Explanatory vs. Predictive Statistical Modeling

Galit Shmuéli

UNIVERSITY OF MARYLAND

ROBERT H. SMITH SCHOOL OF BUSINESS

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United States Military Academy

What is R^2 ?

R-square	Adj R-Sqr	Probability	# of Obs
0.269	0.266	0.000	506

REGRESSION COEFFICIENTS

Independent	Un-stdized Coefficient	Stdized Coefficient	Significance
Intercept	0.193182	0.000000	0.999
Group 1	-0.050325	-0.036319	0.393
Group 2	-0.014610	-0.010544	0.487
Group 3	0.806818	0.512045	0.000

From Goals
To Models

Goal: Explain	Goal: Predict
theory	utility
	relevance
	new theory
causality	
	association
retrospective	
	prospective

Philosophy of Science

"Explanation and prediction have the same logical structure"

Hempel & Oppenheim, 1948

"It becomes pertinent to investigate the possibilities of predictive procedures autonomous of those used for explanation"

Helmer & Rescher, 1959

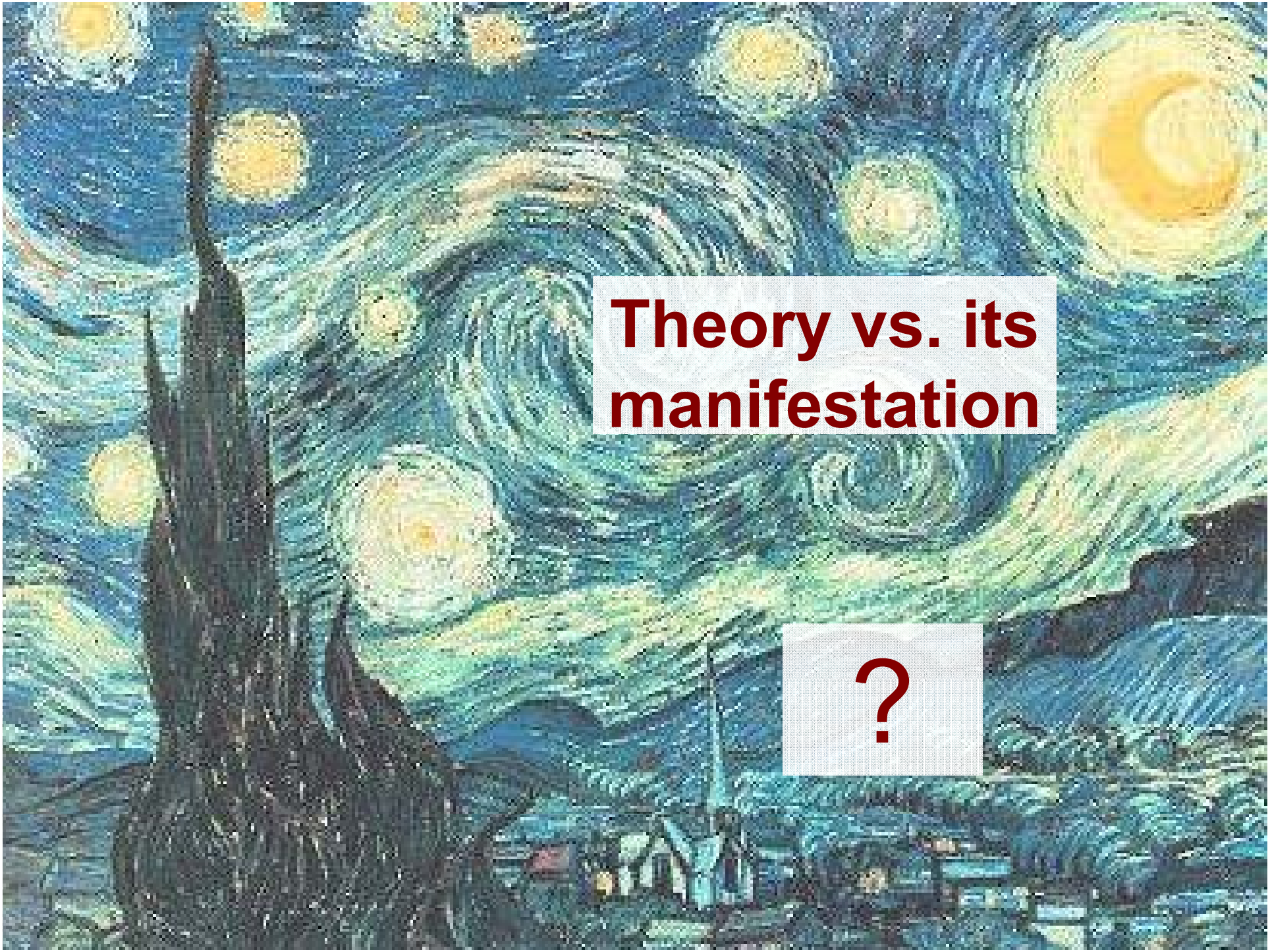
"Theories of social and human behavior address themselves to two distinct goals of science: (1) prediction and (2) understanding"

