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

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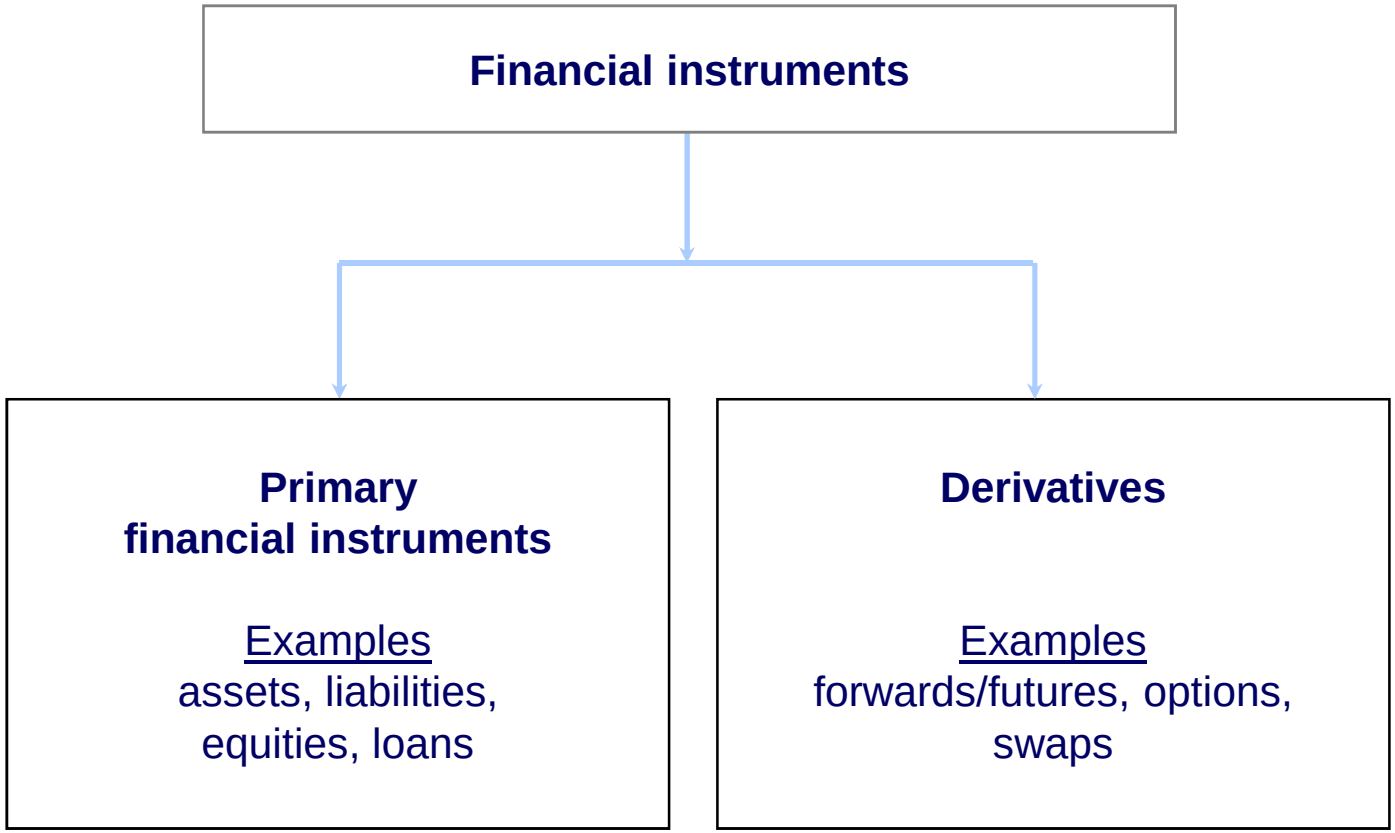
Audit . Tax . Consulting . Financial Advisory .

