



SOCIETY OF ACTUARIES

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**Keynote Luncheon – Theories, Models and
Metaphors in Science & Finance**

Emanuel Derman

Models, Metaphors & Theories ▶ in Science and Finance



An Alternative Investment Specialist

Emanuel Derman
Prisma Capital Partners and Columbia University
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Prisma Capital Partners: Speaker Biography ◀

◆ **Emanuel Derman, PhD**

Emanuel is the Head of Risk Management at Prisma Capital Partners LP and a professor and director of the MS program in financial engineering at Columbia University. Prior to joining Prisma, he was a managing director of firm-wide risk at Goldman, Sachs & Co.

Dr. Derman is known for his joint work on the Black-Derman-Toy model with Fischer Black and for the development of local volatility models. He is an associate editor of The Journal of Derivatives and the Journal of Risk. He was the IAFE/SunGard Financial Engineer of the Year 2000, and included in the Risk Magazine hall of fame 2002. Professor Derman holds a BS degree from the University of Cape Town, a MA and a PhD in Theoretical Particle Physics from Columbia University.



- Metaphors
- Models
- Why Is A Model A Model?
- Why Is A Theory A Theory?
- Spinoza's Theory of Emotions as Derivatives
- Money: Desire Pleasure Pain
- Models in Finance
- Finance vs. Science
- The One Law of Financial Modeling
- The Right Way To Use Valuation Models
- The Financial Modelers' Manifesto

- *Sleep is the interest we have to pay on the capital which is called in at death; and the higher the rate of interest and the more regularly it is paid, the further the date of redemption is postponed.*
- Arthur Schopenhauer
- *Periodicity of sleep and coupons* is the common element of the metaphor.
- Metaphors are an insight that state that something *is something else*.
- But metaphors also extend our understanding.
- Much of our knowledge is a layer of metaphors
- Metaphors and language build on our physical nature
 - Elation/depression
 - Light/dark

- Models are elaborations of metaphorical insights
- Model airplanes: what makes it a model?
Limited but significant resemblance to properties that are important to user
- Fashion model: Only the surface is important
- Weather model: measurable abstractions like pressure, temperature, and known/tested equations; limitations are the features we've omitted
- Economic model: invisible abstractions like supply, demand, untested equations; limitations are the concepts themselves, then the equations and finally the omissions
- The Standard Model: unifies previously disconnected theories via a symmetry; predicts the existence of previously unobserved interactions and particles; *more* than a model, closer to reality

- A model is not the thing in itself: there is a gap between the model and the system.
 - It is a caricature
 - It focuses on parts
 - It is a metaphor with limited applicability
 - It is a fetish, and therefore attractively dangerous
- Models transform consciously learned knowledge into unconscious visceral knowledge
- You need to digest previous metaphors to move up the hierarchy to wider ones
- Models are labor-saving devices, allow you to avoid thinking/working for yourself
 - Feynman diagrams, like silicon chips, bring computation to the masses
- Models reduce dimensionality
- Models extrapolate or interpolate
- Sometimes it's time to make unconscious knowledge conscious again

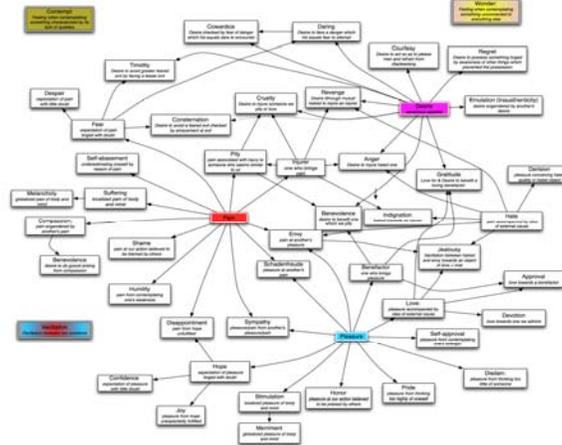
Why Is A Theory A Theory? ◀

- Models are *analogies* and *relative*. Theories are **the real thing**.
- A theory is the ultimate non-metaphor: אֶהְיֶה אֲשֶׁר אֶהְיֶה *I am that which I am*
- Theories tell you what something **is**. Models tell you what something is **more or less** like.
- A model: Othello: *I am not what I am*
- The Dirac equation for the electron
- Maxwell's Equations
$$\begin{aligned}\nabla \cdot \mathbf{B} &= 0 & \nabla \cdot \mathbf{D} &= \rho \\ \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} & \nabla \times \mathbf{H} &= \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\end{aligned}$$
- Why is the Dirac equation a **theory**?
- A theory provides **non-metaphorical** insight, deals in **absolutes**; hence often uses math. Theories are deep, models shallow.
- A correct theory is almost indistinguishable from the world