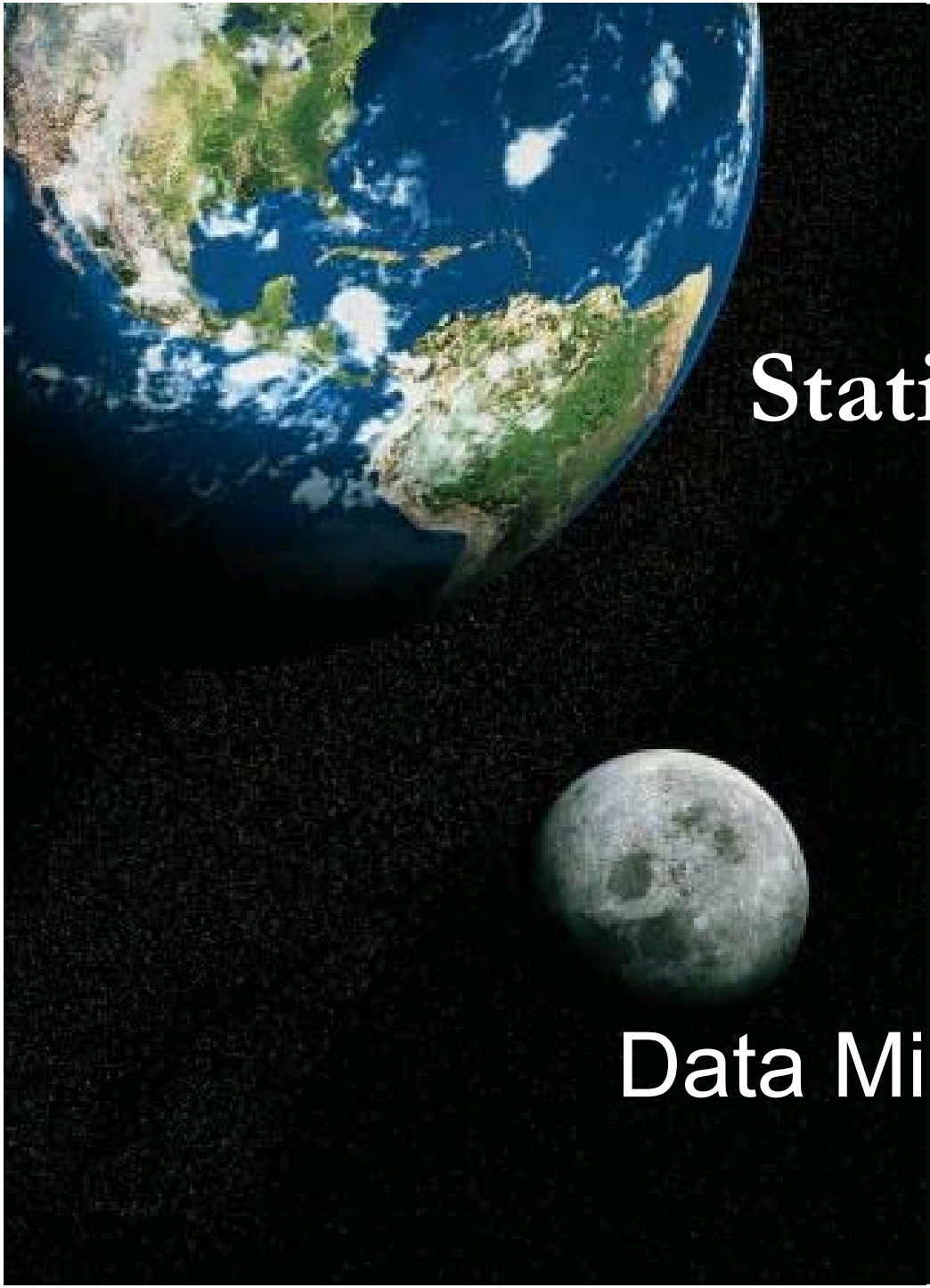
Dubin, *Theory Building*, 1969

Best explanatory model

$\neq$

Best predictive model


Theory vs. its manifestation
?



Statistics = Explain

Data Mining = Predict

Predict ≠ Explain

+

?