Financial Instruments - definition

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



Derivatives

A **derivative** is a financial instrument with all 3 of the following characteristics:

- its **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)

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

- it is **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 that the ordinary settlement period for standard transactions)

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

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, Range Accrual, …
- Zero cost option strategies - Butterfly, Straddle, Strangle, Bull, Bear, …
- Structure option - FX barrier, Digital, Asian, …
- Constant maturity swap (CMS), Credit default swap (CDS), …
- **Embedded derivatives**

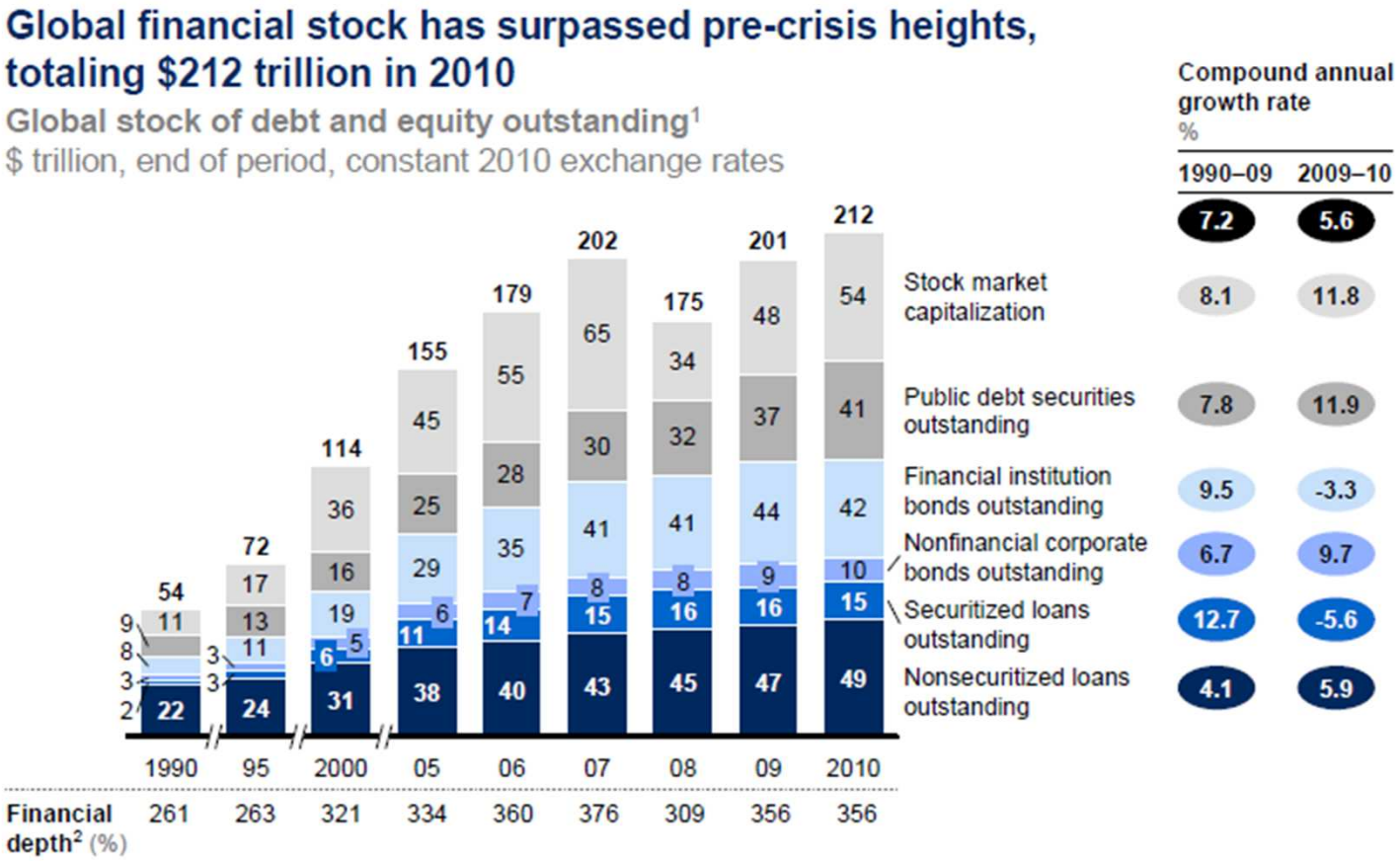
Embedded derivatives - example

- Lease contract with an inflation factor, e.g. annual rental income is adjusted for changes in CPI – then the hybrid contract is the entire lease, the host is the lease contract, and the embedded derivative is the adjustment for CPI