A Non-Physical Theory: Spinoza's Theory of Emotions ... ◀

- Spinoza's treats emotions like Euclid treats geometry: emotions are derivatives
 - Primitives are **Desire**, **Pleasure**, **Pain**
- Good** is everything that brings pleasure, and **Evil** is everything that brings pain.
- Love: **Pleasure** associated with an external object
- Hate: **Pain** associated with an external object
- Envy: **Pain** at another's **Pleasure**
- Hope: Expectation of future **Pleasure** tinged with doubt
- Fear: Expectation of future **Pain**
- Cruelty: **Desire** to inflict **Pain** on a someone **Loved**
- Three more primitives
 - Vacillation, Wonder, Contempt

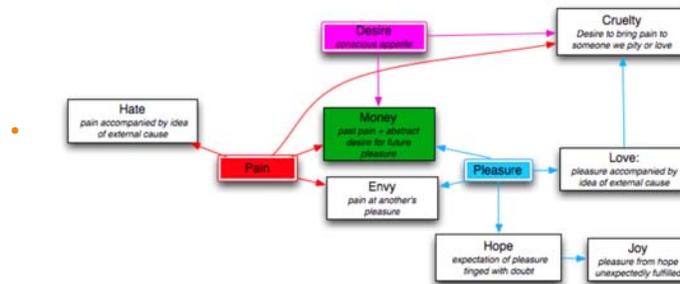
Spinoza's Theory of Emotions as Derivatives ◀



Money: Desire Pleasure Pain ◀

How Money Fits into Spinoza's Model

- *By the sweat of your brow will you eat bread*, said God to Adam and Eve after the Fall.
- In Spinoza's scheme, work is *pain* in the service of the *desire* to survive.
- Money is past *pain* in the service of the *desire* to survive, as well as a key to future *pleasure*.



- Fiat money incorporates only two of the three primitives, *pleasure* and *desire*
- Genuine money should always involve the recollected *pain* involved in creating it.

Models In Finance ◀

- The point is not usually divination, which rarely works
- A typical valuation model: apartment pricing & calibration
- Models transform intuitive linear quantities into nonlinear dollar values
 - Price per square foot to apartment price
 - Future yield to bond price
 - Future volatility to option price
- Models in finance calibrate the future, predict the present
- Models are used to rank securities by value on a 1-D scale
- Models interpolate from liquid prices to illiquid ones

Finance vs. Science ◀

- Science (mechanics, electrodynamics) is reductive, seeks principles
- Engineering is constructive
- From Newton to Mechanical Engineering
- From Maxwell to Electrical Engineering
- From ??? to Financial Engineering?
- Scientists carry out repeatable experiments on isolated systems. History and environment have weak effects.
- Economics deals with coupled systems where history is important and experiments can rarely be repeated.
- Jim Simons vs. Robert Engle
- Stocks are risky, models are uncertain. Uncertainty is worse than risk.
- Science plays against God. Finance plays against people.

The One Law of Financial Modeling ◀

- If you want to know the value of a financial security, use the known price of another security that is as similar to it as possible. All the rest is modeling.
- Any two securities with identical future payoffs, no matter how the future turns out, should have identical current prices.
- To build a model:
 - Specify all future scenarios (the science).
 - Prove the similarity of the payoffs (the engineering).

The Right Way to Use Valuation Models ◀

- Assume the bare minimum: static replication, dynamic replication, risk replication, utility
- Avoid axiomatization
- In physics it pays to drop down deep, formulate a principle, then come back up again. In finance, shallow is better. Use vulgar variables in a sophisticated way. (Vanna Volga)
- Sweep dirt under the rug if you need to, but tell people about it.
- Think of models as *Gedanken* experiments.
- There is no TOE; you're lucky if there's a TOA. To confuse the model with the world is to embrace a future disaster driven by the belief that humans obey mathematical rules.
- *If a fool would persist in his folly he would become wise.*
- A little hubris in modeling is OK.
- Somewhere north of common sense but south of hubris lies the appropriate use of models.

The Financial Modelers' Manifesto ◀

- ◆ I will remember that I didn't make the world, and it doesn't satisfy my equations.
- ◆ Though I will use the models I or others create to boldly estimate value, I will always look over my shoulder and never forget that the model is not the world.
- ◆ I will not be overly impressed my mathematics. I will never sacrifice reality for elegance without explaining to its end users why I have done so.
- ◆ I will not give the people who use my models false comfort about their accuracy. I will make the assumptions and oversights explicit to all who use them.
- ◆ I understand that my work may have enormous effects on society and the economy, many beyond my apprehension.
- ◆ MODELERS OF ALL MARKETS, UNITE! You have nothing to lose but your illusions.



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PRISMA CAPITAL PARTNERS

Prisma Capital Partners LP

One Penn Plaza
Suite 3515
New York, New York 10119
Phone: (212) 590-0800 Fax: (212) 590-0810
www.prismapartners.com

Prisma Capital Management International LLP

6 Chesterfield Gardens
London W1J 5BQ
Phone: +44 (0) 20 7016 6485
Fax: +44 (0) 20 7016 6460