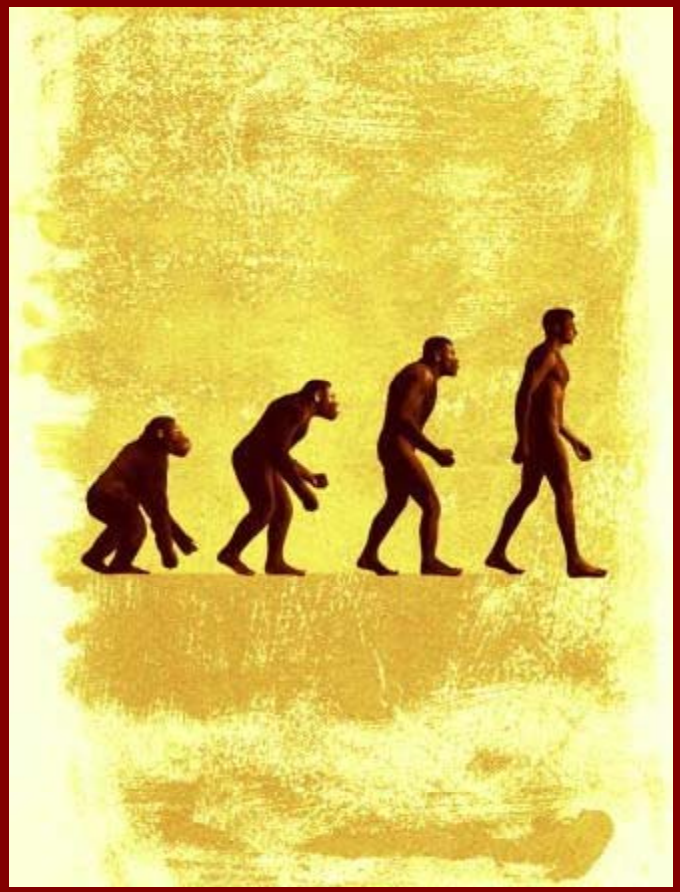
Predict ≠ Explain

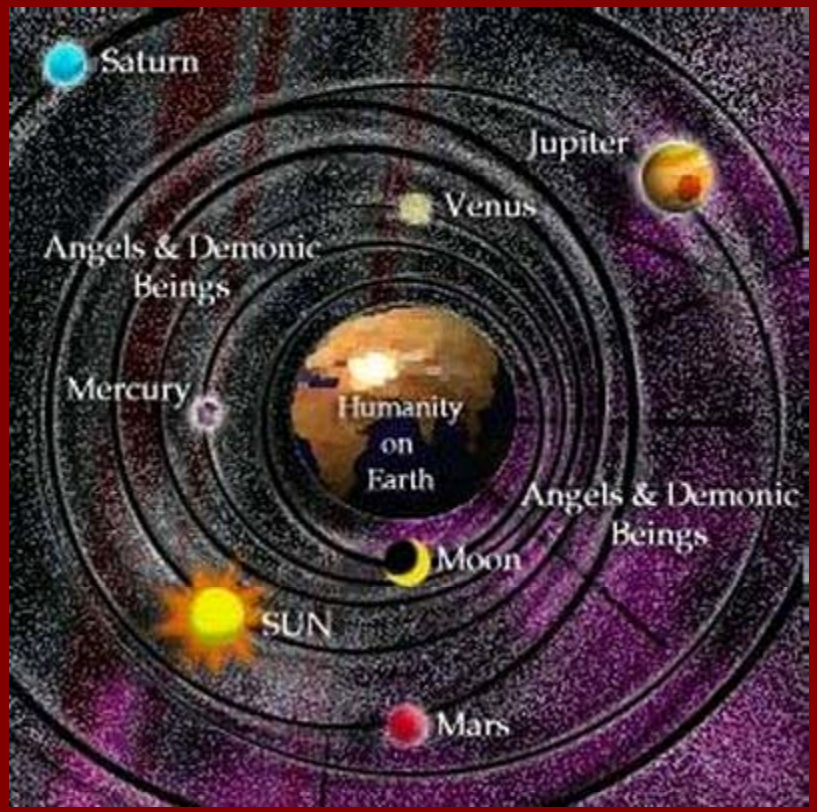
The FDA considers two products **bioequivalent** if the 90% CI of the relative mean of the generic to brand formulation is within 80%-125%

"We are planning to… develop predictive models for bioavailability and bioequivalence"