- Sale contract in a foreign currency, e.g. Czech company with functional currency CZK makes sale to EU Company with functional currency EUR, the contract is signed in USD – then the hybrid contract is the entire sale contract, the host is the sale contract, and the embedded derivative is the USD/CZK FX forward defined by the contract.

- Put or call options embedded in the capital instrument (an issued debt carrying the right to be sold for a fixed price prior to its maturity, an option to increase rental in connection with the development of the pricing level in Martinique)

Global financial assets = 212 trillion USD



1 Based on a sample of 79 countries.
2 Calculated as global debt and equity outstanding divided by global GDP.
NOTE: Numbers may not sum due to rounding.
SOURCE: Bank for International Settlements; Dealogic; SIFMA; Standard & Poor's; McKinsey Global Banking Pools; McKinsey Global Institute analysis

Size of derivatives market = 647 trillion USD

Table 19: Amounts outstanding of over-the-counter (OTC) derivatives

By risk category and instrument

In billions of US dollars

	Notional amounts outstanding					Gross market values				
Risk Category / Instrument	Dec 2009	Jun 2010	Dec 2010	Jun 2011	Dec 2011	Dec 2009	Jun 2010	Dec 2010	Jun 2011	Dec 2011
Total contracts	**603,900**	**582,685**	**601,046**	**706,884**	**647,762**	**21,542**	**24,697**	**21,296**	**19,518**	**27,285**
Foreign exchange contracts	**49,181**	**53,153**	**57,796**	**64,698**	**63,349**	**2,070**	**2,544**	**2,482**	**2,336**	**2,555**
Forwards and forex swaps	23,129	25,624	28,433	31,113	30,526	683	930	886	777	919
Currency swaps	16,509	16,360	19,271	22,228	22,791	1,043	1,201	1,235	1,227	1,318
Options	9,543	11,170	10,092	11,358	10,032	344	413	362	332	318
Interest rate contracts	**449,875**	**451,831**	**465,260**	**553,240**	**504,098**	**14,020**	**17,533**	**14,746**	**13,244**	**20,001**
Forward rate agreements	51,779	56,242	51,587	55,747	50,576	80	81	206	59	67
Interest rate swaps	349,288	347,508	364,377	441,201	402,611	12,576	15,951	13,139	11,861	18,046
Options	48,808	48,081	49,295	56,291	50,911	1,364	1,501	1,401	1,324	1,888
Equity-linked contracts	**5,937**	**6,260**	**5,635**	**6,841**	**5,982**	**708**	**706**	**648**	**708**	**679**
Forwards and swaps	1,652	1,754	1,828	2,029	1,738	176	189	167	176	156
Options	4,285	4,506	3,807	4,813	4,244	532	518	480	532	523
Commodity contracts	**2,944**	**2,852**	**2,922**	**3,197**	**3,091**	**545**	**458**	**526**	**471**	**487**
Gold	423	417	397	468	521	48	45	47	50	82
Other commodities	2,521	2,434	2,525	2,729	2,570	497	413	479	421	405
Forwards and swaps	1,675	1,551	1,781	1,846	1,745					
Options	846	883	744	883	824					
Credit default swaps	**32,693**	**30,261**	**29,898**	**32,409**	**28,633**	**1,801**	**1,666**	**1,351**	**1,345**	**1,586**
Single-name instruments	21,917	18,494	18,145	18,105	16,881	1,243	993	884	854	962
Multi-name instruments	10,776	11,767	11,753	14,305	11,752	558	673	466	490	624
of which index products	...	7,500	7,476	12,473	10,466					
Unallocated	**63,270**	**38,329**	**39,536**	**46,498**	**42,609**	**2,398**	**1,789**	**1,543**	**1,414**	**1,977**
Memorandum Item:										
Gross Credit Exposure						3,521	3,581	3,480	2,971	3,912

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.

