Computational Finance: Past, Present, and Future

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Overview

- What are the functions of a financial system?
- What are the principal subfields of computational finance?
  - Technical challenges
  - Role within the financial system
- Where do we go from here?

Functions of a Financial System*

*(Merton, 1995)

1) A financial system provides a payments system for the exchange of goods and services.

2) A financial system provides a mechanism for the pooling of funds to undertake large-scale indivisible enterprise.

3) A financial system provides a way to transfer economic resources through time and across geographic regions and industries.

Functions of a Financial System (cont.)

1) A financial system provides price information that helps coordinate decentralized decision-making in various sectors of the economy.
2) A financial system provides a way to deal with the asymmetric-information and incentive problems when one party to a financial transaction has information that the other party does not.
3) A financial system provides a way to manage uncertainty and control risk.

Why the Emphasis on Functions?

- Functions are vastly more stable than institutions.
- Institutions are shaped by:
  - Regulatory framework
  - Legal and tax framework
  - Psychology and biases of customers
  - Prevailing level of technology

1973

$$C = SN(d_1) - Ke^{-r(T-t)}N(d_2)$$

where

$$d1 = \frac{ln(S/K) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$$

$$d2 = d1 - \sigma\sqrt{T-t}$$

Computational Finance

- Derivatives pricing
- Structured finance
- Risk management
- Clearance, settlement, and margining
- Automated and semi-automated market-making and liquidity provision

The Black-Scholes Model and Subsequent Derivative Pricing Models

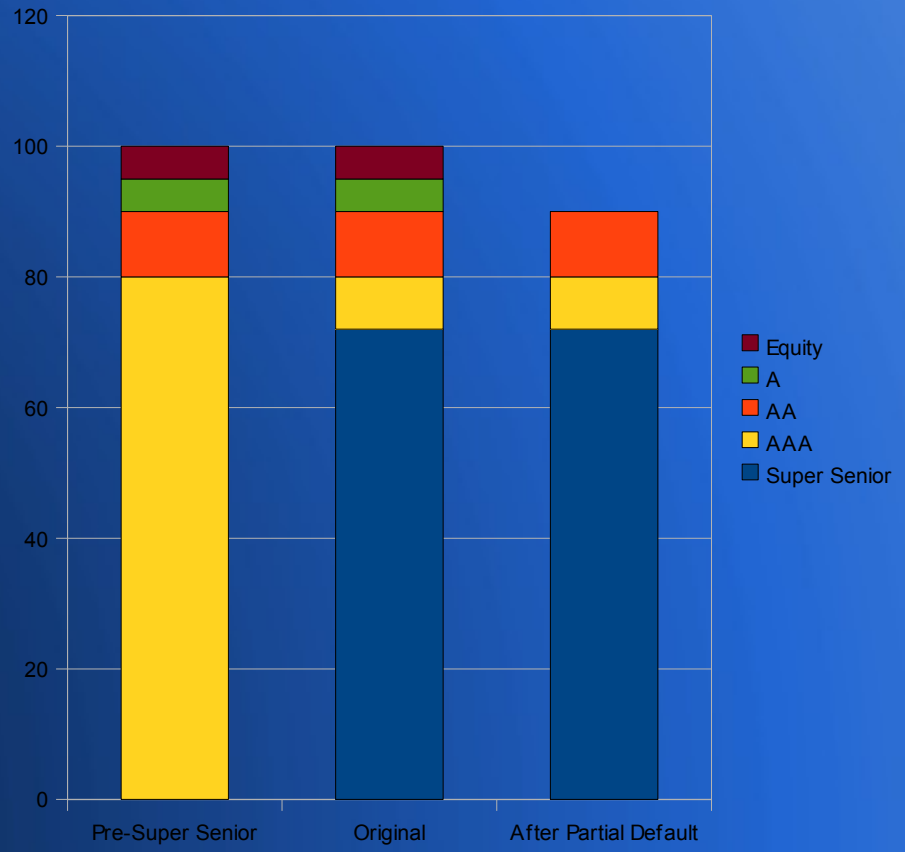
Similarities	Differences
These are toy models in the sense of a macroeconomic model, rather than hard models in the sense of a physicist's model	Many subsequent models do not have closed-form solutions
Risk can be managed in terms of “greeks” (derivatives of value with respect to variables and/or parameters)	Many subsequent models are not even recombinant

Consequences of Black-Scholes, etc.

