non-financial institutions have their own derivatives analysts. For example oil companies spend quite a lot of money on derivatives research which may seem as an odd activity unrelated to the industry’s main business. Why then derivatives are so popular among so many? It turns out that different businesses love derivatives for different reasons.

**Why derivatives are used?**

- To hedge risks
- To reflect a view on the future direction of the market
- To lock in an arbitrage profit
- To change the nature of a liability
- To change the nature of an investment without incurring the costs of selling one portfolio and buying another
Motivation

“I’m looking for a hedge against my hedge funds.”
A **financial instrument** is any contract that gives rise to a financial asset of one entity and a financial liability or equity instrument of another entity.

**Financial Instruments**

- **Primary financial instruments**
  - Examples: assets, liabilities, equities, loans

- **Derivatives**
  - Examples: forwards/futures, options, swaps
A derivative is a financial instrument with all 3 of the following characteristics:

- **value changes in response to a change in a specified underlying** (e.g. interest rate, financial instrument price, commodity price, foreign exchange rate, index of prices or rates, credit rating or credit index)

- **no or very small initial net investment** (when a derivative contract originates, the entity does not pay or collect the notional amount)

- **settled at a future date** (the period from the trade date of the derivative transaction to the settlement date is longer than for spot transactions, i.e. longer than the ordinary settlement period for standard transactions)
Agreement Confirmation

“This Agreement is made and entered into as of July 1, 2012, by and between Client and Counterparty.

This agreement requires Client to pay a fixed rate of interest 4.5% and receive a variable rate of three-month PRIBOR + 1.2%, reset on quarterly basis.

The notional amount of the agreement is 100 million CZK, Client prepays the fixed leg at inception. The maturity is December 31, 2018.”

Is this Agreement a derivative?
**Confirmation**

A *confirmation* is the legal agreement underlying a derivative. It has to be signed by representatives of the two parties.

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**Business Snapshot 7.1**  
*Extract from Hypothetical Swap Confirmation*

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade date</td>
<td>27-February-2004</td>
</tr>
<tr>
<td>Effective date</td>
<td>5-March-2004</td>
</tr>
<tr>
<td>Business day convention (all dates)</td>
<td>Following business day</td>
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<tr>
<td>Holiday calendar</td>
<td>US</td>
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<tr>
<td>Termination date</td>
<td>5-March-2007</td>
</tr>
<tr>
<td><em>Fixed amounts</em></td>
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</tr>
<tr>
<td>Fixed-rate payer</td>
<td>Microsoft</td>
</tr>
<tr>
<td>Fixed-rate notional principal</td>
<td>USD 100 million</td>
</tr>
<tr>
<td>Fixed rate</td>
<td>5.015% per annum</td>
</tr>
<tr>
<td>Fixed-rate day count convention</td>
<td>Actual/365</td>
</tr>
<tr>
<td>Fixed-rate payment dates</td>
<td>Each 5-March and 5-September, commencing 5-September-2004, up to and including 5-March-2007</td>
</tr>
<tr>
<td><em>Floating amounts</em></td>
<td></td>
</tr>
<tr>
<td>Floating-rate payer</td>
<td>Goldman Sachs</td>
</tr>
<tr>
<td>Floating-rate notional principal</td>
<td>USD 100 million</td>
</tr>
<tr>
<td>Floating rate</td>
<td>USD 6-month LIBOR</td>
</tr>
<tr>
<td>Floating-rate day count convention</td>
<td>Actual/360</td>
</tr>
<tr>
<td>Floating-rate payment dates</td>
<td>Each 5-March and 5-September, commencing 5-September-2004, up to and including 5-March-2007</td>
</tr>
</tbody>
</table>
Example

Currency Exchange Agreement

“This Agreement is made and entered into as of September 1, 2011, by and between Client and Counterparty. Upon Client request Counterparty agrees to sell Client required Client’s functional currency amount (or foreign currency amount) in exchange for equivalent of foreign currency amount (or functional currency amount) using Exchange Rates provided in Article 1.

This Agreement is effective from September 1, 2011 to August 31, 2012.

Exchange Rates (Article 1):
Counterparty buy/sell 1 EUR for 25.80 CZK / 26.30 CZK”

Is this Agreement a derivative?
Example

**Provision Agreement**

“This Agreement is made and entered into as of September 1, 2011, by and between Client and Counterparty. The Counterparty is obliged to provide a buy/sell good (metal plate) contract for the Client. The Client is then obliged to provide a provision for the Counterparty according to signed amount of the provided contract.

