

Financial Engineering

VL #1

Intro: Notion, Function, Applications

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Preliminaries

The notion of '*Financial Engineering*' (FE)

- ▷ From the dictionary:
to engineer: to lay out, construct, manage; to modify or produce.
- ▷ From the New Palgrave (J.Finnerty, 1992):
“Financial engineering involves the design, the development, and the implementation of innovative financial instruments and processes, and the formulation of creative solutions to problems in finance.”
- ▷ FE and Financial innovation
almost synonymous
“Financial innovation is the act of creating and then popularizing new financial instruments as well as new financial technologies, institutions, and markets.” (P.Tufano, 2003, Handbook of the economics of finance)

Preliminaries

Three examples

- ▷ Stripped (zero-coupon) Treasury securities
Splitting of Treasury notes into single coupon and principal payments, trading as separate securities.
- ▷ Adjustable Rate Convertible Debt
IR payment varies directly with dividend rate. (meanwhile considered as equity by the US tax authority, IRS)
- ▷ Discount certificate
Certificate to an underlying stock/indices with a cap; trades at a discount.

Preliminaries

FE - Types, Applications, Functions

- ▷ **Types**
 - ▷ Products
 - Consumer-type instruments
 - Securities
 - ▷ Systems and Processes

- ▷ **Applications**
 - ▷ Capital market products (supply side)
 - ▷ Risk management (demand side)
 - ▷ Corporate finance solutions

Preliminaries

Functions

- ▷ Exploiting tax and other regulations
- ▷ Minimizing transaction costs
- ▷ Reducing / reallocating risk
- ▷ Completing markets
- ▷ Agency problems and asymmetric information
- ▷ Response to technological 'shocks'

FE - Functions

Tax-induced innovations

- ▷ *“The major impulses to successful innovations over the past twenty years have come, I am saddened to have to say, from regulation and taxes.”*
M.Miller (1986)
- ▷ Zero-coupon bonds
Delaying the tax burden
(Originally, the US tax system allowed for deduction of the discount on bonds relative to their par value)
- ▷ Various preferred stock issues
 - Tax advantage if taxes on dividends are lower than on coupon payments.
 - Corporate investors (US) benefit from dividend deductions (70%) (E.g. auction rate preferred stock)

FE - Functions

(Bank) Regulation-induced innovations

- ▷ Bank capital requirements
Preferred stocks; qualifying as (tier 1) capital.
- ▷ Off-balance sheet activities
E.g. credit derivatives
- ▷ Regulatory capital arbitrage (Basel I)
Impulse for securitization
- ▷ (Islamic banking)
Ban on interest; but sale-repurchase contracts

FE - Functions

Transaction costs

▷ Issuance expenses

Extendible Notes e.g. are open-ended debt obligation which resets every few years to a new interest rate based on negotiations between the issuer and the investor.

▷ Intermediation fees

Euro Notes and CP. Direct investment rather than through intermediaries.

▷ Processes

ATMs, debit cards. (retail) Open-IPO (corporations)

FE - Functions

Reallocating risk

- ▷ Improving risk transfer and allocation
 - Derivatives in general
 - Mortgage-backed securities (Diversification)
 - Credit derivatives (CDS market and insurance companies)

- ▷ Serve risk preferences
 - Stripped MBS (Interest-Only, Principal-Only)
 - Decomposition of a fixed note to a FRN and a inverse FRN
 - Portfolio insurance (process innovation)

FE - Functions

Digression: Complete markets

Markets are said to be *complete*, if any arbitrary payoff can be generated with the existing assets.

Consider an economy with three states and the following two assets:

$$A = (1 \ 2 \ 3)$$

$$B = (1 \ 1 \ 1)$$

It is possible to 'replicate' (to buy) the payoff $(0 \ 2 \ 4)$.

→ buy 2 units A and sell 2 units B .

It is **not** possible to replicate e.g. the payoff $(2 \ 0 \ 0)$.

→ try to solve the equation:

$$\alpha (1 \ 2 \ 3) + \beta (1 \ 1 \ 1) = (2 \ 0 \ 0)$$

there are no values for α and β to solve that.

FE - Functions

Now, introduce a third asset C :

$$\begin{aligned} A &= (1 \ 2 \ 3) \\ B &= (1 \ 1 \ 1) \\ C &= (0 \ 2 \ 0) \end{aligned}$$

It is possible to find $(\alpha \ \beta \ \gamma)$, such that *state-contingent payoffs* can be constructed (so-called Arrow-Debreu securities).

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} -0.5 & 1.5 & -0.25 \\ 0 & 0 & 0.5 \\ 0.5 & -0.5 & -0.25 \end{pmatrix} \cdot \begin{pmatrix} 1 & 2 & 3 \\ 1 & 1 & 1 \\ 0 & 2 & 0 \end{pmatrix}$$

Then it is possible to construct **any** payoff $(x \ y \ z)$ since:

$$(x \ y \ z) = x (1 \ 0 \ 0) + y (0 \ 1 \ 0) + z (0 \ 0 \ 1)$$

FE - Functions

Complete markets and FE

- ▷ Possibility to shift funds across time and contingencies (risk management)
- ▷ Strips (s.above) have been empirically found to complete the market (Grinblatt/Longstaff (2000,JoF))

- ▷ Derivatives pricing

Market completeness is important for derivatives valuation.

If prices for the three securities above exist, we can back out implied probabilities.