Lester M. Crawford, 2005
Acting Commissioner of Food & Drugs

Controversy



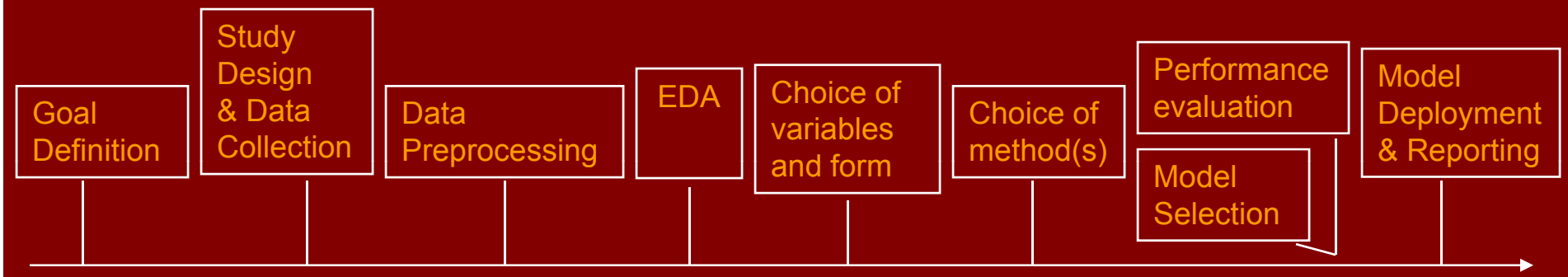


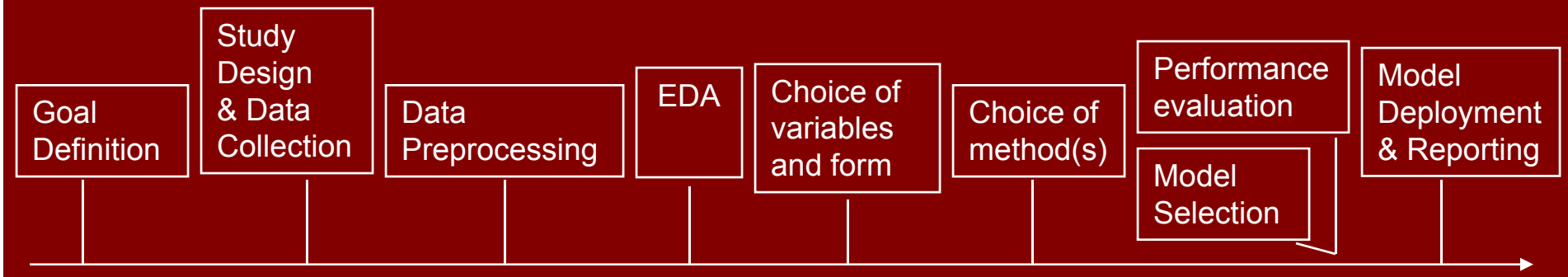
Ptolemaic astronomy

Two statistical modeling paths

China's Diverging Paths, photo by Clark Smith

Find the Differences





Model Deployment & Reporting

explain phenomena
predict new data

support / refute theory

reality check

evaluate predictability

lead to new theory

Performance Metrics

interpretation

out-of-sample

p-values

prediction accuracy

R^2

costs

goodness-of-fit

run time

type I,II errors

over-fitting

What is **Optimized?**

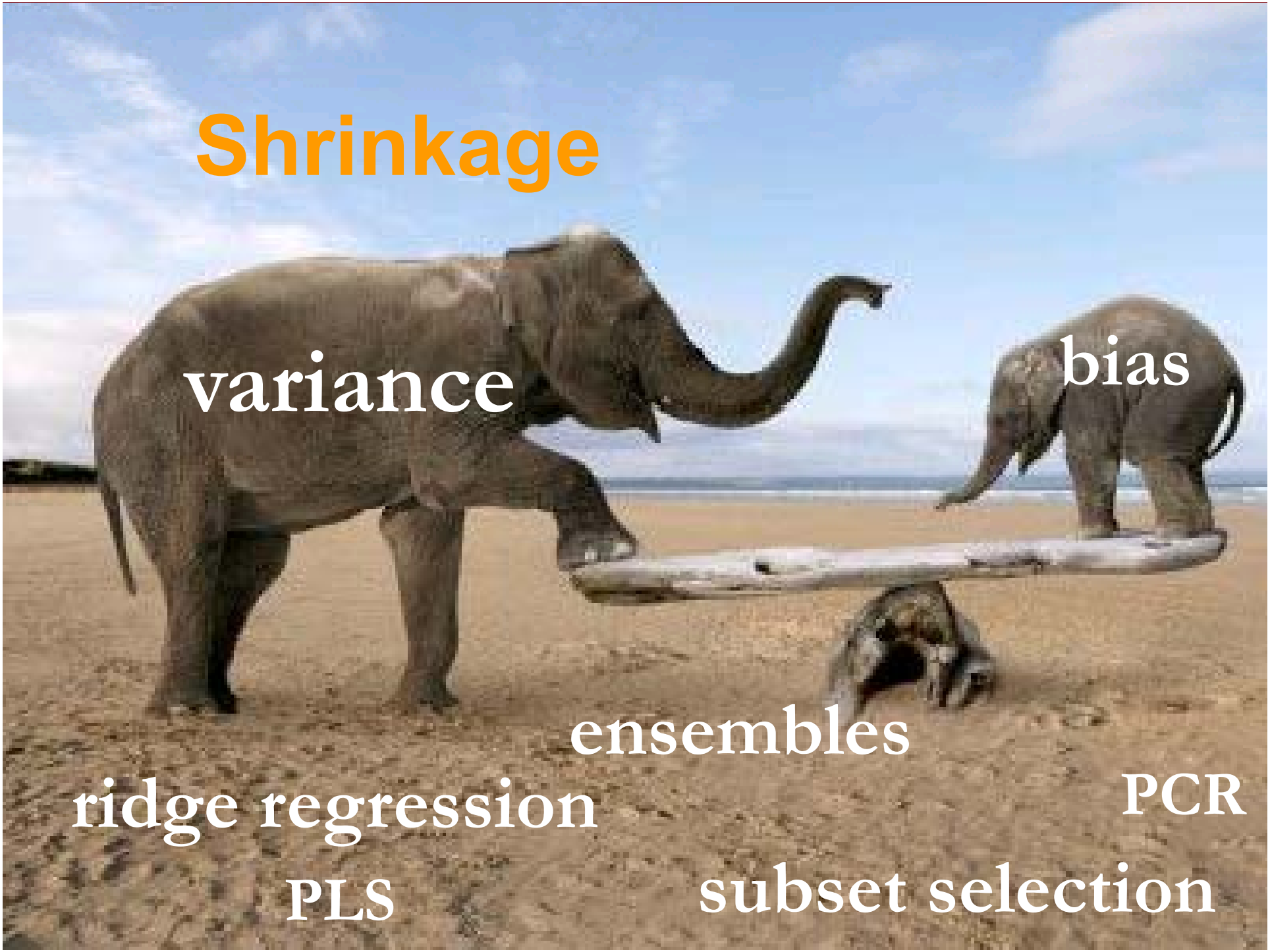
Bias or **Prediction MSE**

$$
\begin{aligned}
MSE = E(Y - \hat{Y}|x)^2 &= E(Y - \hat{f}^*(x))^2 \\
&= E(Y - f(x) + f(x) - f^*(x) + f^*(x) - \hat{f}^*(x))^2 \\
&= E(Y - f(x))^2 + (f^*(x) - f(x))^2 + E(\hat{f}^*(x) - f^*(x))^2
\end{aligned}
$$