How to compute fair value of derivatives?

Quantitative methods involved

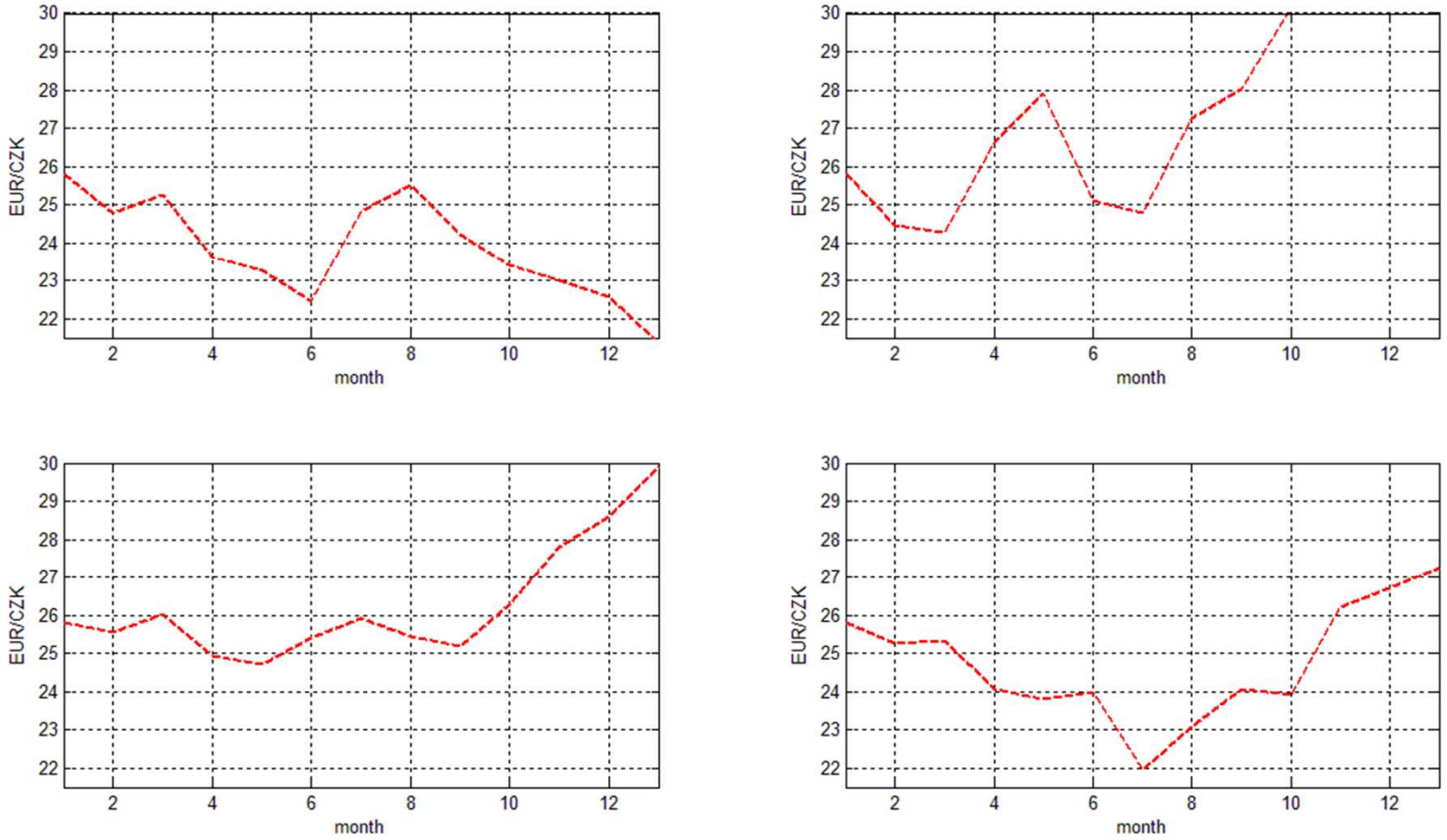
Topics often discussed in derivatives valuation:

- expected value, expected return, mean, median
- standard deviation, historical volatility, exponentially weighted volatility, correlation matrix, Cholesky decomposition, Copula function
- probability concept, joint and conditional probability
- discrete probability distribution, binomial and Poisson distribution
- random variable, standard normal distribution
- time value of money, future value, present value, discount factors
- sampling method and sampling distribution
- Markov chain, Markov process, Jump-diffusion process

Many quantitative methods should be combined to compute fair value of complex financial instruments, e.g. using Monte Carlo simulation.

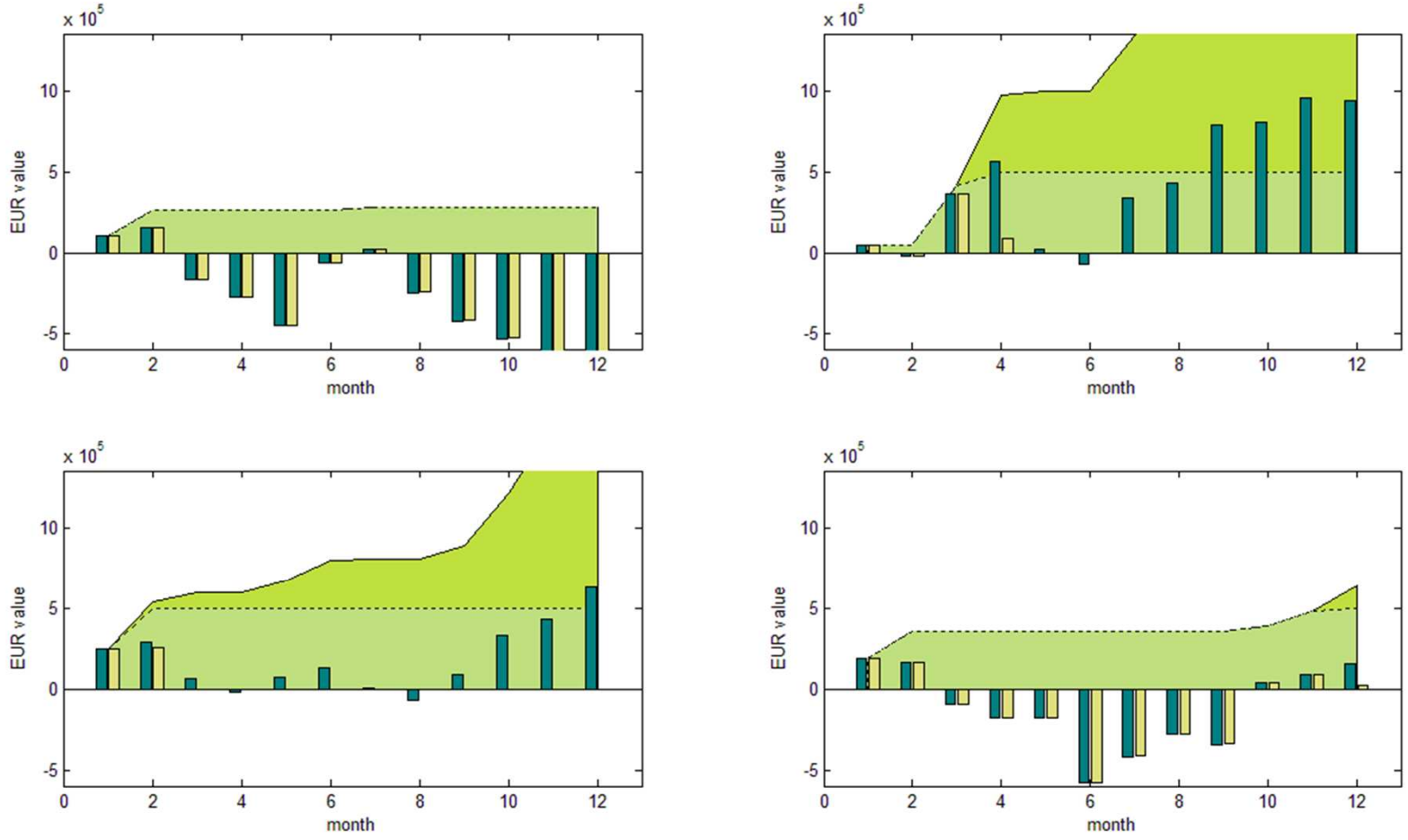
Monte Carlo simulation

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



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)