The provision is set according to the following formula:

\[
\text{Provision} = 1200 \text{ EUR/mt} \times \text{volume of delivered good} - \text{market price of good (in EUR/mt)} \times \text{volume of delivered good.}
\]

Is this Agreement a derivative?
Most commonly used derivatives

The most used instruments

- FX forward, FX option (call, put), Forward rate agreement (FRA), …
- Interest rate swap (IRS), Cross currency swap (CCS), Forward-start interest rate swap, Amortizing swap, Accreting swap, Roller Coaster swap, …
- Interest rate option - Cap, Floor, Collar, Swaption, …
- Zero cost option strategies - Butterfly, Straddle, Strangle, Bull, Bear, …
- Structure option - FX barrier, Digital, Asian, …
- Constant maturity swap (CMS), Credit default swap (CDS), …
- Range accrual
FX forward, FX swap, and FX future

- **Foreign exchange (FX) forward** is an agreement to buy/sell defined amount of currency for another currency in defined forward rate at the agreed date in the future.

- **FX swap** is a combination of spot transaction and opposite forward transaction.

- **FX future contract** is an agreement to buy or sell an asset for a certain price at a certain time, which is identical to forward contract, however whereas a forward contract is traded OTC, a futures contract is traded on an exchange.
Example – FX forward

- Company enters into contract agreement to sell goods (cars) for 1 mil EUR in March 2013
- Company buys inputs from local contractor and provide wages to its employees, payments are made in CZK
- Current exchange rate is 25.3 CZK/EUR
- Company is exposed to currency risk, therefore company enters into FX forward agreement (derivative) to sell 1 mil EUR and buy 25.3 mil CZK in March 2013, current fair value of derivative is zero
- On December 2012 the company computes market value of derivative: loss if current market forward rate < contract rate, and profit vice versa
Financial Instruments

Areas guided by IAS 32, IAS 39 and IFRS 7

- IAS 32 – Presentation
- IAS 39 – Recognition and Measurement
- IFRS 7 – Disclosures

Three steps

- Definitions
- Initial recognition
- **Subsequent measurement**
Motivation

“Oh, that three billion dollars.”
Motivation – Czech version

“Oh, that 120 million CZK.”
Profit/Loss at the termination date

![Diagram showing Profit/Loss, Spot Exchange Rate, and Forward Rate with Long and Short positions.]
Option

• **An option** is a right to buy (call option)/sell (put option) given amount of financial instrument for predetermined strike price at the determined date or during agreed period.

**Remember:**

• **European option** – can be realized only at the exact day (maturity)
• **American option** – can be realized at any time during the agreed period
• **Buyer (long)** – has a right to realized option, must pay option premium
• **Seller (short)** – has to deliver underlying instrument for agreed price (if he is asked to do that), his reward is option premium
Option – valuation

<table>
<thead>
<tr>
<th>Option</th>
<th>Value of the option</th>
<th>Price of the underlying</th>
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<tbody>
<tr>
<td>In the money</td>
<td></td>
<td></td>
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<tr>
<td>At the money</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out of the money</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Value of the option**
- **Price of the underlying**
- **In the money**
- **At the money**
- **Out of the money**

**Time value**
Black-Scholes equation

- Process for stock movement (discrete version):

\[ \Delta S = \mu S \Delta t + \sigma S \Delta z \]

- Let \( f \) be the price of a call option that depends on \( S \). The variable \( f \) depends, then \( S \) and \( t \). Then according to Ito’s lemma:

\[ \Delta f = \left( \frac{\partial f}{\partial S} \mu S + \frac{\partial f}{\partial t} + \frac{1}{2} \frac{\partial^2 f}{\partial S^2} \sigma^2 S^2 \right) \Delta t + \frac{\partial f}{\partial S} \sigma S \Delta z \]
Fischer S. Black (1938–1995) was an American economist, he had a PhD in applied mathematics from Harvard and worked at Arthur D. Little (the renowned consulting firm). He later was on the faculty at the University of Chicago and MIT.

Myron S. Scholes (1941) is a Canadian-born American financial economist who is best known as one of the authors of the Black–Scholes equation. In 1973, Myron Scholes published a paper with Fischer Black on 'Pricing of Options and Corporate Liabilities'.

Robert C. Merton (1949) is an American economist, finance professor at Harvard, and Nobel laureate in economics. In 1973 he was drafting a paper that improved on the Black-Scholes Model. Merton had already gained fame in academic circles for developing a theory of 'continuous time finance' which assumed that financial market prices varied in infinitesimally small steps.
Option – valuation

How to make option cheaper?

• sell call option / buy put option – zero cost structure
• add barrier to plain vanilla option
• combine options and forwards

Types of strategies:

• Take a position in the option and the underlying
• Take a position in 2 or more options of the same type (A spread)
• Combination: Take a position in a mixture of calls & puts (A combination)
Two rules

1. **Forwards are not forwards**
   - Foreign currency forward
   - Booster forward
   - Forward plus
   - Leveraged forward extra
   - Target profit forward
   These “forwards” are actually options strategies

2. **Options are not options**
   - Foreign currency option (call, put)
   - Himalaya option
   - Annapurna option
   - Everest option
   - Amarante option
   These “options” are structure products
Structured derivatives

**Structured derivatives** is an investment strategy, which is based on derivatives, such as a single security, a basket of securities, options, indices, commodities, debt issuances, foreign currencies, and/or swaps.