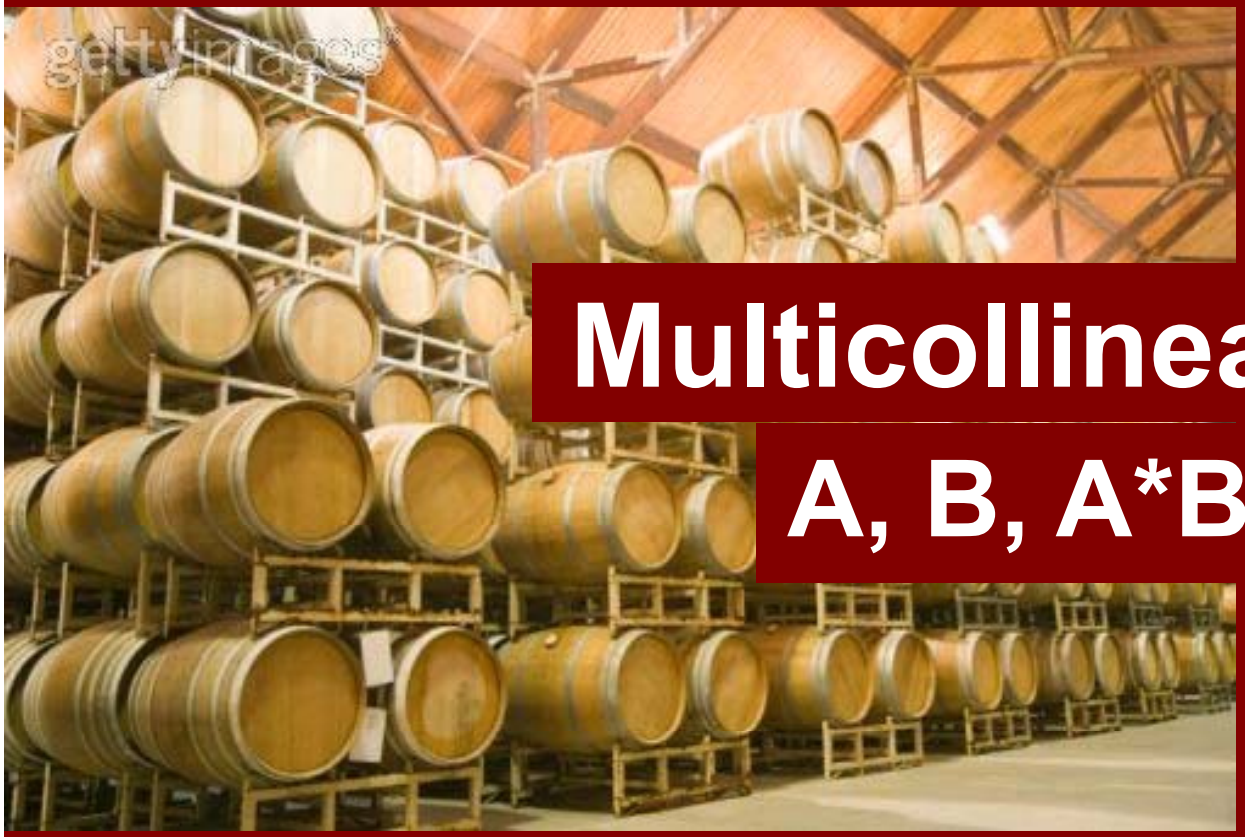
Var(Y)= uncontrollable

bias^2 = model misspecification

estimation (sampling variance)


Shrinkage
variance
bias
ensembles
ridge regression
PCR
PLS
subset selection

Which Variables?



Multicollinearity?

A, B, A*B?

theory

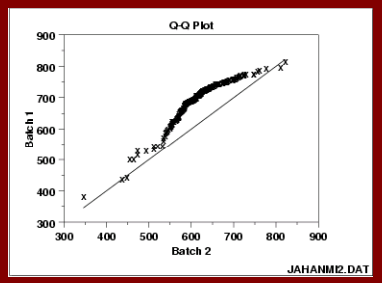
associations

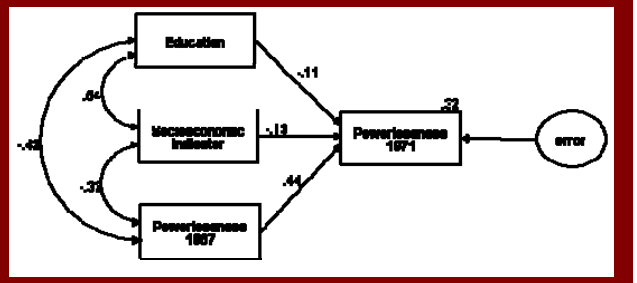
ex-post availability

summary stats *plots*

Explore!

