Financial Engineering

VL #1

Intro: Notion, Function, Applications

Jochen Lawrenz
Department of Banking & Finance
Innsbruck University
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/indice 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:

\[
A = \begin{pmatrix} 1 & 2 & 3 \end{pmatrix} \\
B = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}
\]

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:

\[
\alpha \begin{pmatrix} 1 & 2 & 3 \end{pmatrix} + \beta \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} = \begin{pmatrix} 2 & 0 & 0 \end{pmatrix}
\]

there are no values for \(\alpha\) and \(\beta\) to solve that.
FE - Functions

Now, introduce a third asset $C$:

\[
A = \begin{pmatrix} 1 & 2 & 3 \end{pmatrix} \\
B = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \\
C = \begin{pmatrix} 0 & 2 & 0 \end{pmatrix}
\]

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 accessability 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)

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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.