FE - Functions

Agency conflicts and asymmetric information

- ▷ Agency conflicts between manager-owners and debt holders
Management may take actions, which are not in the interest of debt holders, and are not 'verifiable' (incomplete contracts). Contracts may be designed to align incentives.

- ▷ Asymmetric information
 - Security innovations: By offering specific contracts, firms may *signal* unobservable characteristics.
 - Process innovations: Improving overall accessibility of information.

→ e.g. Rating-trigger step-up bonds.

FE - Functions

Technological-driven innovations

- ▷ Improvements in IT
 - Pricing of complex products (More powerful computers allow numerical solutions to pricing problems, e.g. Monte Carlo simulation)
 - Facilitates trading (Electronic trading platforms, e.g. Eurex)

- ▷ 'Intellectual technologies'
 - Pricing models (e.g. Black/Scholes/Merton formula)
 - Risk measures
 - Life-cycle asset allocation

FE - Applications (the management perspective)

Capital market products

- ▷ The supply of new products:
 - may offer a profitable business (extracting rents)
 - may signal competence, know-how, reputation
 - may foster customer relationships

- ▷ Problematic: Financial innovations are not patentable. Successful products will be imitated.

- ▷ How much resources should be directed towards financial innovation?

FE - Concepts

Market for 'Zertifikate' (D)

Übersicht Emittenten										
Emittent	Alle Zert.	Dis-count	Index	Bas-ket	Hebel	Band-breite	Kapital-schutz	Bonus	Akt-anl.	Hedge-Fonds-Zert.
Alle Emittenten	146200	70919	4273	2395	12129	2213	5081	2049	10000	35
<u>HSBC Trinkaus</u>	17932	4511	159	56	4945	4912	181	1959	7772	--
<u>Sal. Oppenheim</u>	17234	8202	129	18	1231	7975	69	228	7189	--
<u>Commerzbank</u>	12142	10000	519	58	4828	10000	848	1035	2099	1
<u>Goldman Sachs</u>	10737	333	170	50	3203	7095	211	1000	698	--
<u>UBS Deutschland...</u>	10433	10000	234	84	69	4588	80	1000	390	--
<u>Deutsche Bank</u>	10352	9034	323	215	3038	4060	215	1001	168	10
<u>Dresdner Bank</u>	10109	9828	171	47	2409	2904	1315	63	61	3
<u>BNP Paribas</u>	10012	9381	18	26	5195	10000	65	1	--	1
<u>ABN Amro</u>	9829	2637	362	118	3382	3114	245	1000	63	3
<u>Cit</u>	9887	5249	99	21	1538	2793	8	1000	--	--
<u>Société Général...</u>	8600	1243	263	87	2450	4493	80	261	4	2
<u>DZ BANK AG</u>	3677	1443	233	675	824	518	705	354	49	--
<u>BHF-BANK</u>	3447	731	41	3	--	598	64	464	2098	--
<u>Vontobel Financ...</u>	2055	638	57	84	29	392	70	128	854	--

FE - Applications

Risk management

- ▷ Non-financial firms
Originally: FX- and IR-risks after the end of Bretton Woods ('73). Use of the then new class of derivatives.
Meanwhile: Use of sophisticated risk transfer instruments.

- ▷ Financial firms
 - 'Classic' risks of financial intermediation (IR, Liquidity)
 - Evolution towards risk intermediation
 - The need to increase risk-adjusted returns

FE - Applications

Corporate finance

- ▷ Modigliani & Miller Theorem
Capital structure does not matter, if...
→ Unbundled Stock Units (USU)

- ▷ Allocation of control and cash-flow rights
Tracking (Letter) stocks
Project finance

- ▷ Optimal security design to:
 - mitigate agency problems,
 - signal information,
 - avoid unfriendly takeovers

FE - Institutions

Institutions promoting FE

- ▷ Non-financial firms
 - Larger or smaller firms ?
 - Which industry sector?

- ▷ Financial firms
 - Evidence suggests that larger investment banks are leading innovators.
 - but: Upstart financial firms should be likely to establish them through innovative products.
 - Possibly self-reinforcing mechanism: More innovations lead to higher market share, and vice versa?

FE - Benefits

Benefits of FE

- ▷ For whom ?
Consumers, Innovators, Imitators, Financial market, Economy, Society?
- ▷ Increased market efficiency?
“Increasingly complex financial instruments have contributed to the development of a far more flexible, efficient, and hence resilient financial system than the one that existed just a quarter-century ago.” A.Greenspan (2005)
- ▷ Increased market volatility and fragility ?
Portfolio insurance was claimed to be responsible for the 1987 crash.
Derivatives are *“financial weapons of mass destruction”* W.Buffett.
- ▷ Academic results: at best mixed (see special issue of JET, 65, 1)

FE - Concepts

Two important concepts for FE

Replication - 'Synthetics'

- ▷ *to synthesize*: to put together, to combine or produce a whole by diverse parts.
- ▷ Replication
Analyze a complex (unknown) contract in terms of a bundle of simpler (known) contracts. In particular for pricing purposes.
- ▷ Synthetics
Creating new (more complex) financial products by combining existing (simpler) contracts.

FE - Concepts

Arbitrage-free valuation

▷ Arbitrage

Opportunity to make a self-financing, riskless profit.

▷ Absence of arbitrage

implies that two securities which provide the same stream of cash-flows have to trade for the same price. (E.g. a complex security and its replicating portfolio)

▷ Risk-neutral valuation

If uncertain cash-flows are involved, the pricing needs to take into account risk-aversion. In complete markets, risk-neutral probabilities can be used instead.