trends *outliers*



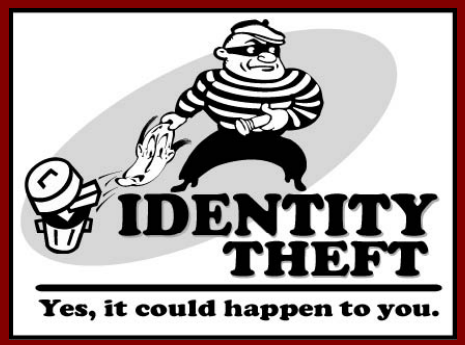


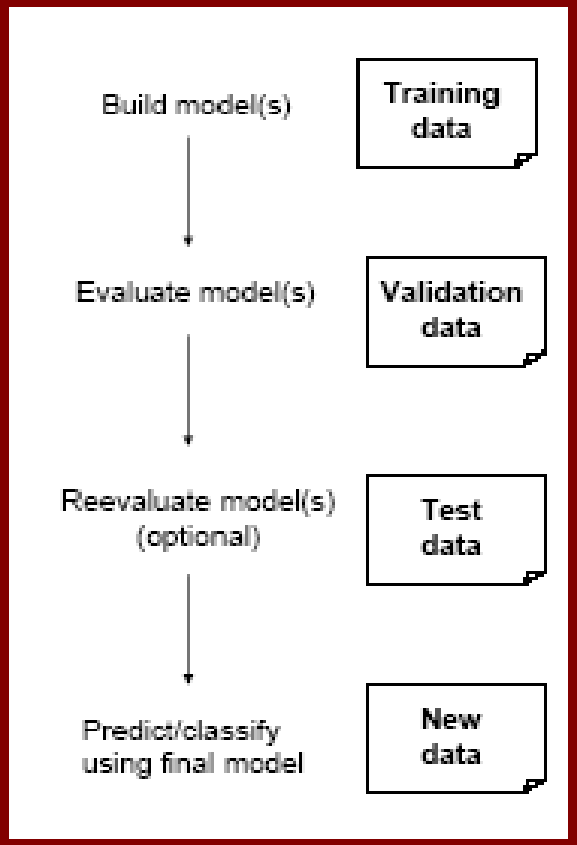
PCA
SVD

Data Preprocessing

missing

reduced-feature models





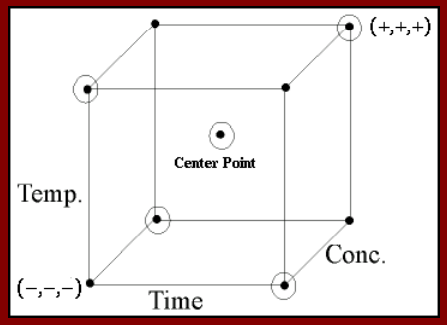
partitioning

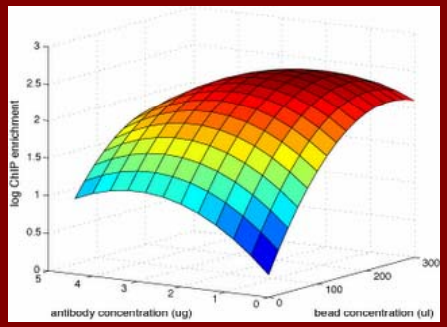
Study Design & Data Collection

How much?