**Structured derivatives** refers to a group of financial instruments with varying terms, payout and risk profiles on a range of underlying assets.

**Structured derivative** is an instrument that derives its price in a non-linear way from multiple derivatives and/or multiple cash instruments.

**Two implications:**

1. Banks like structuring such deals because of the fees it provides.
2. Clients (usually) don't understand the risk related to this type of investment.
Motivation

“We structure the deal so it won’t make any sense to you.”
Target profit forward

- **Target profit forward** - the series of synthetic FX forwards (usually with leverage) with knock out barrier - the barrier is activated if the sum of received cash flow exceed the targeted profit (e.g. 500 000 EUR)
Monte Carlo simulation

- **Monte Carlo simulation** are usually more efficient than other methods when there are many stochastic variables, provides a standard error for the estimates, can handle more complex stochastic processes.
Four examples of structured derivatives

**Stochastic instruments**

- **Himalaya** (1999) - at a given frequency, the level of the best performing underlying is locked-in until the end; at maturity, the investor receives his capital invested plus the average of the locked-in performances

- **Annapurna** (2001) - payout equals to the greater of a capital guarantee plus a fixed coupon and a participation in the performance of the underlying basket, the fixed coupon level and the performance participation rate depend on whether and when the worst-performing stock breaches a downside barrier, the later the breach, the higher the fixed coupon and performance participation rate

- **Kilimanjaro** (2002) - an enhanced reverse convertible including a capital protection. The investor receives a fixed annual coupon if no stock has breached the limit on any predetermined observation date

- **Amarante** (2004) - the yearly rolling average performance (since launch) is calculated for thee investment profiles: secure, balanced and dynamic, at maturity the investor receives the capital invested plus the best of this yearly rolling average performance
Himalaya option
Amarante option - the annual performance is calculated for three investment profiles: at maturity the investor receives the best of this annual rolling average performance.

- **Investment profiles**: dynamic (mainly equities), balanced (mix between the four asset classes) and conservative (mainly fixed-income).

- **Asset classes**: equity markets (Europe, US, Japan, UK, China), fixed income, real estate, commodities, etc.
The main issues (mistakes in valuation) from the last year:

- **3.8 million EUR mistake identified** in valuation prepared by renowned European company in case of commodity derivatives due to an error in valuation model and usage of improper data – possible fraud
- **2.5 million EUR mistake identified** in valuation prepared by renowned European bank in case of derivatives due to an usage of the improper EUR yield curve – communication issue
- **1.1 million EUR mistake identified** in valuation of interest rate swap prepared by renowned banking group due to a human factor – control mechanism failure
- **0.8 million EUR mistake identified** in valuation of structure product prepared by renowned banking group due to an incorrect parameters set in valuation model
- **unknown EUR mistake identified** in valuation prepared by renowned European bank in case of FX profit target forward due to an error in valuation model – knock out barrier issue
Hot topics in financial instrument valuation

**Hot topics related to financial instrument valuation:**

- Curve construction
- Multi-curve valuation approach
- Credit value adjustment
- Liquidity margin
- Basis risk
- Commodity derivatives
- Interest rate derivatives
Strong risk management

How to avoid losses in derivatives transactions:

- Use the most simple derivatives as most as possible
- Make sure you understand the risk involved in transactions
- Make sure you are able to quantify the risk
- Double check the computed results with intuition
- Use benchmark model
- Provide regular monitoring
- Prepare rescue plan
Quantitative teams within Deloitte

There are several strong quantitative teams within the firm:

- **Banks (Financial Institutions)** – financial instruments valuation, Basel II related activities (market, credit, and operational risk models), early warning systems

- **Insurance** – Solvency II related activities

- **Forensics** – fraud detection and credit scoring, predictive modeling, forecasting, segmentation analysis, statistical market analysis, propensity modeling

- **Energy** – quantitative models primary focused on electricity consumption and prediction of spot prices
Výběrový proces

- Předvýběr kandidátů – strukturovaný životopis a motivační dopis
- 1. kolo – testy z analytických a jazykových schopností
- 2. kolo – pohovor se zástupci HR
- 3. kolo – účast v Assessment Centre/ Case study a panelové pohovory
- 4. kolo – pohovor s jedním z partnerů společnosti Deloitte

Otevřené pozice

- Pojistný matematik – Consulting
- Business analytik – Consulting
- Konzultant IT security
- Asistent auditora
- Daňový konzultant
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