Complex structured products

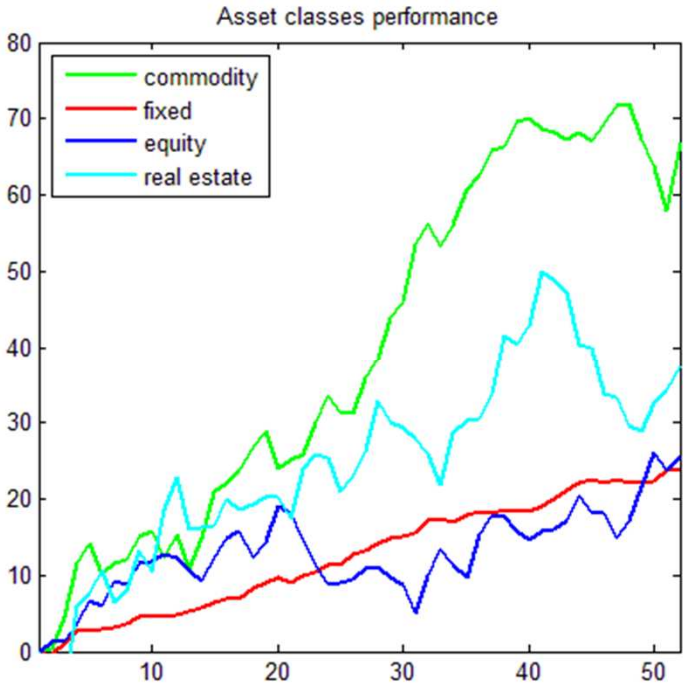
Stochastic instruments:

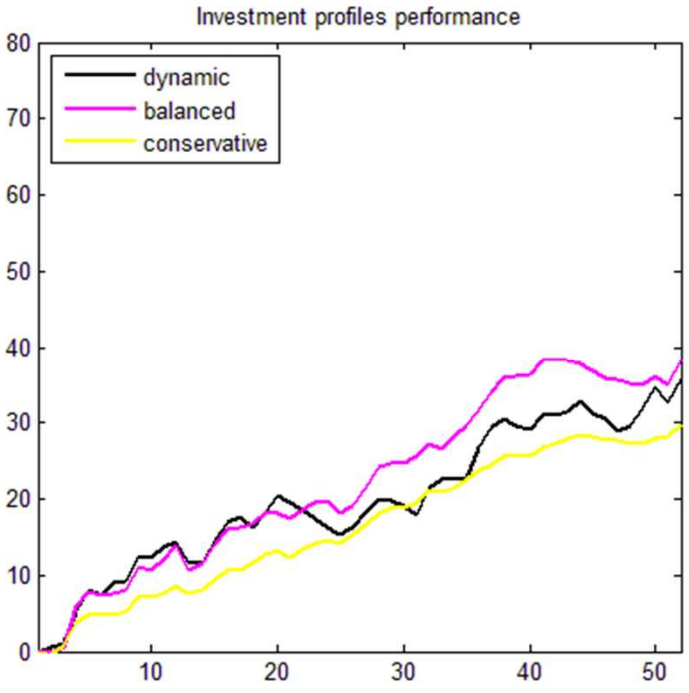
- **Himalaya** - at a given frequency, the level of the best performing underlying is locked-in until the end; at maturity, the investor receives his capital invested plus the average of the locked-in performances
- **Annapurna** - payout equals to the greater of a capital guarantee plus a fixed coupon 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** - 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** - 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

Amarante option – example

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.





Derivatives valuation - Top chart

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

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

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