accuracy **power** **cost**

Fixed vs. random effects





DoX

Three Current Problems

Predictive role underappreciated

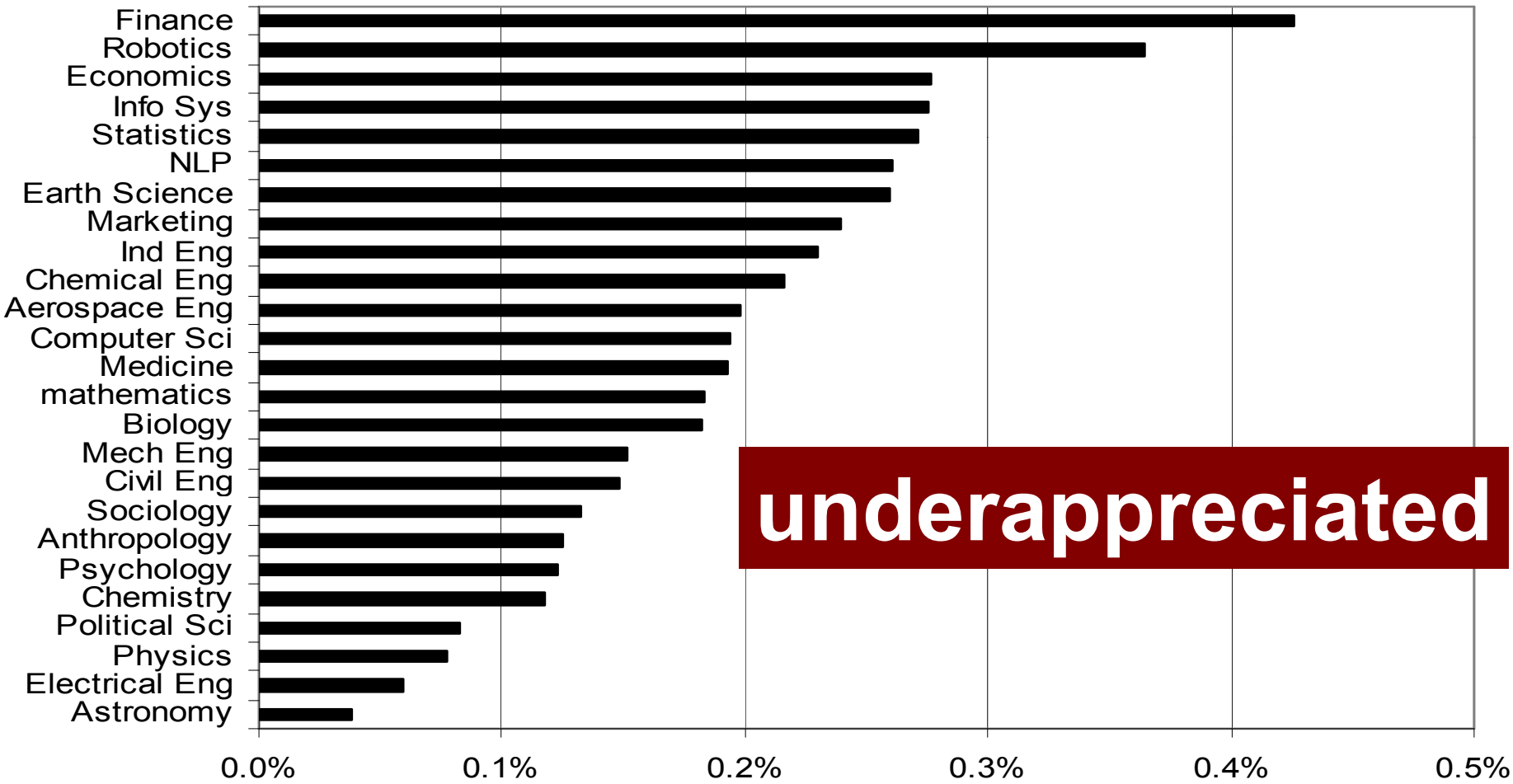
Distinction blurred

Inappropriate modeling

"While the value of scientific prediction… is beyond question… the inexact sciences [do not] have…the use of predictive expertise well in hand."

Helmer & Rescher, 1959

% of "Predictive Model" hits on Google Scholar



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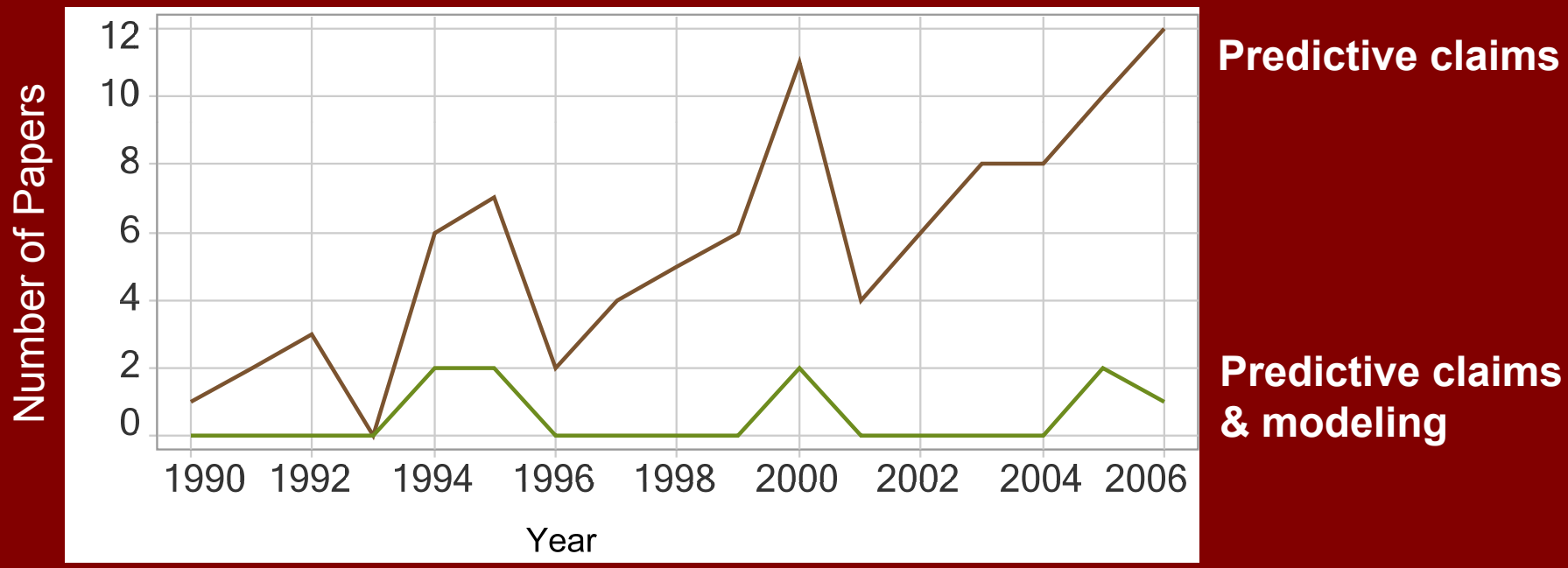
Published Date from Jan Yr: 1990 to Dec Yr: 2006
Publication MISQ ISR

MIS Quarterly

Predictive goal stated?
Predictive modeling followed?