- In the land of the blind the one-eyed man is king
- Inventories in securities → inventories in risks
  - Growth in gross exposures
  - Increasing sensitivity to errors in models
- Purely model-driven risk management
  - Increased demand for computing power

Structured Finance – An Example

- Risk aversion and risk transfer in finance theory
- Insurance basis for junior tranches
- Little theoretical support for senior tranches except diversification
- In practice, issuing banks held equity and super-senior tranches



Risk Management

- Change in inventory model of Wall Street / City led to demand for new risk management techniques
- Risk management techniques, applied to complex derivatives and structured finance books, are a key driver of IT needs and parallel computing infrastructure
- Combination of non-stationarity, kurtosis, and brittle models, together with ever-growing inventory sizes, means that risk management cannot be formalized

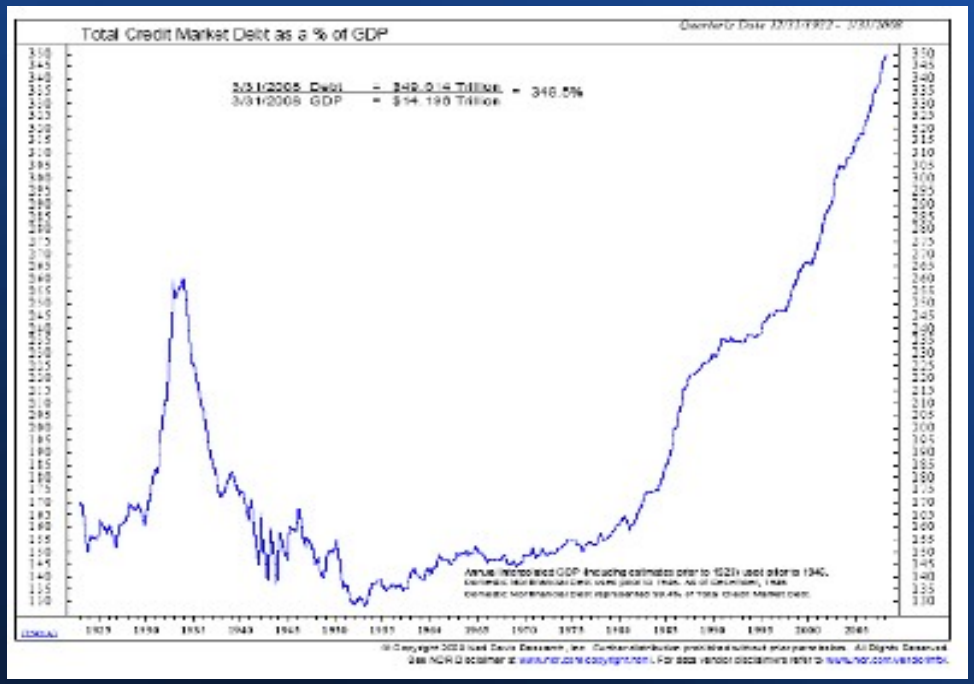
Automated Trading

- Data mining to find historical relationships in large data sets
- The random walk holds as a first approximation, so all statistical relationships are weak, and overfitting is a big concern
- One can look for relationships using either bottom-up or top-down methodology

Automated Trading (cont.)

- Adverse selection from delays → latency sensitivity
- Treadmill effect causes practitioners to push out to the edge of the capabilities of present-day IT
- There is a plethora of potentially interesting approaches, and the problem is completely open-ended

Earlier Inventory Model



- The demise of Lehman: 1974 vs 2008
- GS partners' capital in 1970: $53mm
- Morgan Stanley partners' capital in 1973: $10mm

The Functional Approach Revisited

- Derivatives and Structured Finance
  - Risk management
  - Intermediation function vs. insurance function
  - Need for a return to an earlier inventory model
- Risk Management
  - Always and everywhere a core function of financial intermediaries
  - Need to use the equivalent of robust statistical techniques

The Functional Approach Revisited (cont.)

- Risk Management
  - Inherently imperfect risk models can only provide risk insulation when financial leverage is reasonable
- Clearance, Settlement, and Margining
  - Risk insulation via collateral agreements has failed
  - Risk insulation via the exchange clearinghouse model has succeeded

The Functional Approach Revisited (cont.)

- Automated Trading
  - Liquidity services provided by automated traders will continue to be in demand
  - Demand will decrease as the economy definancializes
  - Demand will increase as the exchange clearinghouse model gains ground
  - Will the activity remain lucrative in the presence of the treadmill effect?

Conclusions

- We will have a new financial system which continues to satisfy the financial functions
- Changing perceptions of ability of modern risk management to perform risk insulation will force a return to the old inventory model, to the detriment of derivative trading and structured finance
- Leverage will be lower, and markets will be less complete
- Hedge funds or similar institutions with different fee structures will perform insurance / risk warehousing functions
- Automated trading will continue to provide liquidity services, and the overall impact of likely changes in the financial framework on this field is difficult to predict

Thank You!

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