"Examples of [predictive] theory in IS do not come readily to hand, suggesting that they are not common"

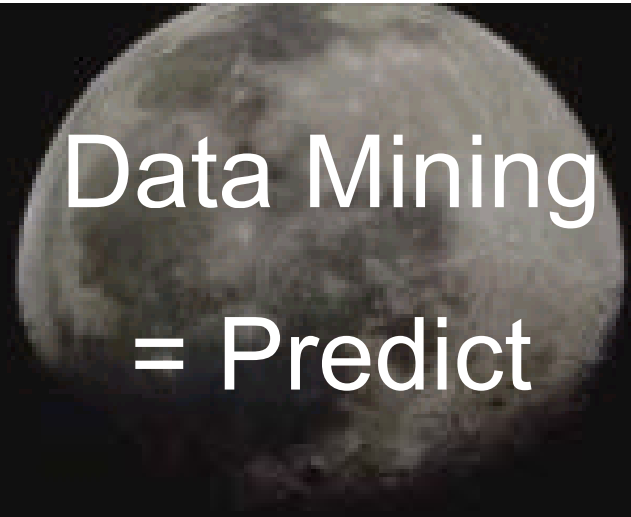
Gregor, MISQ 2006

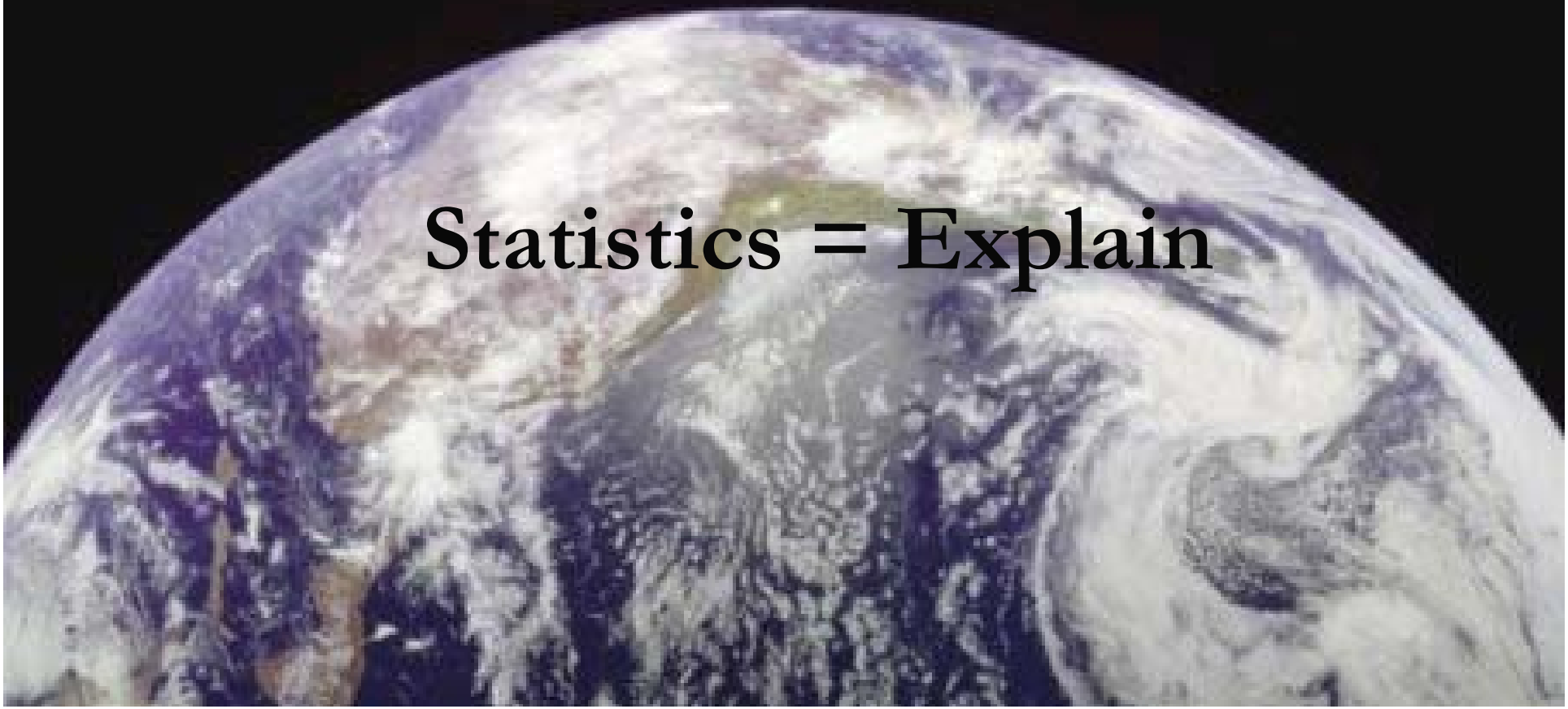


Sound predictive modeling is rare

Modeling 101:

What do we teach?





Bottom Line: Acknowledge!

Philosophy:

explaining and **predicting** are **different, necessary**

Statistical Modeling

distinction blurred

↓

incorrect modeling